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Agricultural Socialization Services and Agricultural and Rural Modernization Under Digital Empowerment

Qian Xia[1, *]

[1]Anhui University of Finance and Economics, Bengbu 233030, China
[*] Corresponding author

Abstract: This study explores how agricultural socialized services facilitate the modernization transformation of agriculture and rural areas in the digital era. With the continuous development of agricultural socialized services, particularly under the empowerment of digital technologies, profound changes are taking place in agricultural production and service models. Based on the theoretical mechanisms by which agricultural socialized services enhance total factor productivity, bridge smallholder farmers with modern agriculture, and promote green agricultural development, this research analyzes their role in advancing agricultural and rural modernization. The findings indicate that agricultural socialized services not only improve production efficiency but also provide smallholder farmers with greater market access and resource allocation flexibility. Meanwhile, the application of digital technologies has made these services more precise and efficient, thereby driving sustainable agricultural development. Through empirical analysis, the study reveals heterogeneous performance across different regions and farm scales in the adoption of agricultural socialized services, offering critical insights for policymakers. Finally, a series of policy recommendations are proposed to further refine the agricultural socialized service system, promote comprehensive modernization of agriculture and rural areas, and contribute to the realization of rural revitalization and sustainable development goals.

Keywords: Agricultural socialized services; Agricultural and rural modernization; Digital empowerment; Total factor productivity; Sustainable development.

1. Introduction

1.1. Background

The modernization of agriculture and rural areas is a crucial component of achieving high-quality economic development in China. With the accelerating urbanization process, traditional agriculture faces numerous challenges, such as low production efficiency and subpar product quality. Therefore, promoting the modernization of agriculture and rural areas has become an urgent demand of the times. From a global perspective, agricultural modernization is not only key to enhancing food security and resource utilization efficiency but also a vital pathway to ensuring increased income for farmers and improving rural living conditions.

The rapid advancement of digital technologies has provided new momentum for the modernization of agriculture and rural areas. Agricultural socialized services, serving as a critical bridge connecting smallholder farmers with modern agriculture, can leverage digital empowerment technologies to enhance the intelligentization of agricultural production and promote precision management. This, in turn, effectively improves total factor productivity, helps smallholder farmers swiftly adapt to market changes, facilitates technological progress, and strengthens the resilience and competitiveness of agricultural production.

The modernization of agriculture and rural areas is not only an inherent requirement for economic development but also a crucial step toward achieving sustainable development and advancing comprehensive rural reforms. In this process, it is essential to drive the deep integration of various socialized services with agricultural production through policy guidance, technological innovation, and the improvement of service systems, thereby meeting the expectations for agricultural and rural modernization in the new era.

1.2. Research objectives and content

1.2.1. Theoretical Objective: Mechanism Analysis

When studying the relationship between agricultural socialized services and agricultural and rural modernization, the theoretical focus primarily lies in analyzing their mechanisms of action. The core of this mechanism analysis is to reveal how agricultural socialized services enhance the modernization level of agriculture and rural areas by improving total factor productivity, optimizing resource allocation, and facilitating technology dissemination.

Agricultural socialized services help bridge smallholder farmers and modern agriculture, achieving efficient resource utilization and enhanced production efficiency. Through service outsourcing, farmers gain access to more specialized technical and managerial services, thereby driving the transformation of their production models toward green and high-efficiency practices and improving agricultural green total factor productivity [1]. Digital empowerment provides new opportunities for agricultural socialized services, as the widespread application of information technology transforms traditional agricultural production methods, further enhancing the digital level and production capacity of modern agriculture [2].

Clarifying the practical pathways for optimizing agricultural policies and service supply ensures that the theoretical analysis not only holds academic significance but also provides effective guidance for practical operations. These factors collectively constitute the key driving forces of agricultural socialized services in advancing agricultural and rural modernization.

1.2.2. Practical Objectives: Policy Recommendations

To effectively promote the synergistic development of agricultural socialized services and agricultural and rural modernization, we can take the following measures:

Improve the agricultural socialized service system. Local governments can formulate relevant policies based on local conditions to provide institutional support for the development of agricultural socialized services. At the same time, they should strengthen the training and management of service personnel to enhance service quality and efficiency, ensuring effective linkage between smallholder farmers and modern agriculture.

Promote the application of digital technologies in agricultural socialized services. Leveraging modern information technologies such as big data and cloud computing can optimize agricultural resource allocation and enable scientific management. Digital empowerment enhances the precision of services, making agricultural production more intelligent and eco-friendly.

Encourage farmers to participate in diversified cooperative models. For example, establishing farmer cooperatives and integrating them into agricultural industry chains can improve economies of scale in production. Additionally, strengthening financial support and expanding financing channels for services can lower barriers to farmer participation, thereby fostering the sustainable development of agricultural socialized services.

1.3. Research implications

Theoretical Significance:

Current literature on agricultural modernization and socialized services is abundant, yet primarily focuses on agricultural productivity and technological advancement, with relatively limited research on the impact of agricultural socialized services under digital empowerment. This study systematically reviews the theories and developments of agricultural socialized services and agricultural/rural modernization, contributing to a deeper understanding of how these services play a pivotal role in digital transformation. Through empirical analysis, it demonstrates the significant positive effect of digital-enabled agricultural socialized services on agricultural green total factor productivity (GTFP), providing valuable theoretical insights. These findings advance research on agricultural socialized services and lay a foundation for subsequent studies.

Practical Significance:

Based on an analysis of the current state of agricultural socialized services, this research employs data collection and case study methods to highlight their positive role in enhancing rural economic development. The study strengthens the capacity of smallholder farmers to engage with modern agriculture, fosters overall rural economic growth, and improves farmers' adaptability during agricultural transformation. The findings offer actionable references for policymakers, practitioners, and researchers, underscoring the study's practical relevance.

1.4. Research Status

1.4.1. Current status of domestic research

(i) Impact of Agricultural Socialized Services on Agricultural Green Total Factor Productivity

Leng Langping (2023) employed macro-level provincial data and micro-level farmer data, using a hybrid distance function model to measure Agricultural Green Total Factor Productivity (AGTFP). By constructing dual fixed-effects models and spatial econometric models, the study found that agricultural socialized services significantly promote AGTFP with spatial spillover effects, while demonstrating heterogeneity across regions and farm scales. The research also identified pathways such as farmland scale operations and adoption of green agricultural technologies to enhance AGTFP.

Li Yuchao and Zhang Lijie (2024) developed a farmer-centered theoretical framework and empirically verified through provincial data that agricultural socialized services significantly improve AGTFP, with a more pronounced effect on part-time farmers than full-time farmers. Urbanization was found to have threshold moderating effects.

Cheng Yongsheng and Zhang Deyuan (2024) constructed a theoretical framework integrating agricultural socialized services with AGTFP, using decomposed components as mediating variables to explain the mechanisms [3]. Further empirical tests by Cheng Yongsheng, Zhang Deyuan and Wang Xia (2024) demonstrated that socialized services reshape agricultural production behaviors by improving green agricultural technology efficiency and technological change at the farm level, thereby elevating GTFP. The study also revealed complementary effects between farmer factor endowments and socialized services [4].

Gu Yu (2024) conducted nationwide analysis across 31 provinces through theoretical, status-quo and empirical examinations, confirming that agricultural socialized service levels significantly boost grain GTFP. The effects varied across service types and regions, with pathways including scaled operations and technological progress [5]. These studies provide multidimensional evidence for policymaking by thoroughly analyzing the complex relationship between agricultural socialized services and AGTFP.

(ii) Exploration and Development of Agricultural and Rural Modernization

Wu Yuxing (2024) systematically reviewed the CPC's century-long modernization journey regarding agriculture, rural areas and farmers - from "agricultural modernization (early modernization)" to "agricultural and rural modernization" - highlighting transformations in conceptual positioning, practical focus, distinctive features, historical context, integrated strategies and implementation pathways [6].

Gong Qianwen (2023) defined the scientific connotation of Chinese-style agricultural and rural modernization, characterizing it by features including intelligentization, marketization, legalization, localization and greening, while establishing an evaluation index system and implementation pathways [7].

Peng Wei and Luo Ying (2024) analyzed the generative logic and scientific essence of agricultural and rural modernization, identifying current challenges such as low agricultural productivity and proposing technology empowerment among solutions [8]. These studies provide theoretical guidance by examining modernization through historical, conceptual and implementation lenses.

(iii) Practices and Development Pathways of Agricultural Socialized Services

Gong Ping et al. (2023) proposed that the Beidahuang Group should leverage its leadership in modern large-scale agriculture to promote the "1241" agricultural socialized service model, using service modernization to drive high-quality development of agricultural and rural modernization [9].

Zhang Yunhe and Zhao Liang (2023) examined China's agricultural socialized service platform through a case study of Suzhou, Anhui Province, demonstrating its effectiveness in resolving pain points like demand-supply matching in agricultural production trusteeship services [10].

Tian Yun and Xia Rui (2024) acknowledged the existing foundation for high-quality development of agricultural socialized services while identifying challenges such as misalignment between service providers and policies, recommending optimized service supply systems among solutions [11].

Liu Anzhi and Yang Shuguo (2024) developed indicator systems and models to analyze the coupling coordination between agricultural socialized services and modernization in Heilongjiang Province, offering recommendations for synergistic development [12]. These practice-oriented studies provide both empirical experience and policy recommendations for advancing agricultural socialized services.

1.4.2. Summarize the comments

Based on the comprehensive review and analysis of current literature, domestic scholars' research on "digital-enabled agricultural socialized services and rural economic development" primarily focuses on three key areas: agricultural modernization, service supply, and economic outcomes. Substantial achievements have been made in these domains, with studies examining the significance of agricultural socialized services through lenses such as service model innovation, digital technology application, and policy implementation. These contributions have established a robust theoretical foundation and practical experience for advancing agricultural and rural modernization.

The majority of domestic scholars agree that digital empowerment can effectively enhance the efficiency and quality of agricultural socialized services. They argue that promoting rural economic development requires integrated approaches encompassing technological innovation, financial support, and policy guidance. Existing research has concentrated on digital agriculture and service systems, with empirical studies predominantly focusing on agricultural technology and new agricultural business entities, including cooperatives and family farms.

However, research on the ecological and social equity implications of digital technologies remains relatively limited. Most case studies center on the agricultural supply chain, while fewer explore rural social governance or differentiated impacts across farm scales. Nevertheless, the extensive body of work on digital empowerment, agricultural socialized services, and rural sustainable development has laid a rich theoretical groundwork and provided numerous practical case references. These studies have significantly propelled both theoretical and practical progress in rural economic development, while also serving as key references for this paper's case analysis and policy recommendations.

2. Overview of Agricultural Socialization Services

2.1. Definition and classification of agricultural socialization services

Agricultural Socialized Services refer to a series of integrated and optimized activities encompassing production, processing, and marketing through socialized platforms and market mechanisms, aiming to enhance agricultural productivity and farmers' income. By adopting specialized approaches, these services compensate for smallholders' deficiencies in resource allocation and technological application, facilitating their effective integration into modern agricultural systems and promoting sustainable development.

Agricultural socialized services can be categorized into several types based on service content: Production Services: Including field operations, agricultural mechanization services, cultivation technical guidance, and pest control. Operational Services: Covering market information, product distribution, and capital flow management. Value-added Services: Focusing on deep processing of agricultural products, brand development, as well as advertising and marketing.

2.2. Development History of Agricultural Socialized Services

As a crucial instrument for promoting agricultural modernization, agricultural socialized services underwent significant evolution during China's rural economic system reform in the late 20th century, which quietly transformed agricultural production methods. Initially, these services primarily focused on providing basic production support to farmers, including technical guidance and machinery operations, laying the foundation for smallholders to enhance productivity.

Entering the 21st century, massive rural labor migration and accelerated agricultural modernization expanded the scope and depth of these services. They evolved from simple production assistance to diversified, specialized offerings encompassing technology, information, finance, and market services. Innovations like agricultural technology extension, production trusteeship, and cooperative organizations emerged as vital forces driving agricultural transformation.

Recent years have witnessed digital technologies unlocking new opportunities for agricultural socialized services. Digital empowerment has enriched service formats, streamlined information dissemination, and increased farmer engagement, establishing a more robust foundation for sustainable development of these services.

2.3. Current Status and Challenges of Agricultural Socialized Services

Currently, agricultural socialized services play an increasingly pivotal role in China's agricultural modernization. In recent years, multi-tiered service systems covering technical support, market information, and logistics distribution have been established nationwide, fostering agricultural specialization and scale operations. Nevertheless, several challenges persist:

Inadequate service quality and limited coverage constrain effectiveness. Many local service institutions suffer from weak capacity and professional talent shortages, failing to meet diverse farmer needs and resulting in resource waste and imbalance.

An immature market mechanism creates disconnects between service supply and demand. Low farmer acceptance and participation in modern agricultural technologies hinder service adoption.

Insufficient systemic policy guidance remains an obstacle. Governments must intensify efforts in funding, R&D, and service platform development to elevate overall service standards and better serve agricultural and rural modernization goals.

3. Digital-Enabled Agricultural Socialized Services

3.1. Application of Digital Technologies in Agricultural Socialized Services

3.1.1. Integration of Digital Platforms with Agricultural Socialized Services

Digital platforms can aggregate data from farmers, enterprises, and service institutions, leveraging big data technologies to provide accurate market analysis, technical consultation, and agricultural production guidance. Farmers gain real-time access to market prices, cultivation techniques, and other directives, significantly mitigating risks associated with information asymmetry.

These platforms also drive innovation in service models. Through online service platforms, farmers can more easily access machinery rentals, technical services, and logistics distribution. This transformation in service delivery not only enhances service quality but also alleviates burdens on smallholder farmers, enabling them to focus more on production and operations.

3.1.2. Data-Driven Decision Support Systems

A data-driven decision support system utilizes modern information technologies to comprehensively analyze various data in agricultural socialized services, assisting decision-makers in making scientific and rational choices. By evaluating data on crop growth conditions (e.g., climate, soil characteristics) and market demand, the system provides farmers with precise planting recommendations and management strategies. Additionally, it simulates different decision scenarios to predict potential outcomes, helping farmers assess risks and returns, thereby enhancing flexibility in daily operations.

3.2. Impact of Digital Empowerment on Agricultural Productivity

3.2.1. Mechanisms for Enhancing Total Factor Productivity (TFP)

Advancing agricultural and rural modernization requires improving Total Factor Productivity (TFP). Advanced agricultural socialized services boost TFP by coordinating and integrating production factors. These systems consolidate agricultural resources, reducing costs while improving synergy across production processes.

The digital transformation of agricultural socialized services further accelerates TFP growth. Information technologies streamline data and capital flows, enabling finer management. This not only minimizes resource waste but also optimizes production structures, promoting sustainable development.

3.2.2. Digital Transformation of Smallholder Farmers

With digital technologies increasingly applied in agriculture, the digital transformation of smallholder farmers has become a critical step toward modernization. Digital tools empower farmers to access market information, optimize resources, and enhance production management more effectively.

This transformation encompasses product marketing, resource allocation, and farm management. E-commerce platforms, for instance, allow smallholders to sell directly to consumers, eliminating intermediaries and strengthening market competitiveness. Data-driven production decisions reduce costs while increasing output value.

To support this transition, governments should implement targeted policies and technical training programs. Encouraging investments in digital infrastructure—such as universal internet access and smart technologies—will enable smallholders to participate more fully in the digital economy, thereby accelerating rural agricultural modernization.

4. The Impact of Agricultural Socialized Services on Agricultural and Rural Modernization

4.1. The Role of Agricultural Socialized Services in Enhancing Agricultural Productivity

4.1.1. Improvement of Green Total Factor Productivity (GTFP)

Green Total Factor Productivity (GTFP) serves as a crucial indicator for evaluating agricultural sustainable development and resource utilization efficiency. The development of agricultural socialized services has promoted the rational allocation and utilization of production factors, thereby significantly improving agricultural GTFP.

By providing technical support, market information, and resource integration, agricultural socialized services help smallholder farmers enhance production efficiency while reducing resource waste. The introduction of modern agricultural technologies and management models facilitates the green transformation of agricultural production.

4.1.2. Transformation of Agricultural Production Methods

The transformation of agricultural production methods represents a critical component in advancing agricultural and rural modernization. With the continuous development of agricultural services, traditional smallholder farming models are gradually transitioning to more scaled and intensive modern agriculture. Through more rational resource allocation and flexible utilization of production factors, agricultural socialized services can effectively improve production efficiency and support the upgrading of production methods.

Digital technologies provide robust technical support for this transformation. For instance, the application of digital technologies enables more efficient information sharing, allowing farmers to access real-time market demand and weather information, thereby enabling precise adjustments to production plans.

4.2. Mechanisms Through Which Agricultural Socialized Services Connect Smallholders with Modern Agriculture

4.2.1. Expansion of Market Opportunities

The establishment of digital platforms enables smallholder farmers to connect more easily with broader markets, increasing their market participation. This integration provides farmers with multiple alternative sales channels, liberating them from traditional marketing strategies. The professional support offered by agricultural socialized services helps farmers make significant strides in product quality improvement and brand building, thereby further expanding market access. By fully leveraging these market opportunities, farmers can establish their competitive position and development path in challenging market environments.

4.2.2. Optimization of Resource Allocation

Agricultural socialized services enhance the efficiency and effectiveness of agricultural production through optimized resource allocation. In the context of digital empowerment, such optimization extends beyond traditional labor and capital to encompass modern technologies and information resources. Agricultural socialized services can establish multi-level service platforms to achieve precise resource matching, helping farmers obtain necessary production materials and technical support to improve production efficiency.

The optimization of resource allocation also reflects the rational integration of agricultural production factors. Agricultural socialized services enhance the role of agricultural machinery and tools, thereby reducing overall production costs for smallholders. Through intensive resource utilization, farmers can achieve economies of scale while maintaining production quality, further advancing the process of agricultural modernization.

5. Policy Recommendations and Implementation Pathways

5.1. Improving the Agricultural Socialized Service System

As agricultural services become increasingly socialized, the application of digital technologies has significantly enhanced the efficiency of agriculture and related activities, providing farmers with broader market access. Farmers can easily obtain market-related information, enabling them to adjust production plans accordingly and strengthen competitiveness. Both farmer income levels and the entire agricultural industry chain stand to benefit substantially.

We should promote collaborative cooperation among agricultural operators of different scales and types to establish a co-constructed and shared service network. By developing agricultural socialized service platforms, we can achieve efficient allocation of production factors and optimal integration of resources, thereby better serving agricultural production and improving overall agricultural productivity and economic returns.

5.2. Promoting the Application of Digital Technologies in Agriculture

The rapid development of digital technologies has brought unprecedented opportunities to agriculture. These technologies not only improve production efficiency but also enhance resource allocation and promote sustainable agricultural development. Many modern technologies enable farmers to practice precision agriculture, helping mitigate the impacts of environmental changes. For instance, through sensors, farmers can obtain real-time climate and soil information to implement more precise irrigation and fertilization, thereby reducing resource waste and increasing yields.

By establishing digital platforms, farmers can conveniently access market information, technical support and financial services, achieving information transparency. Policymakers should encourage the development of agricultural socialized service platforms and provide more smallholder farmers with digital technology application support to facilitate agricultural digital transformation.

5.3. Strengthening Support Policies for Smallholder Farmers

To promote the comprehensive development of agricultural socialized services, we should enhance supportive policies for smallholder farmers. This includes improving credit and financial assistance systems through measures such as establishing agricultural development funds, agricultural financiers, and loan programs to help smallholders achieve self-development. The government needs to substantially expand infrastructure, provide support for cutting-edge agricultural technologies like digital agriculture and smart agriculture, and offer relevant agricultural education resources to strengthen smallholders' self-development capabilities.

Optimizing agricultural product sales channels is another important measure to support smallholders. By promoting the development of cooperatives and professional farmer associations, we can guide smallholders to achieve scaled operations, enhance their market bargaining power, and protect their interests. Maintaining good working relationships between smallholders and large agricultural enterprises will help smallholders access markets and achieve resource and risk sharing.

6. Conclusions and Prospects

6.1. Research Conclusions

Specialized services can significantly enhance agricultural production efficiency. Through resource integration, service providers can offer more precise technical support and management recommendations to agricultural producers, thereby facilitating the transformation of production methods. This transformation not only improves production efficiency but also strengthens the market competitiveness of agriculture.

Professional agricultural socialized services enable smallholder farmers to access advanced production technologies and management expertise, reducing uncertainties in the production process while improving the quality and yield of agricultural products. As the production efficiency of smallholder farmers increases, the overall development of the rural economy accelerates, thereby promoting the realization of agricultural and rural modernization.

6.2. Policy Optimization Recommendations

6.2.1. Constructing a Multi-stakeholder Collaborative Supply System

Establishing a multi-stakeholder collaborative supply system is crucial for advancing agricultural and rural modernization. This system should integrate resources from government, market, and society to provide coordinated agricultural socialized services that enhance both quality and efficiency. The government should encourage active participation from service providers and develop comprehensive service systems that meet the increasingly diverse needs of agricultural production and rural livelihoods.

Market participants are equally indispensable, as they can provide agricultural socialized services through various mechanisms. By improving service standards and fostering industry innovation, social organizations and agricultural enterprises can be attracted to participate in service provision.

Achieving information sharing and precise service matching will improve the responsiveness and service level of the supply system. Establishing this multi-stakeholder collaborative system will provide farmers with higher-quality and more efficient services, driving high-quality development in agriculture and rural areas.

6.2.2. Strengthening the Linkage Mechanism for Smallholder Farmers

Strengthening the connection mechanism with smallholder farmers represents a critical component in advancing agricultural socialized services and rural modernization. As the mainstay of China's agricultural production, enhanced linkage mechanisms will not only encourage smallholders to participate more actively in modern agriculture but also facilitate resource sharing and information connectivity, thereby improving the overall competitiveness of agriculture.

To achieve effective integration between smallholders and modern agriculture, policies should encourage closer cooperation between agricultural socialized service providers and smallholder farmers. Through agricultural service organizations and specialized cooperatives, comprehensive support in technology, market information, and financing should be provided to help smallholders establish their position and expand development opportunities within modern agricultural systems.

6.2.3. Future Research Directions

Future research should focus more deeply on the integrated effects of agricultural socialized services and digital technologies. Establishing effective agricultural socialized service platforms and evaluating their impact on smallholder production efficiency and income levels should become core research priorities.

Considering regional disparities and differences among farmers of varying scales, research should also examine the targeted applicability and sustainability of agricultural socialized services. In central and western regions, exploring how to effectively integrate agricultural socialized services with local rural economic development presents an important research question. Additionally, empirical studies on policy implementation effectiveness should be strengthened to assess how these policies contribute to agricultural and rural modernization. Such research will provide scientific basis for policy optimization and offer theoretical and practical guidance for further improving and innovating agricultural socialized services in the future.

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