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Research on Innovation Paths of Operation Models for Specialized Farmer Cooperatives Driven by Smart Agriculture

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Abstract: In recent years, with the high emphasis on agricultural modernization by the state and the strong support of relevant policies, smart agriculture technology has gradually been promoted and applied in rural areas. This has provided new ideas and opportunities for the transformation and upgrading of specialized farmer cooperatives. Therefore, this paper explores the innovation path of the operation model of specialized farmer cooperatives driven by smart agriculture. It first analyzes the difficulties faced by traditional specialized farmer cooperatives in production, management, marketing, and profit distribution. It then elaborates on the empowerment value of smart agriculture for specialized farmer cooperatives. Finally, it constructs the innovation path of the operation model of specialized farmer cooperatives driven by smart agriculture, covering intelligent production, digital management, networked marketing, shared profits, and the improvement of the support system. Through the application of smart agriculture technology, specialized farmer cooperatives can effectively overcome the limitations of the traditional model and promote the transformation, upgrading, and sustainable development of the cooperatives.

Keywords: Specialized Farmer Cooperatives; Smart Agriculture; Operation Models.

1. Introduction

Nowdays, the development level of agriculture is directly linked to a country's food security and the quality of life for farmers. With the rapid development of global technology, the agricultural sector has also welcomed the emerging technological wave of smart agriculture. Specialized farmer cooperatives, as an important bridge connecting farmers and the market, bear the important mission of integrating resources, enhancing competitiveness, and safeguarding the interests of farmers. However, traditional specialized farmer cooperatives face many challenges in their operations, such as the dominance of experience and the lack of standardization in production, information asymmetry and inefficient governance in management, the disconnection between supply and demand and weak bargaining power in the market, and vague profit distribution and an incomplete risk-sharing mechanism in terms of benefits. These problems seriously restrict the development of cooperatives and the income increase of farmers.

Smart agriculture technology can not only achieve precision and intelligence in the agricultural production process, improving agricultural production efficiency and the quality of agricultural products, but also enhance the management transparency and decision-making scientificity of cooperatives through digital management platforms, and strengthen the participation and cohesion of members [1]. In the market segment, with the help of big data analysis and Internet sales channels, cooperatives can better grasp market demand, achieve precise marketing and brand building of agricultural products, and increase product added value and market competitiveness. At the same time, the establishment of a diversified profit distribution mechanism and a risk-sharing system can effectively safeguard the economic interests of members, stimulate their enthusiasm and creativity, and promote the sustainable development of cooperatives. Therefore, in-depth research on the innovation path of the operation model of specialized farmer cooperatives driven by smart agriculture is of great theoretical and practical significance for promoting agricultural modernization and realizing the rural revitalization strategy.

2. The Dilemma of the Traditional Operation Models of Specialized Farmer Cooperatives

2.1. Production Link: Experience-Dominated and Lack of Standardization

Due to the reliance on fragmented farming operations by individual households, the standards for planting and breeding are often determined by individual experience, lacking strong support from scientific data. For instance, in pest and disease control, the main method is manual inspection to identify problems. This approach is not only inefficient but also prone to excessive use of pesticides, which can affect the quality of agricultural products and pose environmental risks. In terms of irrigation and fertilization management, farmers mostly rely on their personal experience, which can easily lead to waste of resources and environmental pollution. According to the research results from the Ministry of Agriculture and Rural Affairs, only 23% of the cooperatives have established unified production standards at present. This results in uneven quality of agricultural products, which fails to meet the strict quality requirements of the high-end market.

2.2. Management Link: Information Asymmetry and Inefficient Governance

Firstly, the governance model of cooperatives largely relies on the “capable person decision-making” by core members. Under this model, key information such as the financial status and resource allocation of the cooperative is often held by a small number of core members, with very low transparency. Ordinary members, lacking sufficient information, find it

difficult to effectively participate in the daily management and decision-making processes of the cooperative. In this situation, the “free-rider” phenomenon is very prominent, with many members indifferent to the affairs of the cooperative, resulting in weak cohesion and centripetal force within the organization. Secondly, due to the lack of effective digital tools, cooperatives often fail to keep real-time track of inventory levels, leading to frequent occurrences of inventory overstock or shortages. The order tracking process is also inefficient due to the lack of an automated system, with long order processing times and a high likelihood of delays and errors. Moreover, due to the absence of effective oversight and checks and balances mechanisms, there are evident flaws in the governance structure of cooperatives. Core members often lack sufficient external supervision in the decision-making process, making them prone to decision-making mistakes or issues of self-dealing. Ordinary members, lacking channels for participation and informational support, find it difficult to effectively oversee and provide feedback on the decisions made by core members, further exacerbating the governance dilemma within the cooperative.

2.3. Marketing Link: Disconnect Between Supply and Demand and Weak Bargaining Power

Cooperatives mainly rely on intermediaries to connect with the market and often fail to obtain real-time data on consumer demand. This results in product structure adjustments always lagging changes in market demand. Under such circumstances, it is difficult for cooperatives to adjust production plans and product types in a timely manner according to market dynamics, leading to a mismatch between products and market demand, and consequently, problems such as overstocking, which bring significant economic losses to cooperatives. In addition, most of the products of cooperatives are sold in the form of primary agricultural products, lacking brand building and brand premium capacity. The added value of primary agricultural products is relatively low, usually less than 20%, which puts cooperatives at a disadvantage in market competition. Faced with market price fluctuations, due to the lack of brand support and product differentiation, cooperatives often find it difficult to cope by increasing the added value of products and can only passively accept market price fluctuations, resulting in unstable income. These issues seriously restrict the market competitiveness and sustainable development capacity of cooperatives.

2.4. Profit Link: Ambiguous Allocation and Lack of Risk-Sharing Mechanisms

Traditional profit distribution mechanisms in specialized farmer cooperatives primarily rely on share capital or transaction volume, failing to effectively quantify the contributions of critical factors such as technology and data. Under this model, core members often secure higher dividends due to their financial advantages. For instance, in some livestock cooperatives, core members receive up to 60% of the profits, while ordinary members see limited income growth. Additionally, cooperatives lack robust risk-sharing mechanisms to address challenges like natural disasters and market price fluctuations. In 2024, extreme weather events caused losses for 35% of cooperatives, exposing farmers’ weak capacity to withstand risks and severely impacting the stable development of cooperatives and members’ economic interests. This imbalance in distribution and inadequacy in risk management not only dampens the enthusiasm of ordinary members but also hinders the long-term sustainability of cooperatives. Urgent improvements are needed through innovative allocation mechanisms and the establishment of comprehensive risk-sharing systems to address these structural issues.

3. The Empowerment Value of Smart Agriculture for Specialized Farmer Cooperatives

3.1. Production Empowerment: From Experience-Based Decision-Making to Data-Driven

In the field of agricultural production, the traditional experience-based decision-making model is gradually being replaced by a data-driven smart agriculture model. This new model leverages advanced technologies such as IoT sensors and drone inspections to collect key information in real time, including soil moisture, nutrient content, meteorological data, and the growth status of crops. These data are transmitted to cloud platforms, where big data analysis and artificial intelligence algorithms are used to build precise digital production models. Based on these models, agricultural producers can achieve "input according to needs and precise management," such as precisely fertilizing, irrigating, and spraying pesticides according to the actual needs of crops, thereby effectively reducing labor costs and resource waste. At the same time, the data-driven precision production model can also significantly improve the stability of agricultural product quality and reduce quality fluctuations caused by environmental changes or human errors. This model not only improves agricultural production efficiency but also provides the possibility for agricultural products to enter the high-end market. It brings revolutionary changes to agricultural production and promotes the modernization and intelligent development of agriculture.

3.2. Management Empowerment: From Closed Governance to Transparent Collaboration

The traditional closed governance model is gradually falling behind the times, while the transparent collaborative model is becoming mainstream. The application of blockchain technology provides a solution for on-chain storage and certification of financial and transaction data, enabling members to view the cooperative's income and expenditure as well as resource allocation in real time through mobile applications, and actively participate in voting and decision-making on major issues. The introduction of the ERP system integrates data from various aspects such as inventory, orders, and logistics, achieving digital management of the entire process and increasing inventory turnover by 50%. This transparent and collaborative management model not only improves management efficiency but also enhances members' participation and trust, laying a solid foundation for the stable development of the cooperative [2].

3.3. Market Empowerment: From Channel Dependence to Precise Connection

In the marketing segment, a new market empowerment model is assisting cooperatives in breaking free from their reliance on traditional channels and achieving precise

connection with the market. Big data analytics, by delving into e-commerce consumption data, offers robust guidance for cooperatives to optimize their product structures. Meanwhile, the rise of emerging business models such as live-streaming e-commerce and community group buying has significantly shortened the distribution chain of agricultural products. This allows cooperatives to establish direct contact with consumers, reducing the middleman markup by over 50%. Additionally, blockchain traceability technology endows agricultural products with a “digital identity,” which greatly enhances brand credibility and boosts the premium capacity of agricultural products to 40%. This market empowerment model, which shifts from channel dependence to precise connection, not only improves the economic benefits of cooperatives but also strengthens their competitiveness in the market.

3.4. Profit Empowerment: From Singular Distribution to Diverse Sharing

With the vigorous development of smart agriculture, new factors of production such as data and technology have begun to participate in profit distribution. Some cooperatives have taken the lead in implementing a “data points system,” which converts the completeness of production data uploaded by farmers and the quality of equipment maintenance into specific points, closely linking these points with secondary dividends. This innovative measure has greatly motivated farmers to actively participate in the application of smart agriculture technology, resulting in increased income for farmers who adopt new technologies. Meanwhile, to further enhance the risk resistance of cooperatives, they have also collaborated with insurance companies to develop “weather index insurance” and “price index insurance.” These insurance products, based on data collected through IoT technology, can automatically trigger compensation mechanisms, providing stronger risk protection for cooperatives. This diversified and shared profit empowerment model not only significantly increases the economic income of farmers but also enhances the risk resistance of cooperatives in the face of natural disasters and market fluctuations, promoting the transformation and upgrading of cooperatives from traditional models to modern and intelligent directions.

4. Constructing the Innovation Path of the Operation Model of Specialized Farmer Cooperatives Driven by Smart Agriculture

4.1. Intelligent Production: Building a Data-Driven Standardized Production System

In the agricultural production link, through the extensive promotion of "IoT + AI" monitoring equipment, including advanced tools such as soil condition sensors, weather stations, and video surveillance, agricultural producers can perceive the subtle changes in the production environment in real time. These devices provide a solid data support for precise decision-making. Meanwhile, the introduction of intelligent equipment such as drones and autonomous agricultural machinery has greatly improved the efficiency of operations, reduced labor input, and made agricultural production more efficient and convenient. On this basis, agricultural production is gradually establishing a standardized production system based on data. By collecting and analyzing a large amount of production data, scientific and reasonable key indicators such as crop growth cycle standards and pesticide residue thresholds are formulated. The intelligent decision-making system automatically generates agricultural suggestions based on these data, such as precise fertilization, timely irrigation, and optimal harvesting time, achieving closed-loop management from "environmental data" to "production decision" and then to "equipment execution." Through these innovative measures, agricultural production is gradually building a data-driven standardized production system, injecting new vitality into agricultural modernization [3].

4.2. Digital Management: Creating a Transparent and Democratic Governance Platform

The “Cooperative Digital Mid-Platform” is developed, integrating three core modules of member management, financial management, and decision support, supporting synchronized operations on both PC and mobile ends, which greatly improves the convenience and efficiency of management. By implementing the “data governance” model, members can view the cooperative's operational data in real-time through a dedicated APP, enhancing the transparency of information and allowing members to more intuitively understand the cooperative's operation. At the same time, members can also participate in voting on major cooperative matters through the APP, truly realizing democratic decision-making and increasing members' participation and enthusiasm. In addition, the cooperative has established a “data contribution assessment system,” quantifying members' behaviors in technology adoption, data upload, equipment maintenance, and training participation as points. These points are not only an important basis for members' excellence evaluation but also linked to dividends, thereby encouraging members to more actively participate in the digital construction and technological innovation of the cooperative.

4.3. Networked Marketing: Building a “Demand Insight - Product Innovation - Direct Channel” Chain

The cooperative taps into consumer data from e-commerce platforms and social media, employing natural language processing technology to conduct in-depth analysis of consumer reviews and accurately identify latent demands, such as for organically certified products, items with regional characteristics, and smaller packaging sizes. Based on these demand data, the cooperative develops customized products like “cartoon-packaged vegetables” and “high-protein mixed grain combinations” to cater to the personalized needs of different consumer groups. To enhance brand credibility and market competitiveness, the cooperative utilizes blockchain technology to achieve full-chain traceability, creating a brand image of “direct supply from origin” and “fully visible.” Consumers can scan the QR code on the product to view real-time information on the entire process of the product's cultivation, processing, and transportation, thereby increasing their trust in the product. Meanwhile, the cooperative actively builds its own e-commerce platform or joins mainstream e-commerce platforms to engage in new business forms such as live-streaming sales, community group buying, and

agricultural product adoption. By directly delivering products to consumers, it reduces intermediary links and lowers sales costs [4].

4.4. Shared Profits: Designing a Distribution Mechanism with Multiple Elements Participation

Based on retaining the traditional dividend distribution by capital contribution and transaction volume, the cooperative extracts 30% of the additional income brought by smart agriculture for secondary distribution. This portion of the income will be distributed according to members' data contribution, technology adoption, equipment maintenance quality, and training participation, thereby encouraging farmers to actively integrate into the smart agriculture technology system. In addition, to enhance the risk resistance of the cooperative, a "data insurance fund" has been established, and a series of index insurance products have been jointly developed with insurance companies. These products include drought insurance based on satellite remote sensing data and hog price insurance based on market price data. Through these insurance products, the cooperative can achieve automatic risk assessment and quick compensation, effectively reducing the impact of natural disasters and market fluctuations on members' economic interests. This distribution mechanism with the participation of multiple factors not only increases members' economic income but also enhances the stability of the cooperative, providing strong support for its sustainable development.

4.5. Support System: Breaking Through the Barriers of Technology Application and Organizational Fit

At the policy level, the government should increase the financial subsidy for the construction of digital platforms and the purchase of intelligent equipment for cooperatives. The subsidy ratio can be moderately increased to reduce the transformation cost of cooperatives. Meanwhile, it is necessary to promote the seamless connection between the provincial agricultural data sharing platform and the cooperative system, break the data silos, and realize the efficient circulation and sharing of data resources, providing a solid data foundation for the digital operation of cooperatives.

In terms of talent training, universities should actively open the major of "agricultural digital governance", and cultivate compound talents who are familiar with both agriculture and digital technology - "digital leaders" through systematic curriculum settings and practical teaching. These professional talents will provide intellectual support and management innovation for the digital transformation of cooperatives. In addition, cooperatives should deeply cooperate with technology companies to carry out the "technology into households" training project, and cultivate a group of "farmer data officers" who can skillfully operate intelligent equipment and process agricultural data. It is necessary to effectively solve the problem of "not knowing how to use" in the technical application of cooperatives and improve the overall level of digital application of cooperatives.

In terms of standard construction, relevant departments need to formulate unified "Agricultural Data Collection and Sharing Standards" and "Cooperative Digital Governance Specifications", clarify the ownership, usage rights and profit rights of data, and ensure the flow and use of data within the framework of legality and compliance, eliminating the concerns of cooperative members about data sharing. Through the perfect standard system, the digital operation process of cooperatives is standardized, the management efficiency and transparency are improved, the internal cooperation of cooperatives is promoted, and a good institutional environment is created for digital transformation.

5. Conclusion

This paper has thoroughly explored the innovation paths of the operation model of farmers' professional cooperatives driven by smart agriculture. By analyzing the challenges faced by traditional farmers' professional cooperatives in production, management, marketing, and profit distribution, the paper reveals issues in these cooperatives related to experience-based decision-making, information asymmetry, disconnect between supply and demand, and vague profit distribution. Based on this analysis, the paper elaborates on the empowerment value of smart agriculture for farmers' professional cooperatives, which includes production empowerment, management empowerment, marketing empowerment, and profit empowerment. It also proposes specific approaches to building intelligent production, digital management, networked marketing, shared profits, and a robust support system.

Through intelligent production, cooperatives can achieve precise management, enhance the quality of agricultural products, and reduce production costs. Digital management increases management transparency and decision-making scientificity, and strengthens members' participation and cohesion. Networked marketing helps cooperatives accurately meet market demands, boost brand value, and enhance market competitiveness. Shared profits, through diversified distribution mechanisms and risk-sharing systems, safeguard members' economic interests and motivate them. The improvement of the support system provides policy, talent, and standard guarantees for the digital transformation of cooperatives, promoting the effective application of technology and organizational adaptation.

Looking ahead, with the continuous advancement of smart agriculture technology and increasing policy support, farmers' professional cooperatives are expected to achieve greater breakthroughs in their digital transformation. On one hand, cooperatives should deepen their cooperation with technology companies and actively introduce cutting-edge technologies such as artificial intelligence, big data, and blockchain to improve operational efficiency and management levels [5]. On the other hand, governments and universities should increase the cultivation of digital agriculture talents to provide a solid talent support for the sustainable development of cooperatives. Meanwhile, improved data sharing and governance standards will create a better institutional environment for the digital transformation of cooperatives.

The innovation of the operation model of farmers' professional cooperatives driven by smart agriculture can not only effectively address the limitations of the traditional model but also provide strong support for the implementation of agricultural modernization and rural revitalization strategies. Through continuous technological innovation and management optimization, farmers' professional cooperatives will undoubtedly play a more important role in future agricultural development and become a vital force in

promoting high-quality agricultural development.

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