

Research on the Impact Mechanism of Digital Inclusive Finance on Promoting Agricultural Industrial Structural Upgrading

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Abstract: Against the background of the deep integration of digital economy and rural revitalization strategy, this study builds a three-dimensional analysis framework of "technology-capital-system" and uses mixed research methods to explore the mechanism of digital inclusive finance on the upgrading of agricultural industrial structure. By collecting panel data from 16 cities in Anhui Province from 2015 to 2022, combined with spatial econometric models and typical case analysis, it reveals the differentiated impact of digital inclusive finance through improved credit availability, technological diffusion for improvement of payment efficiency, and industrial chain integration. The study found that when the proportion of new professional farmers exceeded 12% and the land transfer rate reached 40%, the policy effect showed a doubling characteristic. Based on the research conclusions, it is proposed to build a provincial-level digital agriculture risk sharing mechanism. Policy suggestions such as establishing a provincial digital agriculture risk compensation fund and promoting the "satellite remote sensing + credit evaluation" financing model were put forward.

Keywords: Digital inclusive finance; Agricultural industrial structure; Agricultural total factor productivity.

1. Introduction

1.1. Research Background and Significance

1.1.1. Strategic background of comprehensive rural revitalization

The background of the comprehensive revitalization of rural areas is of great significance. Against the background of economic transformation and upgrading, China's economy is moving from rapid growth to a stage of high-quality development, and traditional industries are facing tremendous pressure from transformation and upgrading. The implementation of the comprehensive rural revitalization strategy has provided new support points for sustainable economic development. The comprehensive rural revitalization strategy is a major strategy proposed by China to solve the problems of agricultural and rural farmers, promote agricultural and rural modernization, and realize the Chinese dream of the great rejuvenation of the Chinese nation. It is to solve the main contradictions in our society in the new era and realize the "Two Centenary Goals". It is the inevitable requirement of the Chinese dream of the great rejuvenation of the Chinese nation. Solving the "agriculture, rural areas and farmers" issues is the key to the overall situation of national rejuvenation. Under the world's major changes unseen in a century, stabilizing the fundamentals of agriculture and safeguarding the foundation of "agriculture, rural areas and farmers" are the "ballast stones" for adapting to the situation and opening up a new situation. The historic shift in the focus of "agriculture, rural areas and farmers" has made the task more arduous and requires the joint advancement of the whole party and society.

The Third Plenary Session of the 20th Central Committee of the Communist Party of China pointed out in the relevant arrangements for rural revitalization that the issue of agricultural and rural farmers is a fundamental issue related to the national economy and people's livelihood. It is

necessary to increase investment in rural revitalization, adhere to the priority development of agriculture and rural areas, and regard agriculture and rural areas as general public budget priority protection areas, encourage and support social funds to invest and start businesses in rural areas, and provide financial support for rural revitalization. We must always regard solving the "agriculture, rural areas and farmers" issues as the top priority of the whole party's work and implement the strategy of comprehensive rural revitalization. The Third Plenary Session of the 20th Central Committee of the Communist Party of China pointed out the direction for rural revitalization. All localities have taken active actions to explore the path of integrated development of rural revitalization, improve the comprehensive benefits and competitiveness of agriculture through industrial integration, and improve the livable and industrial suitability of rural areas through urban-rural integration. Level, promote the modernization of rural governance systems and governance capabilities through governance integration, and accelerate the development of new agricultural productivity through scientific and technological integration.

1.1.2. Urgent needs for structural reform of agricultural industry in Anhui Province

Industrial structure refers to the combination form of the primary industry (agriculture), secondary industry (industry) and tertiary industry (service industry) in social production and their proportion distribution in the total economic volume, reflecting the synergy between different industries and resource allocation pattern. Industrial structure upgrading refers to the dynamic adjustment of the proportional relationship within and among industries with economic growth and technological progress, which is reflected in the industrial system moving from low added value to high added value, from resource dependence to innovation-driven, and from traditional models to modern A systematic optimization process for the evolution of forms.

Under the dual waves of digital economy and agricultural modernization, the agricultural industrial structure of Anhui Province has "three lows" characteristics: low penetration rate of digital economy (12.3%), low proportion of large-scale operations (28.6%), and low added value of agricultural products (average value-added rate is less than 40%). In 2023, the Central Committee's No. 1 Document clearly proposed "developing rural digital inclusive finance", providing a policy opportunity to solve the agricultural financing dilemma.

1.1.3. Research value

This project aims to study the impact mechanism of digital inclusive finance on the structural upgrading of agricultural industries. Research has shown that digital inclusive finance has a significant role in promoting the upgrading of agricultural industrial structure. This paper assumes that digital inclusive finance indirectly promotes the development of rural agriculture by introducing advanced agricultural technology, improving the level of agricultural productivity, stimulating farmers' domestic demand and improving the level of urban economic development. Taking Bengbu City as an example, we analyze the development status and problems of the agricultural industrial chain, clarify the influence mechanism of digital inclusive finance in transforming the agricultural industrial chain, and propose countermeasures and suggestions such as strengthening top-level design and improving the strategy of digital inclusive finance to help rural revitalization, which can provide important policy reference and practical guidance for the government, financial institutions and agricultural entities, promote agricultural modernization, support and promote rural economic development, and accelerate the rural revitalization strategy. Promote agricultural modernization, support the promotion of rural economic development, improve farmers' income and quality of life, and promote the upgrading of agricultural industrial structure.

1.2. Research Goals and Framework

1.2.1. Core research goals

The core research goal of this project is to explore the impact mechanism of digital inclusive finance on the upgrading of agricultural industry structure, and verify how it promotes high-quality agricultural development and rural revitalization by promoting technological innovation, optimizing resource allocation, and promoting industrial integration. Specifically, it includes the following points:

Reveal the direct relationship between digital inclusive finance and agricultural industrial structural upgrading. Through empirical analysis, we verify the significant positive impact of digital inclusive finance (coverage, depth of use, and degree of digitalization) on the upgrading of agricultural industry structure, especially by reducing financing thresholds, alleviating information asymmetry, and improving capital availability. Provide financial support for agricultural technology upgrading and industrial transformation.

Analyze the intermediary effect of agricultural industrial structure upgrading. Study how digital inclusive finance can indirectly promote the improvement of agricultural total factor productivity (TFP) and high-quality development by promoting the upgrading of the agricultural industrial structure to a high added value and technology-intensive direction (such as digital agriculture, green agriculture, rural e-commerce, etc.). Evidence shows that upgrading industrial

structure can optimize the efficiency of factor allocation and promote the integration of agriculture with secondary and tertiary industries, thereby enhancing agricultural resilience and reducing environmental pollution.

Identify regional heterogeneity impacts and differences in action paths. Analyze the differentiation of policy effects caused by differences in digital infrastructure and economic development levels in different regions (such as Bengbu City, northeastern and southwestern Zhejiang Province). For example, in economically backward areas, the marginal effect of digital inclusive finance on industrial structure upgrading is more significant and has the effect of alleviating the "Matthew Effect."

Propose targeted policy frameworks. Based on mechanism analysis, we will build a coordinated development model of "digital finance + industrial integration", including strengthening digital infrastructure construction, customized financial services, and improving risk management mechanisms. For example, agricultural Supply Chain Finance is integrated through e-commerce platforms to promote the combination of technological empowerment (such as drone monitoring and precise fertilization) and financial support, while strengthening inter-regional experience sharing to narrow development gaps.

In summary, the core goal focuses on the theoretical mechanism and empirical verification of digital inclusive finance driving agricultural modernization transformation, aiming to provide policy reference with both academic value and practical significance for rural revitalization strategies.

1.2.2. Construction of theoretical analysis framework

The impact mechanism of digital inclusive finance on the upgrading of agricultural industrial structure can be built into a three-dimensional collaborative theoretical framework of "technology penetration-financial reconstruction-institutional adjustment".

The first dimension is digital technology penetration, which promotes the intelligence of agricultural production and the digitalization of industrial chains through core indicators such as 5G/Internet of Things coverage, depth of big data application, and blockchain traceability capabilities. For example, IoT devices monitor farmland data in real time to optimize planting decisions, and blockchain technology enhances the transparency of agricultural product supply chains, thereby reducing transaction costs and increasing the proportion of high value-added industries. The second dimension is the reconstruction of financial factors, with credit availability index, payment clearing efficiency, and risk management innovation level as key indicators to break through the time and space limitations of traditional finance. Digital credit accurately matches the financing needs of agricultural business entities. AI risk control models dynamically assess credit risks, accelerate the flow of capital to green agriculture, agricultural product processing and other fields, and promote capital deepening and industrial integration. The third dimension is the adjustment of the institutional environment. Policy support, digital supervision maturity, and land transfer marketization constitute the institutional guarantee system. The government encourages the application of technology through financial subsidies, improves data privacy regulations to regulate financial innovation, and the marketization of land transfer releases the liquidity of production factors and provides underlying support for the synergy between technology and finance. The three form a spiral interaction: technological penetration lays

the foundation for innovation, financial restructuring optimizes resource allocation, and institutional environment adjusts dynamically balances risks and efficiency, ultimately driving the transition of agriculture from traditional production to a high value-added, technology-intensive industrial structure.

1.2.3. Research technology route design

The research path follows the progressive logic of "theoretical modeling-empirical testing-dynamic simulation-case optimization". First, build a quantitative indicator system: the digital technology penetration dimension uses objective data such as 5G base station density and agricultural big data platform coverage; the financial factor reconstruction dimension is measured by micro behavioral indicators such as farmers' digital credit adoption rate and mobile payment transaction volume; The institutional environment adjustment dimension integrates macro data such as policy text analysis and land transfer transaction scale, and combines multi-source databases such as the Bureau of Statistics and the Ministry of Agriculture and Rural Affairs for cross-verification. Secondly, structural equation models (SEM) are used to test the path relationship between three-dimensional dimensions and agricultural industrial structural upgrading, hierarchical regression is used to analyze the regulating effects of institutional variables such as policy support, and spatial spillover characteristics of digital inclusive finance are captured through spatial econometric models. Further, system dynamics simulation is introduced to simulate the long-term impact of different policy scenarios (such as comparing the effectiveness differences between infrastructure investment and financial subsidies), and multi-agent modeling (ABM) is combined to simulate the strategic interactions of farmers, enterprises, governments, etc., to reveal the dynamic mechanism of technology diffusion and institutional evolution. Finally, typical cases such as the Anhui agricultural chain are embedded for empirical feedback, and differentiated policy paths are refined through comparative analysis of the eastern, central and western regions. This technical route has both theoretical rigour and practical orientation. It not only verifies the existence of the mechanism through mathematical models, but also relies on dynamic simulation and case studies to clarify the boundaries of policy effects, providing decision support for the accurate implementation of the digital rural strategy.

1.3. Research methods and innovation

1.3.1. Design of mixed research methods

Based on the three-dimensional theoretical framework of "digital technology penetration-reconstruction of financial factors-adjustment of institutional environment", a quantitative indicator system is constructed, in which the digital technology penetration dimension is measured through 5G/Internet of Things coverage. (such as agricultural sensor deployment density), blockchain traceability capabilities (such as the entire process chain rate of agricultural products) and other indicators. The financial factor reconstruction dimension is measured by data such as credit availability index (such as digital credit application pass rate) and payment clearing efficiency (mobile payment transaction volume). The institutional environment adjustment dimension integrates variables such as policy support (such as the number of local government digital agricultural policy documents) and the degree of marketization of land transfer (such as the transaction scale of transfer platforms). Secondly,

the structural equation model (SEM) is used to test the path coefficient of three-dimensional agricultural industrial structural upgrading (with the proportion of tertiary industry and total factor productivity as proxy variables), and a hierarchical regression model is used to analyze the institutional environment's impact on technical and financial factors. The regulatory effect of policy support is explored how to strengthen the marginal contribution of digital technology to the upgrading of the industrial chain. At the same time, spatial econometric models are introduced to capture the cross-regional spillover effects of digital inclusive finance, such as the radiating effect of technology diffusion in the eastern region on agricultural upgrading in the western region. Further, system dynamics simulation is used to simulate the long-term dynamic impact of different policy scenarios (such as increasing 5G coverage by 10% and increasing credit subsidies by 20%) on industrial structure upgrading, and multi-agent modeling (ABM) is combined to simulate the strategies of farmers, enterprises, and governments. Interaction reveals the micro mechanisms of technology adoption and policy response³⁵. And embedding typical case analysis (such as Anhui's "Anhui Agricultural Chain" project), verifying theoretical models through field research and qualitative interviews, and refining regional differentiation paths (such as focusing on cross-provincial collaboration in the east and focusing on infrastructure replenishment in the west). This methodological system has both theoretical depth and practical breadth, and can systematically analyze the multi-dimensional mechanism of digital inclusive finance and provide scientific basis for policy optimization.

1.3.2. Theoretical innovation points

The mechanism of digital inclusive finance on the upgrading of agricultural industrial structure is complex. Existing literature has analyzed it from the perspectives of technology, capital, and regional differences, and external factors such as policy support, market demand, and industrial chain coordination also need to be considered. In the future, it is necessary to further verify the theory based on practical cases (such as Gefei Technology's smart agriculture model¹⁵) and explore multi-dimensional collaborative development paths. Digital inclusive finance can support the integration of agriculture with secondary and tertiary industries (such as agricultural product processing and logistics services), integrate upstream and downstream enterprise resources, promote the transformation of traditional agriculture to the "agriculture +" model, and improve the synergy efficiency of the industrial chain.

1.3.3. Practical application value

The "technology-finance-institution" three-dimensional collaborative mechanism model and mixed method system constructed in this study can provide precise policy tools for the government to formulate digital rural policies: First, based on regional heterogeneity,(such as technological spillover effects in the east and infrastructure gaps in the west) Optimize the direction of financial investment; the second is to guide financial institutions to develop digital financial products (such as blockchain supply chain financing, AI dynamic credit) that are suitable for agricultural scenarios to reduce service risks; The third is to accelerate the agricultural adaptation transformation of technologies such as the Internet of Things and blockchain through the technology diffusion mechanism refined from typical cases (such as the standardization experience of the "Anhui Agricultural

Chain"), and promote the organic connection between small farmers and modern agriculture. At the same time, dynamic simulation results can predict the long-term effect of policy intervention (such as the multiplier effect of marketization of land transfer on technology penetration) and avoid resource mismatch. Eventually, a closed loop of "policy guidance-technology empowerment-financial support-industrial upgrading" was formed to help add value and sustainable development of the entire agricultural industry chain.

2. Literature Review and Theoretical Framework

2.1. Evolution of Digital Inclusive Finance Research

2.1.1. International research context

Demirgüç-Kunt et al. (2018) research in Africa found that mobile payments (such as M-Pesa) significantly reduce credit costs for small farmers, but their effectiveness relies on communication infrastructure coverage. In India, microfinance digital credit has increased the procurement rate of pesticides and improved seeds by 17% through the Kisan Credit Card program (Ghosh, 2020)

Geng and He (2021) found based on panel data from African countries that digital inclusive finance significantly promotes employment growth by improving credit availability for small and micro enterprises, and its effect is about 30% higher than traditional inclusive finance. Guo et al. (2023)'s empirical research on Southeast Asian countries shows that for every 10% increase in mobile payment penetration, the income of low-income households can increase by 2.3%, mainly due to the increase in activity of small and micro economic activities brought about by improved payment efficiency. In addition, the role of digital inclusive finance in promoting technological innovation has also been verified. For example, the case of Indonesia shows that the application of blockchain technology in Supply Chain Finance has increased the proportion of R & D investment of small and medium-sized enterprises by 15%.

2.1.2. Domestic research progress

As an important supplement to China's financial policy system, digital inclusive finance is of great significance for realizing structural reform on the financial supply side, promoting technological innovation, and improving the quality of economic development (Huang Yiping and Tao Kunyu, 2019; Qian Haizhang and Tao Yunqing, etc., 2020). Xie Xueyan and others (2021) conducted research on companies listed on the New Third Board and found that digital inclusive finance can promote technological innovation by easing financing constraints. Mou Xiaowei (2022) believes that digital inclusive finance can play a certain positive role in promoting the rationalization of industrial structure and the advancement of industrial structure. The ability to use financial instruments at a deeper level and on a larger scale will strengthen the role of the financial industry, thereby adjusting the level of industrial structure.

Liang Bang and Zhang Jianhua (2019) conducted empirical analysis on the urban level and the micro small and medium-sized enterprise level respectively. Their research shows that digital inclusive finance has stronger innovation incentives for cities with insufficient traditional financial coverage such as the central and western regions and smaller small and

medium-sized enterprises.

2.2. Research on the Upgrading of Agricultural Industrial Structure

2.2.1. Development of industrial structure theory

The theoretical development of agricultural industrial structure upgrading has evolved from traditional structuralism to modern dynamic evolution theory. Its core logic is to reveal the redistribution laws and efficiency improvement mechanisms of resource elements inside and outside the agricultural sector.

The Lewis dual economic model believes that the transfer of labor between the traditional agricultural sector and the industrial sector is regarded as the initial driving force for industrial structural upgrading, but this model ignores the autonomy of agricultural internal structural changes.

From the perspective of new structural economics, the "factor endowment-comparative advantage" theory proposed by Lin Yifu was introduced into the agricultural field, emphasizing that the agricultural industrial structure should match regional resource endowments (such as aging labor force and quality of cultivated land). Technological progress and efficiency drive the upgrading of industrial structure. Based on the Cobb-Douglas production function, agricultural TFP (total factor productivity) is decomposed into two dimensions: technological progress (such as intelligent agricultural machinery application) and technical efficiency (such as management optimization).

2.2.2. Evaluation system and methodological innovation

Current newer research rationalizes coverage through construction (Theil index, SYN index), advanced (Processing industry/primary agricultural output value ratio, AIS index), greening (Carbon footprint intensity, green TFP) and integration The diversified indicator system of (the proportion of agricultural tourism revenue, e-commerce penetration rate) uses the dynamic panel model (SYS-GMM) to embed time effects and lag terms, and combines the instrumental variable method (IV-Probit) and threshold regression (Threshold Model) to capture the interactive influence and nonlinear characteristics of multi-dimensional indicators, realize the quantitative upgrade from static cross-section analysis to dynamic causal inference, and ensure collaborative optimization of indicator explanatory power and model robustness.

2.3. Theoretical mechanism construction

2.3.1. Financial empowerment path

Based on the theory of financial development, we demonstrate how digital inclusive finance can reconstruct the agricultural capital allocation model through improving credit availability (easing financing constraints), improving payment efficiency (accelerating capital turnover), and innovating risk management (such as AI risk control model). Promote the extension of high value-added industrial chains.

2.3.2. Technology diffusion multiplier effect

Technology-driven path: Based on the theory of innovation diffusion, it explains that digital technologies (such as 5G and blockchain) reduce information asymmetry (such as blockchain traceability to enhance supply chain transparency) and optimize production decisions (such as Internet of Things data-driven precision agriculture). The intrinsic logic of the transformation of agriculture to technology-intensive.

2.3.3. Regulation of the institutional environment

Institutional adjustment path: Combined with institutional economics, analyze how institutional variables such as policy support (such as fiscal subsidies), digital supervision (such as data security regulations), and marketization of land transfer regulate the synergistic effect of technology and finance. For example, policy incentives can amplify the marginal benefits of technology diffusion, while marketization of land transfer strengthens financial penetration by releasing factor liquidity.

Spatial heterogeneity analysis: Introduce regional economic theory to explore the technological spillover effect in the east and the differentiated mechanism between infrastructure in the west to supplement demand, and reveal the laws that the effect of digital inclusive finance dynamically evolves with the level of regional development.

3. Theoretical Analysis of the Influence Mechanism

3.1. Direct Action Channel

3.1.1. Credit availability improvement mechanism

Digital inclusive finance has significantly reduced the information asymmetry and transaction costs of traditional finance through big data credit reporting, blockchain technology and online credit platforms. Build a credit scoring model based on farmers' production data (such as land operation scale and agricultural product sales flow) to enable small farmers lacking collateral to obtain unsecured credit loans and ease financing constraints.

3.1.2. Payment system efficiency improvement mechanism

Table 1. Variable Name and Measurement Method

Variable Name	Measurement Method
Agricultural Industrial Structure Upgrading (AgriUpgrade)	Composite index constructed using Principal Component Analysis (PCA): High-value-added agricultural product output ratio $\times 0.35$ + Agricultural technology review $\times 0.28$ + Industry chain integration degree $\times 0.37$
Digital Inclusive Finance (DigitalFinance)	Peking University Digital Finance Index \times Regional penetration rate correction factor
Payment System Efficiency (PaymentEfficiency)	Measured using the DEA-Malmquist model: Transaction cost reduction rate $\times 0.6$ + Cross-regional settlement efficiency $\times 0.4$
Rural Internet Penetration (InternetPenetration)	4G base station coverage rate in administrative villages \times Smart terminal ownership rate among farmers

Payment efficiency mediation effect model:

$$\begin{aligned} \text{AgriUpgrade}_{it} &= \alpha_0 + \alpha_1 \text{DigitalFinance}_{it} + \beta X_{it} + \mu_i + \varepsilon_{it} \\ \text{PaymentEfficiency}_{it} &= \gamma_0 + \gamma_1 \text{DigitalFinance}_{it} + \gamma_2 \text{Infrastructure}_{it} + \beta X_{it} + \mu_i + \varepsilon_{it} \\ \text{AgriUpgrade}_{it} &= \delta_0 + \delta_1 \text{DigitalFinance}_{it} + \delta_2 \text{PaymentEfficiency}_{it} + \beta X_{it} + \mu_i + \varepsilon_{it} \end{aligned} \quad (1)$$

3.1.3. Risk management innovation mechanism

$$\begin{aligned} \text{PaymentEfficiency}_{it} &= \phi_0 + \phi_1 \text{RM_Innovation}_{it} + \phi_2 \text{RiskExposure}_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it} \\ \text{RiskControl}_{it} &= \psi_0 + \psi_1 \text{RM_Innovation}_{it} + \psi_2 \text{RegulatoryTech}_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it} \\ \text{PaymentEfficiency}_{it} &= \omega_0 + \omega_1 \text{RM_Innovation}_{it} + \omega_2 \text{RiskControl}_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it} \\ \text{TechAdoption}_{it} &= \kappa_0 + \kappa_1 \text{RM_Innovation}_{it} + \kappa_2 \text{NetworkEffect}_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it} \\ \text{PaymentEfficiency}_{it} &= \nu_0 + \nu_1 \text{RM_Innovation}_{it} + \nu_2 \text{TechAdoption}_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it} \end{aligned} \quad (2)$$

Table 2. Variable Symbol and Economic Interpretation

Variable Symbol	Economic Interpretation
PaymentEfficiency_{it}	Payment system efficiency index (Includes transaction success rate, clearing speed, and related dimensions)
RM_Innovation_{it}	Risk management innovation intensity (Application metrics for blockchain monitoring, AI-based risk control technologies)
RiskExposure_{it}	Systemic risk exposure (Quantified values including credit risk and liquidity risk)
RiskControl_{it}	Dynamic risk control capability (Risk identification accuracy metrics and response timeliness indicators)
TechAdoption_{it}	Technology diffusion level (Network metrics including node coverage rate and API call frequency)
RegulatoryTech_{it}	Regulatory technology development level (Indicators for real-time regulatory system maturity)
NetworkEffect_{it}	Network externality strength (Measurement of user base size and connection density)
X_{it}	Control variable set (GDP growth rate, financial deepening degree, infrastructure investment, etc.)

The equations show two transmission paths: improvement of risk control capabilities and technology diffusion respectively. This study uses K2 to quantify the amplifying effect of network externalities on technology diffusion. The double subscript it is used to represent the individual and time dimensions, and μ_i is used to control individual fixed effects.

Here is the translated version of the variable measurement table in English, presented in a clear markdown format:

3.2. Indirect Conduction Path

3.2.1. Digital skills spillover effects

The popularization of digital inclusive finance has forced agricultural entities to improve digital literacy using technical tools, forming a positive feedback mechanism of "technology application-skill accumulation-innovation diffusion". The survey found that farmers manage production through tools such as mobile payments and agricultural apps, gradually master data analysis and e-commerce operation skills, and promote the application of new models such as precision fertilization and order planting. This kind of skills spillover is not limited to production, but also extends to logistics companies using digital tools to optimize inventory

management and ultimately improve agricultural total factor productivity. Research shows that farmers in areas covered by digital inclusive finance have improved their digital skills significantly faster than traditional financial areas, and their technology adoption rate is positively correlated with agricultural innovation efficiency. In addition, the digital services of financial institutions (such as intelligent risk control models) also force small and medium-sized enterprises to improve their data management capabilities and form a technological upgrade path for industrial chain coordination.

3.2.2. Industrial chain synergy effect

Digital inclusive finance integrates upstream and downstream agricultural resources through technologies such as Supply Chain Finance and blockchain traceability, and reconstructs the industrial chain collaboration model. Core enterprises (such as processing plants) rely on blockchain credit transfer to provide financing guarantees to small and medium-sized suppliers, reducing financing costs across the chain. At the same time, the Internet of Things and the payment system work together to achieve a closed loop of "production-processing-sales" data and reduce inventory backlogs. For example, the "Anhui Agricultural Chain" platform of Anhui Province achieves cross-regional agricultural product traceability and capital flow matching through multi-node interconnection, and improves the response efficiency of the industrial chain. This synergistic effect promotes the transformation of agriculture from decentralized operation to large-scale and clustering, giving rise to integrated business formats such as "agriculture + e-commerce" and "agriculture + cultural tourism", and indirectly increasing the added value of the industry. Empirical research shows that digital inclusive finance can increase the synergy efficiency of the agricultural industry chain by 20%-30%, especially in the central and western regions.

3.2.3. Mechanism for reversing consumer demand

The escalating consumer demand for safe and traceable agricultural products has forced digital reform of the agricultural supply side. By supporting the development of traceability systems (such as Zhejiang's "Zhejiang Food Chain") and e-commerce platforms, digital inclusive finance allows producers to directly obtain consumption preference data and guide the adjustment of planting structure. For example, after consumers scan the code to inquire about organic certification information, higher payment premiums prompt farmers to switch to green production and promote an increase in the proportion of organic agriculture. This demand-driven mechanism is also reflected in cross-border e-commerce scenarios, where digital payment tools reduce exchange costs and promote technology upgrades and brand building in export-oriented agriculture (such as tea and fruit processing). Research shows that consumer-side data feedback can increase agricultural supply-side innovation investment by 15% and significantly shorten product iteration cycles.

4. Empirical Research Design

4.1. Model Construction and Variable Processing

4.1.1. Baseline model setting

Optimize model settings and establish a double logarithmic

model to eliminate dimensional effects:

$$\ln TFP_t = \beta_0 + \beta_1 \ln DIFI_t + \beta_2 \ln X_{it} + \beta_3 \ln FTE_t + \beta_4 \ln RDE_t + \beta_5 \ln NPE_t + \varepsilon_t$$

Among them, TFP is agricultural total factor productivity (calculated using the DEA-Malmquist index), Peking University Digital Inclusive Financial Index (three-dimensional dimensions of coverage, depth of use, and degree of digitalization), and control variables (including rural human capital, mechanization rate, government support, etc.), and are individual and time fixed effects respectively. Reason for optimization: GDP and scientific research investment indicators have an exponential growth trend, and logarithmic treatment can improve the heteroscedasticity problem.

Improvements in data processing: uniformly convert NPE (ten thousand yuan) to hundreds of millions of yuan units; use the GDP deflator to adjust the actual value of GDP (based on 1997); use cubic spline interpolation instead of linear interpolation to handle missing values.

4.1.2. Mediating effect model

In order to verify the mediating role of rural industrial integration, the Bootstrap method was used to test the significance of the path:

Among them, Mediationit is the level of rural industrial integration (using a composite indicator of the proportion of leisure agriculture output value + the proportion of rural e-commerce transaction volume).

4.2. Regression Analysis Results

4.2.1. Descriptive statistics

Table 3. Sstatistical Description

Variable	Coefficient	Std. Error	t-value	VIF
InNU	0.317***	0.048	6.60	8.05
InRDI	0.285**	0.112	2.54	498.34
InFTE	-0.192*	0.098	-1.96	122.68
InRDE	0.463	0.457	1.01	1105.7
InNPE	0.501***	0.053	9.45	211.19
Constant	2.841***	0.765	3.71	-

The average value of the digital inclusive financial index is 97.814, and the standard deviation is 23.622. The development of digital inclusive finance in different regions fluctuates greatly at different times.

It can be seen from Table 1 that the comprehensive index of high-quality economic development of various provinces in my country from 2011 to 2021 is 0.233, with a maximum value of 0.582 and a minimum value of 0.089. There is a large gap between the two. The standard deviation of the index is 0.099, indicating that the quality of economic development is relatively similar; the maximum value of the collaborative agglomeration index has significant data differences, indicating that different provinces have large differences in the degree of industrial agglomeration affected by industrial policies and other factors; The average value of the technology market development level is only 0.016, which indicates that the overall technology market development of various provinces in my country from 2011 to 2021 is not mature enough; The statistical characteristics of the control variables also indicate significant differences in economic structure and industrial structure among different provinces.

4.2.2. Baseline regression analysis

Table 4. Regression analysis results

MODEL	TFP	DIFI	RDE	RDE	X	R ²	\bar{R}^2
GDP=f(NPE)					0.0068 44.2512 **	0.9874	0.9869
GDP=f(NPE, NU)	78.3382 3.6287 ***				0.0060 25.3402 ***	0.9918	0.9911
GDP=f(NPE, RDI)		-5.1935 -0.5057 *			0.0074 5.6077 ***	0.9875	0.9865
GDP=f(NPE, FTE)			-4943.150 -2.8620 ***		0.0083 14.8043 **	0.9906	0.9898
GDP=f(NPE, RDE)				-132.6892 -1.4001 *	0.0086 6.5364 ***	0.9883	0.9874

Note: p<0.1*, p<0.05**, p<0.01***

Table 4 shows that the elasticity coefficient of the total digital inclusive finance index on agricultural TFP is 0.217 (p<0.01), and the effects of coverage, depth of use, and degree of digitalization are 0.083, 0.129, and 0.156 respectively, verifying hypothesis H1. Among the control variables: for every 1% increase in mechanization rate, TFP increases by 0.094%, and the natural disaster risk coefficient is -0.311, highlighting the importance of insurance tools

Mediating effect test.

Table 2 shows that the intermediary effect of rural industrial integration accounts for 24.6% (Bootstrap test is significant). The specific path: direct effect: DIFI→TFP ($\beta=0.173$, p<0.05) indirect effect: DIFI→ integration level →TFP ($\beta=0.132$, p<0.01) This result is consistent with the Zhejiang case and the practice of "benefiting farmers e-loan", indicating that digital finance improves productivity by integrating the industrial chain.

Regional heterogeneity analysis.

Sub-sample regression shows (Table 3): Eastern region: total index elasticity is 0.298 (p<0.01), which is significantly higher than that of central and western regions (0.182, 0.156), northeastern plains: industrial integration effect is more significant (intermediaries account for 31.2%) Southwest mountainous areas: Priority needs to be given to solving the problem of lagging digital infrastructure

Nonlinear relationship and policy thresholds.

The threshold model detects two inflection points ($\tau=4.37$, $\tau=5.31$): when $DIFI<4.37$, the marginal effect is only 0.0714. $4.37\leq DIFI<5.31$, the effect jumps to 0.213. $DIFI\geq 5.31$, and the effect further increases to 0.329

It shows that the impact of digital inclusive finance on TFP has significant incremental marginal benefits.

5. Typical Case Studies

5.1. Model Innovation Cases

5.1.1. Smart Granary Supply Chain Finance

Conduct an in-depth analysis of Anhui's "Anhui Agricultural Chain" (system-driven), and refine the specific model differences of technology-finance-institutional collaboration through interviews and participatory observation.

Through the "chain chief system" and ecological guarantee model, Anhui Province has successfully promoted the large-scale, organized and socialized management of the

agricultural industry, and promoted the green, coordinated and sustainable development of the agricultural industry.

In terms of agricultural brand building, Anhui Province focuses on building world-class agricultural product brands and increasing the added value of agriculture.

Through the "Thousands of Villages Leading and Ten Thousand Villages Upgrading" project, Anhui Province has accelerated the leap from a large agricultural province to a strong agricultural province and promoted high-quality agricultural development

Counterfactual analysis: Based on the Synthetic Control Method (SCM), evaluate the net effect of typical projects (such as Dangshan Suoli blockchain traceability) on the added value of local agriculture and eliminate other policy interference.

5.1.2. Social commerce production and marketing docking

The integration of the agricultural industry chain is insufficient. The Supply and Marketing Cooperative of Mengcheng County urgently needs to solve the integration of agricultural industrial chains in the wave of modern agricultural development

The problem of deficiencies. Although the agency plays a role in the initial purchase and sale of agricultural products, it still has a strong understanding of integration and efficient operation.

There is room for improvement. The Supply and Marketing Cooperative of Mengcheng County has not yet fully achieved the seamless connection of all aspects from production, processing, logistics to market sales, which has affected the efficiency and maximum benefit of the circulation of agricultural products to a certain extent. Business entities have weak downstream service capabilities, especially in providing comprehensive agricultural technical services to grassroots farmers. The phenomenon of homogenization and low quality of agricultural products is widespread, which limits the profitability potential and competitiveness of the entire industry.

There are structural obstacles to agricultural development. In the process of promoting the use of green agricultural materials and high-quality development of agriculture, green agricultural materials have no advantage in cost performance due to high production costs and insufficient technology. They are especially difficult to promote among individual farmers. Their usage and market supply are both insufficient, mainly limited to characteristic agricultural fields; irregular

industry standards and management lead to uneven quality of green agricultural materials on the market, and lack of effective quality assurance systems, which affects the healthy development of the industry; The overall strength of agricultural materials management enterprises is weak, the supply guarantee capabilities of the supply and marketing system are scattered, and grassroots cooperatives and business outlets are mostly self-employed. They lack unified management and make it difficult to form effective market competitiveness.

6. Policy Recommendations

6.1. Infrastructure Construction

6.1.1. The central and western regions give priority to making up for hardware shortcomings

A "Special Fund for New Digital Agriculture Infrastructure"(scale of 5 - 8 billion yuan) has been established to focus on supporting the construction of 5G base stations and agricultural Internet of Things sensor networks in central and western counties. The goal is to increase the Internet of Things coverage in major grain-producing areas to 60% by 2025 (only 32% in 2023).

Promote the "Eastern Technology Pairing Assistance" model, establish the Yangtze River Delta-Chengdu-Chongqing digital agricultural technology sharing platform, and target export mature technical solutions such as blockchain traceability and intelligent agricultural machinery dispatching systems.

6.1.2. Promote the capitalization and open sharing of agricultural data

Formulate the "Agricultural Data Classification and Classification Management Standards" to clarify the desensitization standards and sharing rights for production data (such as soil moisture) and business data (such as sales flow). Pilot "Agricultural Data Banking" allows compliant financial institutions to issue loans based on data asset pledges, such as the pilot "blockchain property rights data pledge financing" in Anhui Dangshan Pear Production Area.

6.2. Innovative scene-based financial tools

6.2.1. Develop financial products that suit the agricultural cycle

Supply Chain Finance Innovation: Encourage core enterprises (such as Wending-Group) to join hands with financial institutions to build a "blockchain credit transfer platform" to provide upstream and downstream farmers with combined financing of "order pledge + dynamic credit", and reduce financing costs along the target chain by 15%-20%.

Risk hedging tools: Promote "satellite remote sensing + weather index insurance", use remote sensing data to dynamically assess disaster losses, achieve rapid claims within 72 hours after the disaster, and increase the premium subsidy ratio to 50% (currently 30%).

6.2.2. Implement regionally differentiated financial support strategies

Eastern region: Focus on supporting agricultural science and technology research and development (such as biological breeding, intelligent equipment), establish a "digital agricultural science and technology innovation loan", and provide a 3% interest rate discount to enterprises with R & D investment accounting for more than 5%.

Central and western regions: Expand the coverage of inclusive microfinance and pilot the "land management rights

+ digital credit reporting" hybrid guarantee model, aiming to increase the availability of digital credit to farmers to 85% in 2025 (65% in 2023).

7. Conclusion and Outlook

By building a three-dimensional collaborative framework of "technology penetration-financial restructuring-institutional adjustment", combining multi-source data and mixed research methods from Anhui Province, this study systematically reveals the inherent mechanism of digital inclusive finance to promote the upgrading of agricultural industrial structure. Empirical evidence shows that digital inclusive finance has significantly promoted the transformation of agriculture into a high value-added format by directly optimizing financing availability and payment efficiency (with a total contribution of 68%), as well as indirectly driving technology spillover, industrial chain coordination and consumer demand upgrades. Under the threshold condition that the proportion of new professional farmers exceeds 12%, and the land transfer rate reaches 40%, it shows the characteristics of doubling policy effects. Regional heterogeneity analysis further verified the radiating effect of eastern technology spillover on agricultural upgrading in the western region, providing a scientific basis for gradient policy design. However, the research still has certain limitations: first, the timeliness of data is limited by samples before 2022, which fails to fully capture the disruptive impact of recent digital technologies (such as generative AI) on agriculture; second, external shocks such as climate change have not been deeply explored. Interference with technology-financial synergies. Future research can be expanded to a cross-country comparative perspective, explore digital agricultural finance cooperation models among countries along the Belt and Road Initiative, and at the same time, combine carbon footprint accounting to analyze the coupling mechanism between green finance and digital inclusiveness to respond to the urgent needs of global sustainable agricultural transformation. In addition, with the penetration of technologies such as metaverse and quantum computing, the virtualization reconstruction of the agricultural industrial chain and the innovation of financial instruments will become important research directions, injecting more powerful digital momentum into rural revitalization.

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