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Article

A Study on Digital Transformation of Financial New Quality Productivity to Promote Supply Chain Modernization in the Rural Industrial Chain

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Abstract: Promoting the development of new-quality financial productivity is an intrinsic requirement for the digital transformation of rural industrial chains and supply chains. This article is based on panel data from 30 provinces in mainland China from 2014 to 2024 and uses interaction effect models, mediation effect models, and other empirical tests to discuss the impact of new-quality financial productivity on the modernization of rural industrial chains and supply chains and its mechanisms. The results indicate that the estimated coefficient for financial new-quality productivity is 0.248, suggesting that financial new-quality productivity has a significant driving effect and positive moderating effect on the modernization of industrial chains and supply chains. The impact coefficients of financial new-quality productivity on the modernization of rural industrial chains and supply chains vary across regions: eastern region (0.5168) > northeastern region (0.1722) > central region (0.1570) > western region (0.0999).

Keywords: financial new-quality productivity; interaction effect model; mediation effect model; digital transformation

1. Introduction

The modernization of rural industrial chains and supply chains is a crucial component of promoting agricultural and rural modernization, closely linked to the goals of thriving industries and prosperous living standards outlined in the rural revitalization strategy [1]. Accelerating the modernization of agricultural industrial chains and supply chains, increasing investment in agricultural science and technology innovation, optimizing the allocation of resources such as human capital, technology, and capital, and deeply transforming agricultural production methods are essential steps toward building an agricultural powerhouse [2-4]. After years of practice and exploration, China has achieved significant accomplishments in the process of building an agricultural powerhouse, including steady improvements in agricultural comprehensive production capacity, the gradual growth of new types of agricultural operators, and the continuous upgrading of logistics service channels, laying a solid foundation for advancing the modernization of agricultural industrial chains and supply chains [5-8]. At the same time, China faces shortcomings such as low levels of agricultural industrial chain integration and obstructed rural sales channels for agricultural products, as well as issues like inadequate agricultural financial systems and weak agricultural industrial chain foundations [9]. How to address these challenges and achieve the modernization of the agricultural industrial chain and supply chain has become a major and urgent practical issue facing China.

The modernization of the agricultural industrial chain and supply chain is an inevitable path toward the modernization of agriculture and rural areas, as well as an extremely important theoretical topic that has attracted close attention from the academic community. Numerous scholars have conducted extensive research on the modernization of the agricultural industrial chain and supply chain, yielding abundant research findings [10-12]. Camanzi, L., et al. [13] argue that the agricultural industrial chain and supply chain encompass a series of production activities, including raw material production, processing, storage and transportation, sales, and other activities, as well as the network structure formed by upstream and downstream enterprises in the agricultural supply chain. Mukherjee, S et al. [14] pointed out that Industry 4.0 has imposed new requirements on the agricultural industrial chain and supply chain, and the modernization of the agricultural industrial chain and supply chain aims to achieve advantages such as efficiency improvements, increased productivity, and enhanced customer satisfaction through digitalization. Kolesnikov, A. V et al. [15] explored the impact of digital transformation on agricultural supply chain management, providing practical cases and related socio-economic effects, aiming to enhance industry efficiency, ensure food security, and strengthen agricultural export potential through modernization measures. Lianguang, M [16] proposed an IoT-based agricultural product supply chain model and analyzed it, aiming to improve traditional logistics models to enhance supply chain operational efficiency and modernization levels in modern agriculture.

With the ongoing evolution of the new round of technological revolution and industrial transformation, digital transformation has become a key driver of agricultural and rural modernization, prompting profound changes in agricultural production, circulation, sales, and services [17-19]. In light of this, the academic community has conducted exploratory research on digital transformation and "three rural issues." Khanna, M [20] research indicates that the digital transformation of agricultural supply chains can improve production efficiency, reduce the excessive use of inputs, decrease waste and pollution, and enhance farm profitability. Digital transformation has become the future trend for innovation in agricultural supply chains. Rimma, Z et al. [21] explored the global status of agricultural digital transformation, focusing on the application trends of digital technologies such as cloud computing, the Internet of Things, and other digital technologies in precision agriculture, and explained how these digital technologies can increase productivity, attract investors, and improve rural living conditions. Mendes, J et al. [22] analyzed eight key dimensions of modern agricultural digital transformation: economy, government, sustainability, infrastructure, technology, collaborative change, talent, and knowledge skills. Shamin, A et al. [23] explored digital transformation in the agricultural industry, through a two-stage process involving digital efficiency metrics and business model implementation, to maximize agricultural automation, reduce losses, and enhance agricultural productivity, thereby creating a more technologically advanced and productive agricultural supply chain. Abashidze, G [24] noted in his research that the digital transformation of agriculture is essential for achieving sustainable agricultural development, as it can lead to higher yields, lower costs, and more sustainable production methods.

New-quality productivity represents innovative, efficient, and green production methods, achieved by introducing new technologies, processes, and materials to establish new production relationships, thereby enhancing industry enterprises' production efficiency and support capabilities [25]. It promotes the transformation and upgrading of traditional agricultural industries, breaks through constraints in the development of agricultural industrial chains and supply chains, empowers the modernization of industrial chains and supply chains, and provides strong impetus for the construction of a modern agricultural system [26]. Zhang, J and Zhang, Y [27] studied the impact of new-quality productivity on green supply chains (GSC), focusing on the mechanism, practical challenges, and implementation pathways of new-quality productivity in advancing GSC modernization. Cui, J, and Du, D [28] utilized data from 31 provinces in China from 2012 to 2022 for their research, which demonstrated that new-type productivity significantly enhances the resilience of industrial chains. They also proposed the theoretical logic and implementation pathways for new-type productivity to ensure the security of industrial chains and supply chains.

This paper utilizes the entropy method to select evaluation indicators, using panel data from Chinese provinces as the research sample. It constructs interaction effect models, mediation effect models, and regional heterogeneity tests to empirically examine the relationship between financial new productive forces and the modernization of rural industrial chains and supply chains, as well as the mechanisms through which these factors influence the modernization of rural industrial chains and supply chains across different regions. Furthermore, panel regression analysis is employed to empirically test the impact and differences of rural industrial chain and supply chain modernization on the resilience of county-level economies.

2. Theoretical Research

2.1. The Impact of New Financial Productivity on the Modernization of the Agricultural Industry Chain and Supply Chain

In 2022, the Central Committee for Deepening Overall Reform reviewed and approved the "Implementation Opinions on Promoting the High-Quality Development of Inclusive Finance," which clearly stated that the goal is to "promote the integration of green finance, technology finance, and inclusive finance with the aim of developing new financial productivity." Against the backdrop of the integration of digital technology and technology finance, new financial productivity in rural areas has advantages such as low payment thresholds, high levels of digitization, broad service coverage, and high convenience, playing an important role. As such, the development of financial new-quality productive forces plays a pivotal role in the construction of rural industrial chains and supply chains. First, it drives the development of rural industrial chains and supply chains by creating new service models. Financial new-quality productive forces utilize continuous updates and optimizations of financial products, improvements in service quality, and expansions of financial service channels to efficiently address various challenges in rural production and construction. This provides agricultural production with safer and more efficient financial service platforms, enhances agricultural risk management capabilities, accelerates rural infrastructure development, and promotes the realization of agricultural modernization. Second, high-tech innovations are driving the development of rural industrial chains and supply chains. It is proposed that, leveraging financial innovation, agricultural producers can integrate digital information technology with agricultural production, processing, management, and sales processes to innovate agricultural industrial chains and supply chains, enhance the innovative capacity of the rural economy, and gradually achieve the transformation and upgrading of rural industrial chains and supply chains [29].

2.2. Indirect Effects of New Financial Productivity on the Modernization of Agricultural Industry Chains and Supply Chains

The mobility and convenience of financial innovation have injected new vitality into the primary, secondary, and tertiary industries in rural areas. The traditional small-scale farming economic model in rural areas is evolving into a digitalized, intelligent, and scaled production model. It is proposed that under the impetus of financial innovation, the improved efficiency of rural production factors can help break through the "ceiling" of grain production and ensure food security. Due to geographical factors, rural areas face severe constraints on financial demand and suffer from significant financial exclusion. Between 2011 and 2018, with the rise of mobile digital payments, the "Hu Huanyong Line" was gradually broken, during which the gap in financial accessibility between the eastern and western regions narrowed by 15%, and the coverage disparity of financial innovation decreased by 500%. The emergence of new-quality financial productivity has continuously reduced financing costs for small and medium-sized enterprises, expanded service coverage, and lowered service costs, thereby providing more efficient and high-quality financial services for industrial integration in rural areas. High-quality industrial integration imposes higher demands on financial supply. Financial new-quality productivity can drive the growth of competitive supply, with a significant pulling effect, providing high-quality financial supply for the integrated development of the three sectors in rural areas. As the pace of rural three-sector integration accelerates in the new era, the interconnectivity between industries continues to strengthen, supply chains are extended, and the cohesion between industries is enhanced, all of which require stronger financial support.

3. Research Design

3.1. Selection of Indicators

(1) Dependent variable: Modernization of the agricultural industrial chain and supply chain $(Icscmion)$

A comprehensive evaluation of the modernization level of the agricultural industrial chain and supply chain should not only focus on the macro level but also take into account the micro level. Drawing on existing research findings, an evaluation indicator system for the modernization of the agricultural industrial chain and supply chain is constructed based on four dimensions: foundation, resilience, coordination, and green development.

Based on this, the entropy method is used to calculate the modernization level of the agricultural industrial chain and supply chain, with the specific process as follows:

First, the data is subjected to extreme value standardization processing:

$$x_{ij}^{*} = \frac{x_{ij} - x_{j\min}}{x_{j\max} - x_{j\min}} \left(x_{ij} \text{ indicates a positive indicator} \right) \quad (1)$$

$$x_{ij}^{*} = \frac{x_{j\max} - x_{ij}}{x_{j\max} - x_{j\min}} \left(x_{ij} \text{ indicates a negative indicator} \right) \quad (2)$$

In this formula, i and j represent the year and indicator, respectively; x_{ij} is the indicator value of indicator j in year i ; $x_{j\max}$ and $x_{j\min}$ are the maximum and minimum values of indicator j , respectively; and x_{ij}^{*} is the dimensionless indicator value of indicator j .

Second, calculate the contribution of the j th indicator in the i th year:

$$p_{ij} = \frac{x_{ij}^{*}}{\sum_{i=1}^{m} x_{ij}^{*}} \tag{3}$$

Third, calculate the entropy value of the j th indicator:

$$e_j = \frac{1}{\ln(m)\sum_{i=1}^{m} p_{ij} \ln p_{ij}} \tag{4}$$

Fourth, calculate the information redundancy of the j th indicator:

$$d_j = 1 - e_j \tag{5}$$

Fifth, calculate the weight of the j th indicator:

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{6}$$

Sixth, calculate the comprehensive index of modernization of the agricultural industry chain and supply chain:

$$I\,\mathrm{csc}\,mion_i = \sum_{j=1}^{m} w_j x_{ij}^{*} \tag{7}$$

Among these, $I\,\mathrm{csc}\,mion_i$ denotes the comprehensive index of agricultural industrial chain and supply chain modernization in year i .

(2) Explanatory variable: Financial New Productivity (FNP)

To avoid issues with the units of measurement in the evaluation indicators, the entropy weight method is used for measurement. The entropy weight method uses the variability of indicator values to determine their weights. The smaller the information entropy value of an indicator, the greater its variability, and the larger its weight in the comprehensive evaluation of the system. Therefore, the entropy weight method can be used to adjust the weights of various indicators, reflecting the superiority of information entropy values, and thereby obtaining effective weights [30].

First, the Z-Score method is used to standardize the raw data:

If x' is a positive indicator:

$$x' = \frac{x - x_{\min}}{x_{\max} - x_{\min}} \left(x' \text{ is a positive indicator}\right) \tag{8}$$

$$x' = \frac{x_{\max} - x}{x_{\max} - x_{\min}} \left(x' \text{ is the reverse indicator}\right) \tag{9}$$

Second, calculate the weights and entropy values of each indicator.

Calculate the weights of each indicator:

$$V_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{n} x'_{ij}} \tag{10}$$

$$i = 1, 2, \cdots, n; j = 1, 2, \cdots, m$$

Calculate the entropy values of various indicators:

$$e_{ij} = -\frac{1}{\ln n}\sum_{i=1}^{n} V_{ij} \ln V_{ij} \quad (11)$$
$$i = 1,2,\cdots,n; j = 1,2,\cdots,m$$

Calculate the weight of the evaluation object:

$$\omega_{ij} = \frac{1-e_{ij}}{\sum_{j=1}^{m}(1-e_{ij})} \quad (12)$$
$$i = 1,2,\cdots,n; j = 1,2,\cdots,m$$

Third, calculate the comprehensive index of new financial productivity:

$$Digital_{ij} = \sum_{j=1}^{m} \omega_{ij} V_{ij} \quad (13)$$
$$i = 1,2,\cdots,n; j = 1,2,\cdots,m$$

In this context, i, j, x' and x represent the evaluation object, the corresponding j th indicator, the standardized value, and the actual value of the indicator, respectively; $x_{\min}$, $x_{\max}$, V_{ij}, e_{ij}, ω_{ij} and $Digital_{ij}$ represent the minimum value, maximum value, the weights of each indicator, the information entropy of each indicator, the weights of the evaluation object, and the comprehensive index score for financial new-quality productivity.

(3) Mediating variables

Aggregation of productive services (Apservices). New urbanization (Nurate). Local economic level (Leconomic). Fiscal support (Fisupport). Technological innovation (Teinnovation). Level of openness (Openlevel). Depth index (SD). Coverage breadth index (GD). Digital support service index (SZ).

3.2. Model Construction

(1) Spatial Weight Matrix

The two most commonly used spatial weight matrices are constructed based on socioeconomic factors and geographic location. Among these, the spatial weight matrix constructed based on socioeconomic factors has clear economic implications and is more aligned with practical application scenarios, but it typically does not satisfy the exogeneity assumption. The spatial weight matrix constructed based on geographic location includes the car-based adjacency matrix, the post-based adjacency matrix, and the distance inverse power weight matrix, which can validate the exogeneity assumption of the spatial weight matrix. Therefore, the Post-type adjacency matrix and Chebyshev adjacency matrix constructed based on geographical location are commonly used in empirical tests. Since the Post-type adjacency matrix and Chebyshev adjacency matrix assume that there is a correlation between two regions and that the degree of correlation is the same, but this assumption is contrary to common sense, this paper adopts a distance-based spatial weight matrix. The specific formula is as follows:

$$W_{ij} = \begin{cases} 1/d_{ij}^{s} & i \neq j \\ 0 & \end{cases} \quad (14)$$

$$d_{ij} = \arccos[\sin\varphi_i \times \sin\varphi_j + \cos\varphi_i \times \cos\varphi_j \times \cos(\Delta_{ij})] \times R \quad (15)$$

In this context, d_{ij} represents the geographical distance between provinces i and j; φ_i and φ_j denote the latitude and longitude of a region, respectively; Δ_{ij} indicates the difference in latitude between the two regions; and R denotes the Earth's radius. In practical applications, the spatial weight matrix must be standardized, with diagonal elements set to 0. Additionally, robustness testing uses a Chebyshev adjacency matrix [31].

(2) Spatial correlation test

There are close economic ties between provinces in China and within provinces, so there may be spatial correlation between provinces in terms of agricultural economic development. Based on the distance spatial weight matrix, the $(Moran's\ I)$ index of the agricultural industry chain and supply chain modernization index is tested using the following formula:

$$Moran's\ I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - \overline{x})(x_j - \overline{x})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{16}$$

In this context, W_{ij}, S^2, and $\overline{x}$ represent the spatial weight matrix, variance, and mean, respectively; x_i and x_j denote the indicator values for province i and province j, respectively. The value range of $Moran's\ I$ is $[-1,1]$. A $Moran's\ I$ value greater than 0 indicates a positive spatial correlation among the study objects; a $Moran's\ I$ value less than 0 indicates the opposite. Observation shows that the P values of the Moran index are all 0.000, indicating that the agricultural industrial chain and supply chain modernization index exhibits a significant positive spatial correlation, and can be studied using a spatial panel econometric model.

(3) Spatial panel model

When spatial dependence between variables is crucial to the model and produces spatial correlation, the spatial autoregressive model (SAR) is used. When spatial correlation appears in the model error term, the spatial error model (SEM) is selected. To more reasonably and effectively verify the relationship between financial new-quality productivity and the modernization of the agricultural industrial chain and supply chain, the following model is constructed for empirical testing.

The spatial autoregressive model (SAR) is:

$$\begin{gathered} Y_{it} = \alpha + \xi W Y_{it} + \beta X_{it} + \sum_{j=1}^{n} \lambda_j controls_{ij} + u_{it} \\ u_{it} : N\left(0, \sigma^2 I\right) \end{gathered} \tag{17}$$

Spatial error model (SEM):

$$\begin{gathered} Y_{it} = \alpha + \beta X_{it} + \sum_{j=1}^{n} \lambda_j controls_{ij} + u_{it} \\ u_{it} = \rho W u_{it} + \varepsilon_{it} \\ \varepsilon_{it} : N\left(0, \sigma^2 I\right) \end{gathered} \tag{18}$$

In this model, i and t represent regions and sample observation years, respectively; Y and X represent the modernization of the agricultural industrial chain and supply chain and the financial new productive capacity evaluation index, respectively; β, ξ, λ, and ρ represent the estimated coefficients; ε_{it} and u_{it} are random error terms following a normal distribution; $controls$, α, W are the set of control variables, the constant term, and the spatial weight matrix, respectively.

(4) Mediating effect model

To further investigate the mechanism through which financial new-type productive capacity influences the modernization of the agricultural industrial chain and supply chain, drawing on relevant research findings, the following mediating effect model is constructed:

$$Y_{it} = \rho \sum_{j=1}^{N} W_{ij} X_{it} + \beta_1 X_{it} + \beta_i controls_{it} + \alpha_i + v_i + \varepsilon_{it} \tag{19}$$

$$I \csc mion = \rho \sum_{j=1}^{N} W_{ij} Iorti_{it} + \gamma_1 X_{it} + \gamma_i controls_{it} + \alpha_i + v_i + \varepsilon_{it} \tag{20}$$

$$FNP = \rho \sum_{j=1}^{N} W_{ij} sti_{it} + \gamma_1 X_{it} + \gamma_i controls_{it} + \alpha_i + \nu_i + \varepsilon_{it} \tag{21}$$

$$\begin{aligned} Y_{it} = \rho \sum_{j=1}^{N} W_{ij} Y_{it} + \delta_1 X_{it} + \delta_2 Iorti_{it} \\ + \delta_3 Sti_{it} + \delta_i controls_{it} + \alpha_i + \nu_i + \varepsilon_{it} \end{aligned} \tag{22}$$

Among these, Icscmion and FNP represent the modernization of rural industrial supply chains and financial new-quality productive forces, respectively. β_1, β_c, γ_1, γ_c, δ_1, δ_2, and δ_3 are estimated coefficients, while ν_i and α_i represent the regression data for intermediary centrality, explanatory variables, and mediating variables, respectively.

3.3. Data Sources

Due to the significant differences in development mechanisms and systems between China's Hong Kong, Macao, and Taiwan regions and the mainland, and the severe lack of data on rural industrial chains and supply chains in the Tibet region, this study selected sample data from 30 provinces in mainland China from 2014 to 2024, totaling 330 observations. The data primarily comes from specialized databases such as the China Statistical Yearbook, the China Financial Yearbook, the China Rural Statistical Yearbook, and the China Agricultural Economics Information Network. Additionally, interpolation was used to fill in some missing data.

4. Empirical Analysis

4.1. Analysis of Benchmark Test Results

By estimating the parameters of the model, the results are shown in Table 1. The AR(2) test P-value is 0.5892, indicating that the model does not have an autocorrelation problem and can avoid endogeneity issues. Additionally, the Hansen test P-value is 1.0000, indicating that the model does not have a mis specification problem, and the research estimation results are fully reliable. The coefficient of influence for the modernization of the agricultural industrial chain and supply chain is 1.0184, which is significant at the 1% level, indicating that the modernization of the agricultural industrial chain and supply chain is a long-term dynamic and continuous process, and the current level of modernization is influenced by previous levels. Furthermore, fixed-effects models and OLS mixed regression models were applied for regression analysis. By comparing the results, it was found that the coefficient of agricultural industrial chain and supply chain modernization obtained through the model falls between the coefficients under the fixed-effects model (0.8847) and the OLS mixed regression model (1.0325), indicating that the regression results are relatively robust. The estimated coefficient for financial new-quality productivity is 0.248, which passes the significance test at the 1% level, indicating that financial new-quality productivity has a significant driving effect on industrial chain and supply chain modernization. As shown in the table, both new-type urbanization and local economic development levels have a significant positive impact on the modernization of the agricultural industrial chain and supply chain. This may be because higher levels of new-type urbanization in a region lay a more solid foundation for the modernization of the agricultural industrial chain and supply chain; better local economic development encourages local governments to allocate more resources to promote the modernization of the agricultural industrial chain and supply chain. The coefficient for the impact of fiscal support on the modernization of agricultural industrial chains and supply chains is 0.2332, which is significant at the 5% level, indicating that fiscal support can effectively drive the modernization of industrial chains and supply chains. Technological innovation has a significant positive impact on the modernization of industrial chains and supply chains, and its regression coefficient is larger than that of other control variables, reaching 0.9632. This means that technological innovation has the most significant driving effect on the modernization of agricultural industrial chains and supply chains. The level of openness to the outside world has a positive impact on the modernization of the agricultural industrial chain and supply chain. This may be because openness to the outside world can attract and aggregate more resources, bring in advanced foreign technologies, and generate spillover effects.

Table 1. Variables descriptive statistics.

Variable	I-SYS GMM Model	Fixed effect model	OLS hybrid regression model
Icscmion	1.0184*** (0.023)	0.8847*** (0.0286)	1.0325*** (0.0187)
FNP	0.248*** (0.1134)	0.204*** (0.1634)	0.1028*** (0.0642)
Nurate	0.0225*** (0.768)	-0.0020 (-0.0502)	0.0206* (0.204)
Leconomic	0.1987** (0.4523)	0.1385 (0.0362)	-0.0032 (-0.1382)
Fisupport	0.2332** (0.3145)	0.1855* (0.1583)	0.1336** (0.0705)
Teinnovation	0.9632*** (0.3152)	0.6587*** (0.1473)	0.9785*** (0.0336)
Openlevel	0.8632*** (1.8457)	0.1336*** (0.0321)	0.9852*** (0.02541)
Constant term	0.0784*** (0.1220)	0.0996*** (0.1845)	0.2786*** (0.1053)
AR (^{2}) test	0.5892		
Hansen	1.002		

4.2. Regional Heterogeneity Test

There are differences in the levels of financial new-quality productive capacity, the concentration of productive services, and the economic foundation across various regions, leading to significant variations in the modernization levels of agricultural supply chains. To conduct an in-depth analysis of the heterogeneous effects of financial new-quality productive capacity on the modernization of agricultural supply chains across different regions, regression estimates were conducted based on the regional classification method of the National Bureau of Statistics, divided into four regions. The results are shown in Table 2. Among these, the coefficient of the impact of financial new-quality productivity is highest in the eastern region, reaching 0.5168, followed by the northeastern and central regions at 0.1722 and 0.1570, respectively, with the western region having the lowest value at 0.0999. All these coefficients pass the 1% significance level test. This indicates that the impact of financial new-quality productivity on the modernization of agricultural industrial chains and supply chains exhibits regional heterogeneity. Except for the western region, where the levels of openness to the outside world and technological innovation have a negative and insignificant impact on the modernization of agricultural industrial chains and supply chains, the impact coefficients of all other control variables are positive and significant at different levels. This empirical result indicates that in the eastern, central, and northeastern regions, new urbanization, local economic level, fiscal support, technological innovation, and level of openness all have a positive promotional effect on the modernization of the agricultural industrial chain and supply chain. In the western region, new urbanization, local economic level, and fiscal support can promote the modernization of the agricultural industrial chain and supply chain.

Table 2. Regional heterogeneity test results.

Variable	Eastern region	Central region	Western region	Northeast
FNP	0.5168*** (0.2841)	0.1570*** (0.1395)	0.0999 (0.252)	0.1722*** (0.3847)
Nurate	0.08412** (0.0118)	0.0724** (0.0933)	0.0263 (0.0742)	0.0653** (0.0785)
Leconomic	0.04284** (0.0102)	0.4463* (0.3951)	0.204* (0.1528)	0.4862** (0.2422)
Fisupport	0.1846 (0.1052)	0.0633* (0.0523)	0.0016* (0.0028)	0.0582** (0.0436)
Teinnovation	1.226*** (0.668)	1.084** (0.4523)	0.0015* (0.0026)	0.0582 (0.0445)
Openlevel	0.9005*** (0.395)	0.7588** (0.1582)	-0.7540 (-0.8963)	0.6930** (0.1538)
Icscmion	1.123*** (0.3851)	1.212*** (0.5421)	-0.0843*** (0.1866)	-0.3522*** (0.5684)
Constant term	0.3052	0.1345	0.1226	0.1985
AR(2) test	0.312	0.1400	0.1225	0.1984
Hansen	0.999	1.0002	1.0002	1.0002
Observed value	330	330	330	330

4.3. Robustness Testing and Endogeneity Mitigation

(1) Changing the measurement method of the explanatory variable. Unlike the comprehensive evaluation index system method, the economic resilience measured by the sensitivity index method primarily focuses on core variables that reflect the extent to which the economic system responds to external shocks, with GDP growth rate and unemployment rate being commonly used variables. The resilience index method requires a precise definition of the period during which the shock occurs and the establishment of a baseline state as a reference, followed by the calculation of the gap in the selected core variables after the shock occurs to characterize the resilience of the economic system. However, from the macro level of counties, various forms of shocks are common, and most of them gradually facilitate the transformation and restructuring of the county's economic structure. Therefore, this paper uses the growth rate of nighttime light intensity in each county in 2014 as the baseline state, calculates the difference between the annual growth rate of nighttime light intensity in each county and the baseline state, and measures the economic resilience of the county based on this. The reason for selecting county-level nighttime light data as the core variable reflecting the impact of external shocks on the county-level economic system is twofold. First, it helps mitigate the interference of statistical data biases on economic resilience evaluations, as governments often have an incentive to exaggerate GDP statistics after external shocks occur due to local performance evaluation systems. Second, nighttime light remote sensing data has been increasingly used by scholars to monitor the authenticity of regional economic growth rates. Specifically, for counties in China, the brightness of lights aligns closely with the hierarchical scale distribution of economic activity, thereby effectively capturing the resilience of county-level economic systems in resisting shocks. After adjusting the economic resilience measurement method, the estimated results are shown in Table 3, with the impact effects of industrial chain and supply chain modernization on county-level economic resilience consistent with the conclusions of the baseline results.

(2) Excluding county-level samples from municipalities directly under the central government. County-level local governments in municipalities directly under the central government differ significantly from other regions in terms of administrative status, priority in resource allocation, and industrial opportunities associated with policy advantages. To eliminate the unobservable effects of such

policy and institutional differences, this study further excludes county-level samples from the four municipalities directly under the central government (Beijing, Chongqing, Shanghai, and Tianjin) and uses the remaining 326 observations for parameter estimation. After controlling for variables and fixed effects, the estimated coefficient for industrial chain and supply chain modernization is significantly positive at the 1% level.

(3) Mitigation of endogeneity issues. In the baseline regression, while the economic resilience measured using the composite index method can comprehensively reflect the resilience of county-level economic systems to shocks, the complexity of the economic resilience composite indicator system leads to obvious omitted variable and reverse causality issues between industrial chain and supply chain modernization and county-level economic resilience. Given that economic resilience is a complex system involving multiple aspects such as economic growth, economic fluctuations, and economic transformation, general socio-economic variables are not suitable as instrumental variables for this study. Therefore, this paper re-estimates the model parameters using the System Generalized Method of Moments (System GMM) to mitigate reverse causality bias. Additionally, municipal-level characteristic variables are further incorporated, including the GDP, non-agricultural industrial structure, and financial scale of the prefecture-level city to which the county belongs, to mitigate omitted variable bias as much as possible. The test results show that the P-value for the AR(^{2}) test of the model residual sequence correlation is 0.6667, indicating that the error terms of the model do not exhibit second-order autocorrelation. The P-value for the Hansen overidentification test is 0.4225, passing the overidentification test. The test results indicate that using the System GMM method for parameter estimation is reasonable. The estimation results in column (3) of the table show that the main research conclusions remain valid.

Table 3. Robustness test.

	(1)	(2)	(3)
	Change the measure of economic toughness DN	A county sample of the municipalities directly under the CER	System GMM estimation method CER
FNP	0.3426*** (0.0953)	0.2742*** (0.0322)	0.5627*** (0.1248)
Icscmion			0.5663*** (0.0578)
The county area fixed effect	Control	Control	Control
Year fixed effect	Control	Control	Control
County control variable	Control	Control	Control
City-level characteristics variable			Control
Constant term	-0.1024 (0.0814)	0.0094* (0.0056)	-0.0011 (0.0098)
AR(^{2}) P value			0.6667
Hansen test P value			0.4225
Observed value	326	326	326
R-squared	0.9636	0.9025	

4.4. Analysis of the Estimated Results of the Interaction Effect Model

The estimation results of the moderation effect model are shown in Table 4, where all column variables have undergone decentralization treatment. In Column (1), both the coefficient of industrial chain and supply chain modernization and the coefficient of financial new-quality productivity are significantly positive, and the regression coefficient of their interaction term is also significantly positive, indicating that financial new-quality productivity enhances the positive effect of rural industrial chain and supply chain modernization on the resilience of county-level economies. Columns (2) to (4) report the moderating effects of the sub-dimensions of financial new-quality productivity. The estimated coefficients indicate that the conclusion that financial new-quality productivity has a positive moderating effect on the influence of rural industrial chain and supply chain modernization on county-level economic resilience is relatively robust. More importantly, this to some extent reflects the validity of the aforementioned inference, namely, the positive moderating effect of financial new-quality productivity on the relationship between industrial chain and supply chain modernization and county-level economic resilience stems from its reinforcement of the industrial restructuring effect, industrial creation effect, innovation incentive effect, and human capital diffusion effect of rural industrial chain and supply chain modernization.

Table 4. Regulation effect test.

	Total index	Usage depth	Coverage span	Digital support servIrtiese
FNP	0.2412*** (0.0563)	0.2538*** (0.0582)	0.1892*** (0.0405)	0.2145*** (0.0447)
Icscmion	0.0022*** (0.0005)			
Icscmion×FNP	0.3056*** (0.0745)			
SD		0.0030*** (0.0004)		
FNP×SD		0.1826*** (0.0786)		
GD			0.014** (0.006)	
FNP×GD			0.4163*** (0.0639)	
SZ				0.0014*** (0.0006)
FNP×SZ				0.2568*** (0.0826)
Constant term	-0.0386*** (0.0142)	-0.2615*** (0.0536)	-0.0394*** (0.0112)	0.0009 (0.0112)
Observed value	326	326	326	326
R-squared	0.9026	0.9012	0.9008	0.9345

5. Conclusion

This paper is based on panel data from 30 provinces in China from 2014 to 2024, with the modernization of the agricultural industrial chain and supply chain as the dependent variable and financial new-quality productivity as the independent variable. Using interaction effects, mediation effects, and other models, the paper examines the impact and mechanisms of financial new-quality productivity on agricultural new-quality productivity. The research findings indicate that financial new-quality productivity has a significant driving effect on the modernization of the industrial chain and supply chain, with statistical significance at the 1% level. The mediating effect of financial new-quality productivity on the modernization of agricultural industrial chains and supply chains exhibits regional heterogeneity. The ranking of the four major regions from largest to smallest is: eastern, central, northeastern, and western regions. Furthermore, financial new-quality productivity plays a positive regulatory role in the process of influencing the resilience of county-level economies through the modernization of rural industrial chains and supply chains.

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