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Rural Revitalization and Agricultural Economic Growth in China: Policy Impacts and Structural Transformation

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ABSTRACT

This study examines the economic effects of China's Rural Revitalization Strategy on agricultural development through an integrated triadic dynamic mechanism framework comprising technological innovation, agricultural industrialization, and industrial structure optimization. Drawing on balanced panel data from 31 provincial-level regions spanning 2013-2022, we employ fixed-effects models, mediation analysis, and dynamic System GMM estimation to systematically identify and quantify transmission pathways and their synergistic interactions. The empirical results demonstrate that rural revitalization policies significantly enhance total agricultural output, with particularly pronounced effects on crop production (coefficient: 1.796), forestry (1.845), livestock (1.093), and fisheries (1.646). Mediation analyses reveal that agricultural industrialization accounts for the largest share of policy impact (62%), followed by technological innovation (46%) and industrial restructuring (17%), confirming their interdependent nature. Regional heterogeneity analysis indicates that eastern provinces exhibit stronger policy responsiveness due to superior fiscal capacity and infrastructure, while central and western regions face resource constraints requiring differentiated policy intensities and longer transformation periods. These findings advance theoretical understanding of rural development mechanisms by demonstrating simultaneous operation of multiple transmission channels rather than isolated pathways. The research provides actionable policy recommendations for enhancing agricultural productivity, promoting sustainable rural transformation, and achieving balanced re-

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gional development in China and other developing economies facing similar structural challenges in agricultural modernization.

Keywords: Rural Revitalization; Agricultural Economic Growth; Agricultural Industrialization; Technological Innovation; Industrial Restructuring; Panel Data Analysis

1. Introduction

Over the past decade, rural China has experienced profound transformation driven by comprehensive policy reforms aimed at promoting agricultural modernization and rural development. Among these initiatives, the Rural Revitalization Strategy launched in 2018 has emerged as a cornerstone of China's national agenda. The strategy seeks to address longstanding structural imbalances between urban and rural areas by improving infrastructure, enhancing agricultural productivity, and fostering diversified rural industrial systems [1].

While considerable progress has been made in expanding agricultural production capacity and upgrading rural infrastructure, persistent structural challenges continue to constrain the sustainable growth of China's agricultural industry. Notably, agricultural technological innovation remains insufficient, with R&D investment accounting for less than 0.6% of the national GDP in 2022, substantially below the 2% threshold typically observed in advanced economies [2]. Furthermore, rural labor shortages have intensified, as evidenced by the declining share of the agricultural labor force (23.8%) and an increasingly aging rural population (23.81% of those aged 60 and above), exacerbating labor constraints in agricultural production.

In addition to human capital limitations, the agricultural industrialization process in China remains underdeveloped. In 2022, the processing rate of agricultural products stood at 65%, significantly lagging behind the 80% benchmark for developed nations. In particular, the grain processing conversion rate was only 40%, compared to 90% in the United States. These limitations reflect broader inefficiencies in value chain development and agricultural market integration [2].

Against this backdrop, the Rural Revitalization Strategy has been positioned as a critical policy intervention to catalyze agricultural modernization and stimulate rural economic growth. While existing studies have documented the broad benefits of rural revitalization, empirical analyses of the specific mechanisms through which rural revitalization influences agricultural development remain limited. In particular, there is a paucity of research that systematically examines how rural revitalization promotes agricultural economic growth through technological innovation, industrialization, and industrial restructuring.

Despite substantial progress, existing rural revitalization research exhibits a critical limitation: studies predominantly adopt single-mechanism perspectives. Recent investigations have examined coupling development between economy and environment [3], agricultural modernization coordination [4], or industrial integration impacts [5] in isolation. While providing valuable insights into individual channels, these studies overlook the simultaneous and interdependent nature of multiple transmission mechanisms. The synergistic interactions among technological innovation, industrialization, and structural optimization as an integrated triadic system remain insufficiently understood, constraining both theoretical advancement and comprehensive policy guidance.

This study addresses these limitations by developing an integrated triadic dynamic mechanism framework that models the simultaneous effects of technological innovation, agricultural industrialization, and industrial structure optimization on agricultural economic growth. Unlike previous studies that apply System GMM to isolated channels, we employ fixed-effects models, mediation analysis, and dynamic System GMM estimation within a unified analytical framework, decomposing total policy effects into direct and indirect pathways and quantifying each transmission channel's relative contribution. Drawing on provincial panel data (2013–2022), our findings advance theoretical understanding of rural development mechanisms and provide actionable pol-

icy recommendations for China and other developing economies facing similar structural challenges.

2. Literature Review

2.1. The Chinese Perspective of Rural Revitalization and Agricultural Economic Advancement

Recent scholarship has advanced comprehensive frameworks for China's rural revitalization. Liu et al.[6] integrate theory, technology, and management dimensions, while Yuan et al.[7] examine rural transition mechanisms from a spatial perspective. Building on these foundations, Chinese research addresses four key dimensions of rural revitalization and agricultural economic advancement.

2.1.1. Rural Revitalization and Agricultural Economic Growth

Several studies have emphasized its role in facilitating agricultural modernization by promoting technological innovation, industrial integration, and improved market access[8, 9]. For example, fiscal support policies and investments in rural infrastructure have been shown to enhance agricultural productivity and the efficiency of circular agricultural economies[4]. Furthermore, empirical analyses suggest that rural revitalization initiatives contribute significantly to regional economic growth, with measurable increases in both agricultural output and farmers' income[10, 11].

While these studies underscore the positive outcomes of rural revitalization, they tend to focus on aggregated economic indicators, without examining the underlying mechanisms that drive these improvements. Consequently, a void persists in research describing the mechanisms through which rural revitalization fosters agricultural economic development, particularly concerning the roles of technological advancement, industrialization, and structural transformation.

2.1.2. Impact on Farmers' Incomes

Existing research highlights the positive association between industrial revitalization and rural household income levels. For instance, Peng et al.[12] report that a 1% improvement in rural industrial revitalization correlates with a 0.35%–0.50% increase in per capita disposable income for rural inhabitants. Similarly, Wang et al.[5] demonstrate that industrial integration in rural revitalization promotes capital accumulation and labor productivity, resulting in a substantial increase in farmers' earnings.

Despite these findings, most analyses focus on short-term income effects, with limited attention paid to the sustainability of income growth and the structural conditions necessary for long-term rural economic stability. Few studies have addressed the extent to which industrial diversification, technological adoption, and market access mediate the relationship between rural revitalization and income growth.

2.1.3. Contribution to Urban-Rural Coordination

Research demonstrates that revitalization efforts contribute to narrowing the income gap by promoting industrial development, improving rural infrastructure, and enhancing public services[13]. For example, Jiang[14] finds that a 1% improvement in rural industrial development reduces the urban-rural income ratio by 0.12–0.18.

Nonetheless, regional heterogeneity presents significant challenges to achieving equitable development outcomes. While rural revitalization has reduced urban-rural disparities in coastal regions, inland and western provinces continue to face persistent developmental gaps. These spatial inequalities suggest the need for more nuanced region-specific policy approaches.

2.1.4. Promoting Rural Sustainability

Several scholars have argued that rural revitalization promotes environmental protection and green agricultural practices by integrating ecological considerations into rural development planning[3, 15]. In recent years, the adoption of green technologies and improvements in rural waste and sewage management have contributed to improved environmental outcomes[16].

However, many existing studies treat sustainability as a peripheral outcome rather than a central component of rural revitalization strategies. There is limited empirical research that systematically examines how ecological initiatives are integrated into economic revitalization plans or how sustainable development indica-

tors are incorporated into performance evaluations of rural revitalization programs.

2.2. International Perspectives on Rural Revitalization and Agricultural Economic Advancement

In recent decades, rural revitalization strategies have been widely implemented across both developed and developing countries in response to rural economic decline, depopulation, and agricultural stagnation [17, 18]. These strategies generally aim to advance sustainable rural development through integrated interventions, industry, governance, and social services [19]. A growing body of international literature provides valuable insights into how rural revitalization influences agricultural economic growth through technological innovation, industrialization, and structural transformation.

2.2.1. Rural Revitalization and Technological Innovation in Agriculture

Technological innovation has long been recognized as a catalyst for agricultural productivity and rural economic development. Policy frameworks and governance mechanisms have increasingly supported the adoption of innovative agricultural technologies in international development contexts [20]. Studies on precision agriculture in Europe and North America have highlighted how digital technologies, such as GPS-based systems, drones, and data analytics, contribute to yield increases, input optimization, and improved farm management [21, 22]. In sub-Saharan Africa, digital information systems and media platforms have improved farmers' access to market information, inputs, and agricultural extension services, with evolving media landscapes shaping rural information access [23, 24].

2.2.2. Agricultural Industrialization and Value Chain Development

The value of agricultural industrialization in fostering rural economic development is well-documented globally. In Latin America, agri-food clusters and contract farming arrangements have facilitated agricultural industrialization by integrating smallholder farmers into global value chains [25, 26]. In Brazil, agri-industrialization strategies supported by public-private partnerships have led to the expansion of processing industries, increased value addition, and enhanced employment opportunities in rural areas [27]. Similarly, in India, initiatives such as Rashtriya Krishi Vikas Yojana (RKVY) and Agri Export Zones(AEZs) have promoted agricultural industrialization by fostering agro-processing, rural entrepreneurship, and market linkages [28].

2.2.3. Industrial Structure Optimization and Rural Economic Diversification

The restructuring of rural industrial systems and promotion of rural non-farm activities are critical components of rural revitalization in many countries. In the European context, the LEADER program has encouraged rural economic diversification through community-led local development initiatives, fostering rural tourism, craft, and renewable energy industries [29, 30]. In Southeast Asia, particularly in Thailand and Vietnam, agricultural industrialization and diversification policies have integrated agriculture with manufacturing and services, facilitating rural-urban linkages and reducing regional development disparities [31, 32].

2.3. Research Gaps

Despite an extensive body of international research examining the correlation between rural revitalization and agricultural economic advancement, several critical gaps remain. Existing studies predominantly adopt a single-disciplinary perspective, lacking an integrated, interdisciplinary analytical framework that may include intricate relationships among the essential elements of rural revival. In particular, there is limited empirical evidence explaining how rural revitalization promotes agricultural economic growth through specific mechanisms such as technological innovation, agricultural industrialization, and industrial structure optimization. This shortfall restricts a thorough comprehension of the mechanisms and processes by which rural revitalization strategies exert their economic effects.

Moreover, although global evidence underscores the importance of governance reforms and community participation in advancing rural development, there is a notable absence of rigorous empirical analyses that ex-

amine their mediating roles in agricultural economic outcomes within the context of rural revitalization. This is particularly applicable to large, swiftly advancing economies such as China, where rural revitalization strategies are characterized by state-led planning, digital governance, and large-scale agricultural industrialization. These distinctive features offer valuable insights for developing countries; however, they remain underexplored in the existing comparative literature.

To address these gaps, this study develops an integrated analytical framework based on a "triadic dynamic mechanism," comprising agricultural technological innovation, agricultural industrialization, and industrial structure optimization. By systematically investigating the pathways through which rural revitalization promotes agricultural economic growth, this study aims to elucidate the internal logic and operational mechanisms underlying rural revitalization initiatives. These findings are intended to contribute to the theoretical advancement of rural development studies and provide empirical evidence to support more effective policy design and implementation in both China and other developing economies.

3. Theoretical Framework and Research Hypotheses

3.1. Theoretical Foundations

3.1.1. Structural Transformation Theory and Agricultural Modernization

The idea of structural transformation asserts that economic progress involves the reallocation of resources, especially labor and capital, from low-productivity agricultural sectors to higher-productivity industrial and service sectors[33]. Timmer[34] further refined this theory, emphasizing that improvements in agricultural productivity are essential not only for ensuring food security but also for stimulating broader economic transformation by releasing surplus labor and driving urbanization.

Rural revitalization strategies in China have facilitated such structural shifts by promoting technological innovation and agricultural industrialization. This aligns with Timmer's argument that agriculture serves as a "leading sector" in the early stages of development but must undergo productivity enhancements and value chain integration to sustain economic growth. The triadic dynamic mechanism proposed in this study operationalizes Timmer's framework by incorporating technological innovation, industrial upgrading, and structural transformation as interconnected drivers of agricultural economic growth.

3.1.2. Dual Economy Model and the Evolving Rural-Urban Nexus

The Lewis[35] dual economy model explains development through the migration of surplus labor from the old agricultural sector to the contemporary industrial sector. However, this model assumes a unidirectional flow of labor and capital, often leading to rural depopulation and widening rural-urban inequality in many developing countries.

China's rural revitalization strategy modifies the traditional Lewis framework by fostering rural-urban integration. Through agricultural industrialization, this strategy creates employment opportunities and value-added activities within rural areas, preventing excessive rural out migration. The bidirectional flow of resources between rural and urban regions facilitates balanced development, offering an alternative pathway to Lewis' s classic labor surplus model. This study extends dual economy theory by demonstrating that rural revitalization policies can stimulate internal rural development while maintaining urban-rural equilibrium, a concept applicable to other developing economies with similar dualistic structures[36].

3.1.3. Global Value Chain (GVC) Framework and Agricultural Industrialization

The Global Value Chain (GVC) framework[37] highlights the importance of upgrading production processes and increasing participation in globalized agri-food systems. Agricultural industrialization, one of the key mechanisms in this study, plays a critical role in integrating rural economies into regional and global value chains.

China' s rural revitalization initiatives have promoted functional, process, and product upgrading in agricultural value chains. These include enhancing pro-

cessing capacity, standardizing production, improving logistics, and expanding market access. Similar strategies have been employed in other developing countries such as Brazil and Thailand, where agricultural industrialization has increased value-added, diversified rural incomes, and improved export competitiveness [26].

The triadic mechanism framework proposed in this study demonstrates how rural revitalization can enhance vertical integration and horizontal coordination in agri-food systems, and improve smallholder participation and bargaining power [38]. This process is particularly relevant for countries in sub-Saharan Africa and Southeast Asia, where fragmented agricultural markets and limited infrastructure remain significant barriers to smallholder inclusion [23].

3.2. The Triadic Dynamic Mechanism Framework

The triadic dynamic mechanism, consisting of technological innovation, agricultural industrialization, and industrial structure optimization, provides a holistic framework for understanding how rural revitalization drives agricultural economic growth (**Figure 1**). While derived from China's rural revitalization experience, this mechanism demonstrates broad applicability to other developing economies, particularly those in the Global South facing similar structural challenges.

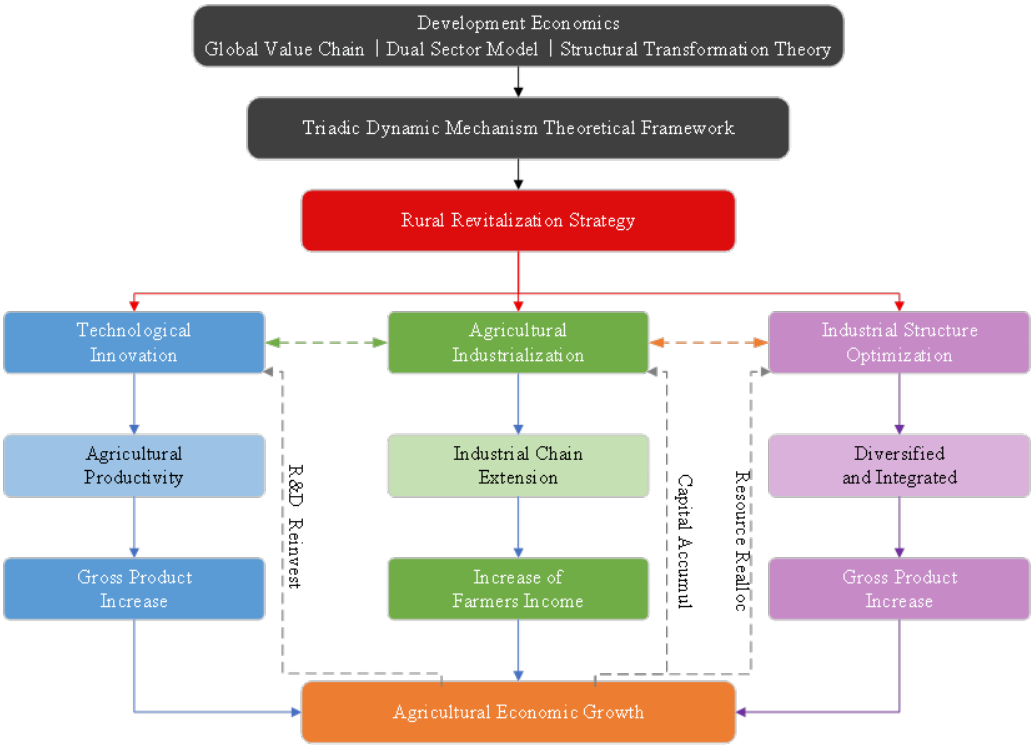

Figure 1. Triadic Dynamic Mechanism Model for Agricultural Economic Growth.

Note: Solid arrows represent direct causal effects; dashed bidirectional arrows between mechanisms indicate synergistic interactions; dashed upward arrows from outcome to mechanisms illustrate dynamic feedback loops. The framework demonstrates how rural revitalization drives agricultural economic growth through simultaneous and interdependent transmission pathways.

The framework operates through three interdependent pathways with synergistic effects. Technological innovation enhances agricultural productivity while simultaneously enabling industrialization, which in turn generates economies of scale and value-added capabilities. Both mechanisms trigger structural optimization as resources and labor shift toward higher-value activities. The framework exhibits dynamic feedback loops whereby economic growth generates resources for reinvestment in technology and infrastructure, while structural changes create demand for advanced innovations. These reciprocal reinforcement effects intensify over time, demonstrating the cumulative and iterative nature of rural revitalization's impact on agricultural economic growth.

3.3. Triadic Dynamic Mechanism and its Cross-National Applicability

The triadic dynamic mechanism framework is not confined to the specific institutional and socio-economic contexts of China, but also holds significant applicability for other developing economies, particularly those in the Global South, including Sub-Saharan Africa, Southeast Asia, and Latin America. These regions often face structural challenges similar to those faced by China prior to its rural revitalization initiatives, such as low agricultural productivity [34], underdeveloped agricultural value chains [26], and persistent rural-urban disparities [39].

Chinese experience demonstrates that targeted policy interventions promoting technological innovation, agricultural industrialization, and industrial structure optimization can facilitate sustainable agricultural economic growth without triggering excessive rural depopulation [36]. The flexibility and adaptability of the triadic dynamic mechanism make it applicable to diverse institutional contexts and resource endowments [40]. By addressing common challenges in agricultural development, such as fragmented markets, weak infrastructure, and limited access to technology [23]—this framework offers a replicable model for rural revitalization strategies in other developing regions.

3.4. Research Hypotheses

Based on the conceptual framework and theoretical foundations outlined in the preceding sections, this study proposes a set of research hypotheses to empirically test the mechanisms by which rural revitalization influences agricultural economic growth in China.

3.4.1. Direct Impacts of Rural Revitalization on Agricultural Economic Growth

Rural revitalization, as a comprehensive national strategy, has significantly contributed to improving agricultural productivity and advancing the integrated development of elementary, secondary, and tertiary sectors in rural regions. This has facilitated improvements in infrastructure, expanded access to modern agricultural technologies, and enhanced financial support for agriculture, forestry, animal husbandry, and fisheries. Empirical studies have shown that targeted initiatives under rural revitalization, such as high-standard farmland construction, intelligent agriculture, and the promotion of eco-agriculture, have effectively enhanced output in various sectors [41–43].

This study posits the following hypotheses concerning the direct influence of rural revitalization on the agricultural economy:

H1a. *Rural revitalization exerts a markedly beneficial impact on agricultural production value.*

H1b. *Rural revitalization positively promotes the production value of the forestry.*

H1c. *Rural revitalization exerts a markedly beneficial effect on the production value of animal husbandry.*

H1d. *Rural revitalization positively affects the production value of the fisheries.*

H1e. *Rural revitalization facilitates comprehensive growth of the total production value of agriculture, forestry, animal husbandry, and fisheries.*

3.4.2. Mediating Role of Agricultural Technological Innovation

Technological innovation is crucial to augment agricultural output, promote crop quality, decrease production costs, and alleviate environmental concerns. Increased investments in agricultural R&D, the dissemination of advanced technologies, and the application of digital agriculture have contributed to optimizing the allocation of agricultural production factors. Prior studies have shown that agricultural technological innovation can boost crop yields by 20%-50% and livestock productivity by over 30% [44, 45]. Precision agriculture, big data analytics, and smart farming technologies have strengthened the resilience and sustainability of agricultural production systems.

H2a. *Technological innovation facilitates the connection between rural revitalization and agricultural economic growth by enhancing productivity and efficiency.*

3.4.3. Mediating Role of Agricultural Industrialization

Agricultural industrialization represents a critical pathway for enhancing the value-added of agricultural

goods, elongating the agricultural value chain, and facilitating the integration of production, processing, and marketing. Industrialization has led to the development of agricultural processing industries, rural cooperatives, and leading agribusiness enterprises, all of which enhance market access, stabilize farmers' incomes, and foster rural employment [46, 47]. The branding and commercialization of agricultural products increases their market competitiveness [48], further stimulating economic growth.

H2b. *Agricultural industrialization facilitates the connection between rural revitalization and agricultural economic growth by increasing value-added and extending industrial chains.*

3.4.4. Mediating Role of Industrial Structure Optimization

Enhancing the rural industrial structure fosters the diversification of rural industries and improves the interaction of agriculture with the secondary and tertiary sectors. This structural adjustment supports the advancement of nascent industries including rural tourism, leisure agriculture, and ecological farming. It also facilitates the efficient use of land, water, and other resources, while promoting environmental protection and sustainable development [49]. Such industrial integration is essential to improve agricultural competitiveness and ensure the long-term sustainability of rural economies.

H2c. *Industrial structure optimization facilitates the connection between rural revitalization and agricultural economic growth by promoting industry integration and diversification.*

In summary, rural revitalization is hypothesized to influence agricultural economic growth both directly and indirectly through three interrelated pathways—technological innovation, industrialization, and industrial structure optimization—constituting the "triadic dynamic mechanism" framework proposed in this study.

4. Methodology

4.1. Data Sources and Sample Selection

This study utilizes balanced panel data from 31 provincial-level administrative regions in China, spanning the period from 2013 to 2022. The dataset was compiled from authoritative and publicly accessible sources including the CCAD database, China Statistical Yearbook, China Rural Statistical Yearbook, China Agricultural Statistical Yearbook, China Population and Employment Statistical Yearbook, China Urban and Rural Construction Statistical Yearbook, and various provincial statistical yearbooks. To ensure data consistency and reliability, missing values were treated using linear interpolation and outliers were winsorized at the 1st and 99th percentiles.

The selected timeframe captures the critical years following the implementation of the Rural Revitalization Strategy, providing a comprehensive perspective on its impact on agricultural economic growth. The final balanced panel comprises 310 observations (31 regions × 10 years).

4.2. Variable Definition and Measurement

4.2.1. Dependent Variables

Following Fan and Zhang [50], Zeng et al. [51], and Wen [52], this study used the total production value of agriculture, forestry, animal husbandry, and fisheries to evaluate agricultural economic growth. This indicator is disaggregated into four subsectors:

TOV: Total production value of agriculture, forestry, animal husbandry, and fisheries, representing the comprehensive scale of the agricultural economy.

AOV: Agricultural output value, reflecting the contribution of crop farming.

FOV: Forestry output value, measuring forest economy activities.

LOV: Livestock output value, assessing the economic performance of animal husbandry.

FV: Fishery output value, indicating the contribution of aquaculture and fisheries.

4.2.2. Independent Variables

Rural revitalization is the core explanatory variable and is evaluated through a composite index based on four dimensions: industrial, talent, ecological, and organizational revitalization. The index was constructed using the Entropy Weight Method (EWM) and Principal Component Analysis (PCA), drawing on the methodologies of Geng et al. [53] and Xiong et al. [54]. This multidi-

mensional evaluation system ensures objectivity and scientific rigour. **Table 1** presents the dimensions, indicators, and weights.

The comprehensive rural revitalization score was calculated using the weighted summation of the standardized indicators.

Table 1. Assessment framework and weighting for rural rejuvenation.

Primary Index	Secondary Index	Three-Level Index	Stats	Weight
Industrial revitalization 0.30785	Agricultural production capacity	Per capita total power of agricultural machinery	+	0.03838
		Overall grain production capability	+	0.03837
		Agricultural labor efficiency	+	0.03837
	Agricultural product processing industry	Principal revenue of large-scale agricultural product processing firms	+	0.03836
	Farmer income level	Net revenue per capita of agricultural producers	+	0.03836
		Growth rate of average income of farmers	+	0.03884
		Urban-rural income ratio	+	0.03878
	Rural economic capacity	Car ownership per 100 households	+	0.03837
Ecological revitalization 0.26921	Agricultural green development	Application amount of pesticides and fertilizers	–	0.03899
		Holistic utilization rate of cattle and poultry excrement	+	0.03836
	Rural environmental governance	Administrative village for the treatment of domestic sewage	+	0.03837
		Administrative village for the disposal of domestic waste	+	0.03837
		Access to sanitary toilets	+	0.03837
		Rural greening rate	+	0.03837
		Access to safe drinking water	+	0.03837
Talent revitalization 0.19181	Educational level	Financial allocations for education, culture, and recreation for rural inhabitants	+	0.03836
		Percentage of full-time educators in rural compulsory education institutions with a bachelor's degree or higher	+	0.03835
		Average years of schooling for rural residents	+	0.03835
	Technology and informatization	Cable coverage	+	0.03837
		Percentage of administrative villages having broadband Internet access	+	0.03838
Organizational revitalization 0.23114	Infrastructure construction	Village road quality	+	0.03837
		Per capita road area	+	0.03836
	Village planning and management	Administrative village activities for which a village plan has been prepared	+	0.03836
		Village director secretary a shoulder to shoulder proportion	+	0.03836
	Social equity and poverty management	Incidence of rural poverty	–	0.03883
		Engel coefficient of rural residents	–	0.03886

4.2.3. Control Variables

This study controls for several factors, following Luo et al.[55]:

Degree of Openness (DOP): Proportion of total import and export volumes to regional GDP.

Financial Support for Agriculture (FS): General budget expenditure on agriculture as a share of regional GDP.

Social Consumption Level (SCL): Proportion of total retail sales of consumer goods to regional GDP.

4.2.4. Mediating Variables

Three mediating variables were introduced to examine the mechanisms linking rural revitalization and agricultural economic growth.

Technological Innovation: Number of personnel engaged in agricultural R&D and extension. This input-based measure reflects technology deployment capacity. Output measures such as patents are unavailable at provincial level.

Agricultural Industrialization: Number of registered agricultural product processing enterprises. Firm count indicates industrialization breadth. Value-added data are preferable but unavailable at provincial scale.

Industrial Structure Optimization: Ratio of tertiary to secondary industry GDP, capturing industrial upgrading and diversification. This economy-wide indicator imperfectly proxies rural structural optimization. Rural-specific measures are preferable but unavailable provincially.

All variables are log-transformed to mitigate scale effects and ensure comparability. **Table 2** presents the descriptive statistical results of pertinent variables.

Table 2. Descriptive statistics of variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
lntov	310	7.835	1.103	4.852	9.403
lnaov	310	7.178	1.15	3.956	8.846
lnfov	310	4.599	1.295	0.747	6.308
lnlov	310	6.54	1.081	3.745	8.193
lnfv	310	4.582	2.159	−1.897	7.549
lnrevital	310	−1.344	0.801	−4.131	−0.107
lndop	310	−1.82	0.97	−4.876	0.229
lnfs	310	−1.37	0.472	−2.254	0.303
lnscl	310	−0.944	0.176	−1.717	−0.494
lnen	310	9.079	1.045	5.476	11.584
lnstn	310	9.613	1.236	5.714	11.588
lnis	310	0.272	0.362	−0.407	1.664

4.3. Regional Classification

For the regional heterogeneity analysis, the 31 provincial-level administrative regions (excluding Hong Kong, Macao, and Taiwan) were categorized as follows:

Eastern: Beijing, Tianjin, Hebei, Shandong, Shanghai, Jiangsu, Fujian, Guangdong, Zhejiang, and Hainan.

Central: Shanxi, Jiangxi, Henan, Anhui, Hunan, Hubei.

Western China: Neimenggu, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Xizang Chaanxi, Gansu, Qinghai, Ningxia, Xinjiang.

Northeast China (Liaoning, Jilin, Heilongjiang).

Figure 2 presents the evolution of comprehensive rural revitalization scores across different regions (eastern, central, western, and northern) between 2013 and 2022, demonstrating a continuous upward trend with evident regional variations.

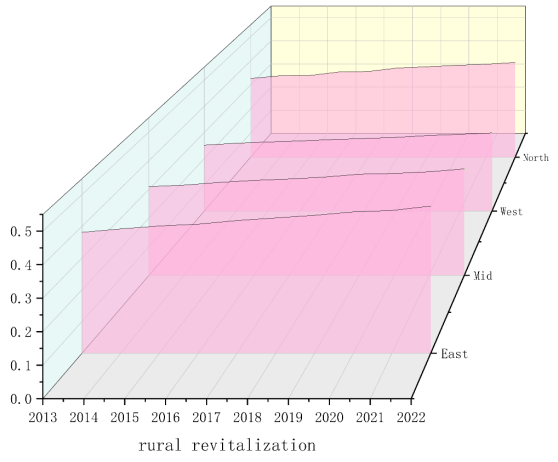

Figure 2. Illustrates the evolving trend of the comprehensive scores pertaining.

4.4. Model Specification

4.4.1. Fixed Effects Regression Model

This study discusses the prevalent regression analysis approach utilized in contemporary academic circles [52, 56] on the influence of the agricultural economy and pertinent research on rural revival as an explanatory variable [12, 14, 57]. Construction of basic measurement model. As shown in Equation 1:

$$\ln(T\,\mathrm{ov}_{it}) = \beta_0 + \beta_1 \ln\mathrm{revital}_{it} + \varepsilon_{\mathrm{it}} \tag{1}$$

$\ln\mathrm{Tov}_{\mathrm{it}}$ and $\ln\mathrm{revital}_{\mathrm{it}}$, respectively, represent the total production value of agriculture, forestry, livestock husbandry, and fisheries in year t of province i and the level of rural revitalization and development, respectively, $\varepsilon_{\mathrm{it}}$ denotes the stochastic disturbance variable.β_0 represents the constant term, and β_1 represents the regression coefficient pertaining to the developmental status. If β_1 is significantly positive, then rural revitalization has an income-increasing effect.

The agricultural economy is related to other factors, including the development level of rural revitalization; therefore, other control variables need to be added to the basic econometric model.

$$\begin{aligned}\ln(T\mathrm{ov}_{it}) = \beta_0 + \beta_1 \ln \mathrm{revital}_{it} + \gamma_1 \ln \mathrm{d}op_{it} \\ +\gamma_2 \ln \mathrm{fs}_{it} + \gamma_3 \ln scl_{it} + \mu_{\mathrm{i}} + \lambda_{\mathrm{t}} + \varepsilon_{it}\end{aligned} \tag{2}$$

In the model specification, i denotes the region, and t represents the year. μ_{i} captures the region-specific fixed effects, while λ_{t} accounts for time-specific fixed effects. The variables $\ln\mathrm{DOP}_{\mathrm{it}}$, $\ln\mathrm{FS}_{\mathrm{it}}$, and $\ln\mathrm{SCL}_{\mathrm{it}}$ represent the degree of openness, the intensity of fiscal support for agriculture, and the level of social consumption, respectively. Coefficients γ_1, γ_2, and γ_3 measure the effects of these control variables on agricultural economic growth.

4.4.2. Mediating Effect Model

This study used agricultural scientific and technical innovation, agricultural industrialization, and industrial structure as intermediary factors to further investigate the economic realization pathway of the rural revitalization plan. Stepwise Regression Analysis was used to clarify the independent and interactive effects of each variable on the economic path of rural revitalization. This study provides theoretical foundation and empirical evidence for policymaking.

(1) To test whether rural revitalization impacts agricultural science and technology innovation, agricultural industrialization, and industrial structure upgrading, if the coefficient of $\ln\mathrm{revital}_{\mathrm{it}}$ in the model is significant, it indicates that rural revitalization influences innovation in agricultural science and technology, agricultural industrialization, and industrial structure upgrading.

$$\begin{aligned}\ln(\mathrm{M}_{it}) = \theta_0 + \theta_1 \ln revital_{it} \\ +\sum \gamma_{\mathrm{k}} \ln control_{kit} + \mu_i + \lambda_t + \varepsilon_{it}\end{aligned} \tag{3}$$

(2) Rural revitalization, economic level, and mediating variables are included in the model to test the mediating effects of agricultural technological innovation, agricultural industrialization, and industrial structure.

$$\begin{aligned}\ln(\mathrm{tov}_{it}) = \delta_0 + \delta_1 \ln \mathrm{revital}_{it} + \delta_2 \ln M_{it} \\ +\sum \gamma_{\mathrm{k}} \ln control_{it} + \mu_i + \lambda_t + \varepsilon_{it}\end{aligned} \tag{4}$$

The indirect effects are calculated using the product of coefficients approach:

$$Indirect\ Effect = \theta_1 + \delta_2 \tag{5}$$

where θ_1 is the effect of $Indirect_{it}$ on the mediator (Model 3), and δ_2 is the effect of the mediator on $\ln(\mathrm{tov}_{it})$ (Model 4).

Significance is tested using bootstrapping (1000 replications) with 95% confidence intervals, assuming no unmeasured confounding and temporal precedence. Stata 17.0 was used.

In this study, lnMi represents the mediating variables, specifically technological innovation ($\ln\mathrm{stn}_{\mathrm{it}}$), agricultural industrialization ($\ln\mathrm{en}_{\mathrm{it}}$), and industrial structure ($\ln\mathrm{is}_{\mathrm{it}}$). Based on the estimation results of Models (2) to (4), the following conditions were used to determine the presence of a mediation effect:

If the regression coefficientsδ_1 andδ_2 in Model (4) are both statistically significant, coefficient$\theta_1$in Model (3) is significant, and the absolute value of δ_1 in Model (4) is lower than that coefficient$\beta_1$in Model (2), which signifies the presence of a partial mediation effect. This illustrates that the influence of rural revitalization on agricultural economic growth is partially mediated by improvements in technological innovation, industrialization, and industrial structure optimization.

4.4.3. System GMM Dynamic Panel Model

In the context of agricultural economic growth and rural revitalization, cross-period panel data often exhibit dynamic inertia, indicating that past agricultural economic performance significantly influences current outcomes. Traditional fixed effects (FE) models are unable to effectively address the endogeneity problem arising from the relationship between lagged dependent variables and error terms. This study utilizes the System Generalized Method of Moments (System GMM) estimator to examine the dynamic panel data model. Rural revitalization is endogenous due to policy spillover and reverse causality. System GMM uses lagged instruments, validated by Hansen J-test and serial correlation tests.

The System GMM approach, based on the methodology established by Arellano and Bover[58] and Blundell and Bond[59], uses the lagged values of endogenous variables as instruments. This method mitigates estimation bias and enhances model efficiency. In this study, the natural logarithm of total agricultural output value (lnTOV) is selected as the dependent variable, while its first-order lagged term (l.lnTOV) is included to capture dynamic effects. The core explanatory variables include rural revitalization (lnRevital), degree of openness (lnDOP), fiscal support for agriculture (lnFS), and industrial structure (lnSCL).

Within the model, both lnTOV and lnRevital were treated as endogenous variables. To address their potential endogeneity, third-order lagged differences lag(3 3) is employed as GMM-style instruments. he "collapse" choice is utilized to diminish the quantity of instruments and prevent over-identification issues. Meanwhile, lnDOP, lnSCL, lnFS, and the year dummy variables are assumed to be exogenous and incorporated into the model as instrumental variables (IV).

This study employs a two-step System GMM estimation approach with the "robust" option to enhance the reliability of the estimate findings and address heteroskedasticity. Additionally, the "small" sample adjustment is applied to correct for potential biases in finite samples, which is specified as follows:

$$\ln tov_{it} = \alpha_1 \ln tov_{it-1} + \beta_1 \ln revital_{it} + \sum \gamma_k \ln control_{kit} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

where $\ln TOV_{it-1}$ captures the dynamic inertia in agricultural economic growth.A significantα_1 indicates the presence of dynamic dependence in agricultural economic performance. Beyond PCA-based checks (Section 5.3.1), our findings are subject to specification sensitivity. Alternative lag structures and regional fixed effects represent potential extensions for future research.

5. Empirical Results and Analysis

5.1. Correlation Analysis

Through correlation analysis, this study examines the distinct function of rural revitalization mechanisms and the value of agriculture, forestry,livestock husbandry, and fisheries industries to reveal the specific role of rural revitalization on agricultural economic growth.

According to the correlation analysis heat map (**Figure 3**), the rural revitalization index (lnrevital) was positively correlated with the overall production value of agriculture, forestry, animal husbandry, and fisheries (lntov); value of agricultural production (lnaov); forestry output value (lnfov); livestock husbandry output value (lnlov); and fishery output value (lnfv). This indicates that rural revitalization might positively influence the overall economic scale of agriculture and the expansion of diverse subsectors.

5.2. Regression Analysis

The execution of the rural revitalization approach may provide varied effects across several sectors of the agricultural economy, with crops, forestry, animal husbandry, and fisheries taking different development paths and benefiting from the policy. To further explore this issue, based on 310 sets of provincial panel data, this study employed a fixed-effects model to analyze the impact of rural revitalization (lnrevital) on the production value of the agricultural, forestry, husbandry, and fishing sectors.

The regression results (**Table 3**) show that rural revitalization significantly enhances agricultural production value. The coefficient of 1.691 ($p < 0.01$) indicates a strong positive effect. This elasticity means a 1% increase in rural revitalization generates 1.69% agricul-

tural output growth, demonstrating strong leverage effects. A 10% policy improvement would increase output by 16.9%, translating to substantial economic gains. The lagged coefficient of 1.049 ($p < 0.01$) demonstrates enduring effects, though the impact magnitude weakens over time.

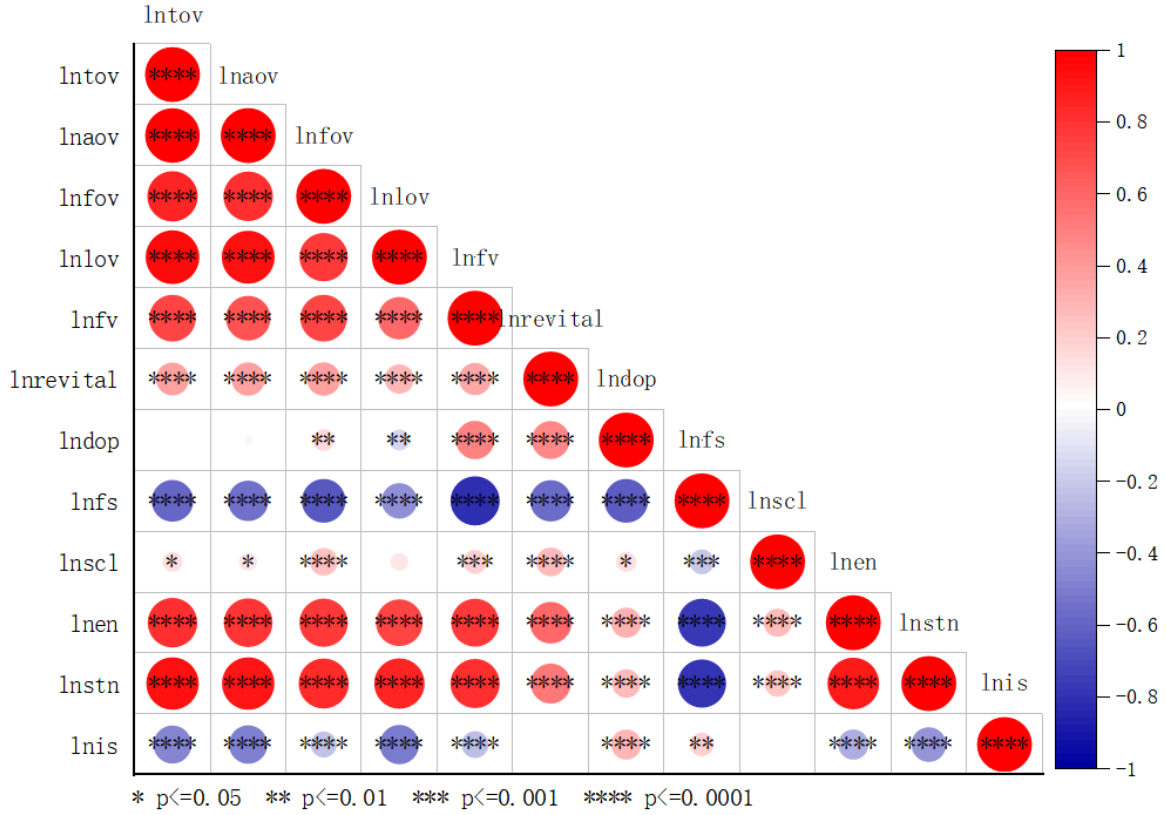

Figure 3. Correlation heat map.

Table 3. Regression analysis results of rural revitalization on the output value of agriculture, forestry, husbandry and fishery.

	The Current Period					One-Period Lag				
	Lntov	**Lnaov**	**Lnfov**	**Lnlov**	**Lnfv**	**Lntov**	**Lnaov**	**Lnfov**	**Lnlov**	**Lnfv**
lnrevital	1.691***	1.796***	1.845***	1.093***	1.646***	1.049***	1.215***	0.966***	0.571*	0.860***
	(14.933)	(16.181)	(10.014)	(6.114)	(10.056)	(7.602)	(8.944)	(4.439)	(2.383)	(4.392)
lndop	−0.099***	−0.069**	−0.129**	−0.149***	−0.054	−0.082**	−0.049	−0.125**	−0.137**	−0.013
	(−3.735)	(−2.653)	(−3.006)	(−3.572)	(−1.403)	(−3.020)	(−1.850)	(−2.936)	(−2.907)	(−0.327)
infs	−0.655***	−0.709***	−0.587***	−0.631***	−0.270*	−0.520***	−0.574***	−0.435**	−0.492**	−0.169
	(−7.345)	(−8.104)	(−4.043)	(−4.482)	(−2.093)	(−5.838)	(−6.544)	(−3.094)	(−3.177)	(−1.337)
lnscl	0.036	0.056	0.130	−0.038	0.222*	−0.234***	−0.199**	−0.130	−0.274*	−0.007
	(0.564)	(0.900)	(1.256)	(−0.380)	(2.408)	(−3.361)	(−2.903)	(−1.184)	(−2.265)	(−0.074)
_cons	9.063***	8.548***	6.162***	6.836***	6.536***	0.304***	0.267***	0.427***	0.255***	0.365***
	(38.982)	(37.505)	(16.285)	(18.623)	(19.445)	(7.305)	(6.518)	(6.505)	(3.527)	(6.185)
N	310	310	310	310	310	279	279	279	279	279
r2	0.607	0.634	0.389	0.290	0.324	0.654	0.672	0.456	0.299	0.368
F	106.055	119.005	43.779	28.037	32.985	92.023	99.414	40.813	20.696	28.315
FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Mean VIF	3.64									

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

Rural revitalization has a substantial beneficial influence on agriculture, forestry, livestock husbandry, and fisheries. During the current period, forestry had the largest impact (1.845), followed by agriculture (1.796). In contrast, the influence on fisheries (1.646) and the natural logarithm of livestock husbandry

(1.093*, t = 6.114) are comparatively minimal, suggesting a notable disparity in the enhancement effect of rural revitalization across several values of agricultural production dimensions. Forestry's higher elasticity reflects greater sensitivity to infrastructure investments, while livestock's lower coefficient suggests sector-specific constraints limiting policy effectiveness.

In the case of a one-period lag, rural revitalization significantly enhanced the metrics of agriculture, forestry, livestock husbandry, and fisheries,but the coefficients of each indicator generally declined, showing a time lag effect. Approximately 62% of policy effects materialize within the first year, with remaining impacts emerging due to technology adoption lags.

5.3. Robustness Test

5.3.1. Replacing the Core Independent Variable

The index technique for evaluating the advancement level of rural revitalization is crucial in examining its effect on the output value of agricultural enterprises. To guarantee the robustness of the research findings, the advancement level of rural revitalization was reassessed using principal component analysis (PCA), and regression analysis was conducted on the total value of agricultural production (lntov), value of agricultural production (lnaov), forestry output value (lnfov), the livestock output value (lnlov), and fisheries output value (lnfv).

Table 4 confirms the robustness of baseline findings. The PCA-based rural revitalization index shows positive and significant effects across all subsectors, with coefficients ranging from 0.517 (livestock) to 1.478 (fisheries). The high Pearson correlation (r = 0.930) for total agricultural output demonstrates strong consistency between PCA-based and entropy-weight measures, confirming that results are not sensitive to index construction methods.

5.3.2. System GMM

This study utilizes the System Generalized Method of Moments (System GMM) estimator and a dynamic panel data model to mitigate biases frequently associated with dynamic panel datasets and address potential endogeneity issues. The system GMM estimated diagnostic test results are shown in **Table 5**, where The Arellano-Bond test results indicate significant first-order autocorrelation in the differenced residuals (AR(1), p < 0.01), while second-order autocorrelation is not statistically significant (AR(2), p = 0.129). These results suggest that the model specification is appropriate and that there is no evidence of second-order serial correlation.

Table 4. Robustness Test: Regression Results Using PCA-based Rural Revitalization Index.

	Lntov	Lnaov	Lnfov	Lnlov	Lnfv
lnpca_revital	0.709***	0.754***	0.866***	0.517***	1.478***
	(*t*-stat)	(*t*-stat)	(*t*-stat)	(*t*-stat)	(*t*-stat)
Constant	7.426***	6.744***	4.100***	6.242***	3.731***
	(*t*-stat)	(*t*-stat)	(*t*-stat)	(*t*-stat)	(*t*-stat)
Control Variables	YES	YES	YES	YES	YES
Fixed Effects	YES	YES	YES	YES	YES
N	310	310	310	310	310
R^2	0.114	0.119	0.124	0.063	0.129
Pearson r	0.930	0.345	0.362	0.261	0.360

Note: Robust standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. Control variables include degree of openness (lndop), fiscal support for agriculture (lnfs), and social consumption level (lnscl). All models include provincial and year fixed effects. The PCA-based rural revitalization index confirms the robustness of baseline results.

Table 5. Diagnostic Test Results of System GMM Estimation.

Test Type	Test Statistic	*p*-Value	Conclusion
Arellano-Bond test for AR(1) in first differences	z = −3.73	0.000	First-order serial correlation detected (expected result)
Arellano-Bond test for AR(2) in first differences	z = −1.52	0.129	No second-order serial correlation (valid model assumption)
Sargan test of overidentifying restrictions	$\chi^2(3)$ = 3.95	0.267	Overidentifying restrictions not rejected (valid instruments)
Hansen test of overidentifying restrictions	$\chi^2(3)$ = 1.36	0.716	Overidentifying restrictions not rejected (valid instruments)

Additionally, the Sargan and Hansen tests produced *p*-values of 0.267 and 0.716, respectively. The null hypothesis is not rejected by these results, which confirms the overall validity of the instrumental variables and suggests that the model does not suffer from overidentification.

5.4. Analysis of Action Mechanism

This study uses agricultural scientific and technical innovation, agricultural industrialization, and industrial structure as intermediate factors to investigate the distinctive influence mechanism of rural regeneration on agricultural economic growth. A fixed-effects regression model was used for analysis.

Regression research indicates (**Table 6**) that technological innovation, agricultural industrialization, and industrial structure significantly mediate the effect of rural revitalization on agricultural economic gains. Mackinnon et al.[60] calculated the proportion of the intermediary effect based on the path coefficient. The precise calculation procedure is outlined as follows:

$$\text{mediated effect} = \frac{\lambda_2{}^*\beta_1}{\lambda_2{}^*\xi_1 + \lambda_1}$$

Table 6. The findings of the mediation effect study on the economic advantages of rural revival.

	Technological Innovation			**Agricultural Industrialization**			**Industrial Structure**		
	lntov	**Lnstn**	**lntov**	**lntov**	**Lnen**	**lntov**	**lntov**	**Lnis**	**lntov**
lnrevital	1.691***	1.297***	0.907***	1.691***	2.640***	0.639***	1.691***	1.561***	1.391***
	(14.933)	(8.957)	(11.081)	(14.933)	(13.542)	(5.998)	(14.933)	(16.813)	(8.722)
Lnstn			0.604***						
			(20.124)						
Lnen						0.398***			
						(15.592)			
Lnis									0.192**
									(2.636)
lndop	−0.099***	0.056	−0.132***	−0.099***	−0.236***	−0.005	−0.099***	0.018	−0.102***
	(−3.735)	(1.655)	(−7.838)	(−3.735)	(−5.179)	(−0.240)	(−3.735)	(0.833)	(−3.902)
lnfs	−0.655***	−0.715***	−0.223***	−0.655***	−0.442**	−0.479***	−0.655***	0.495***	−0.750***
	(−7.345)	(−6.268)	(−3.681)	(−7.345)	(−2.880)	(−7.256)	(−7.345)	(6.761)	(−7.870)
Lnscl	0.036	0.253**	−0.117**	0.036	−0.046	0.054	0.036	0.121*	0.013
	(0.564)	(3.100)	(−2.827)	(0.564)	(−0.417)	(1.165)	(0.564)	(2.324)	(0.199)
_cons	9.063***	10.716***	2.591***	9.063***	11.548***	4.465***	9.063***	3.193***	8.450***
	(38.982)	(36.045)	(7.319)	(38.982)	(28.846)	(13.124)	(38.982)	(16.752)	(25.846)
N	310	310	310	310	310	310	310	310	310
r2	0.607	0.350	0.841	0.607	0.534	0.792	0.607	0.521	0.616
F	106.055	37.076	290.478	106.055	78.703	208.163	106.055	74.846	88.070

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

According to the calculation method and estimated coefficient in **Table 4**, the proportion of the intermediary effect of agricultural scientific and technical innovation, agricultural industrialization, and industrial structure can be calculated as follows:

$$\text{Mediated effect}_{\text{stn}} = \frac{0.604^*1.297}{0.604^*1.297 + 0.907} \approx 46.34\%$$

$$\text{Mediated effect}_{\text{en}} = \frac{0.398^*2.640}{0.398^*2.640 + 0.639} \approx 62.18\%$$

$$\text{Mediated effect}_{\text{is}} = \frac{0.192^*1.561}{0.192^*1.561 + 1.391} \approx 17.73\%$$

According to the above calculation results, rural revitalization has an indirect impact on agricultural economic growth through agricultural science and technological innovation, agricultural industrialization, and industrial structure adjustment. The intermediary effect of agricultural industrialization accounted for the highest proportion (62.18%), indicating that the impact of rural revitalization on agricultural economic growth was mainly achieved by promoting agricultural industrialization. The mediating effect of agricultural scientific and technical innovation (46.34%) was significant, indicating that this innovation is an important pathway for rural regeneration to promote agricultural economic growth.

The intermediate effect of industrial structure (17.73%) was relatively low. However, it still plays a role,

indicating that enhancing agricultural industrial frameworks can augment the economic advantages of rural rejuvenation. Consequently, the preceding analysis supports the alternative hypotheses H2a, H2b, and H2c.

The cumulative mediation (126.25%) exceeds 100%, which is statistically valid in multiple mediation models and reflects mediator intercorrelations whereby technological innovation facilitates industrialization, which drives structural optimization. When mediators correlate positively, indirect effects compound rather than add. This indicates complementary pathways generating multiplicative benefits, consistent with rural revitalization as an integrated policy triggering reinforcing transformations. Each mediation effect remains statistically valid.

5.5. Regional Heterogeneity Analysis

Regional distribution analysis revealed significant heterogeneity in rural development in China, with the economic impact on agriculture varying from region to region. Therefore, further study of regional differences is essential to promote rural revitalization and to investigate regional heterogeneity. The 31 provinces of China were categorized into four regions: eastern, central, western, and northeast, according to the categorization approach outlined in Section 3.3.1. The forest plot clearly shows the regression coefficient (coef) of this indicator on farmer income in four regions (East, Middle, North, and West) and its 95% confidence interval (CI). If the confidence interval (CI) excludes zero, the effect size is statistically significant.

The results (**Figure 4**) show that this index's impact on farmers' income is significantly different in different regions, demonstrating obvious regional heterogeneity.

5.5.1. The East

The direct consequences of rural revitalization on the total value of agricultural production is 1.06 [0.71, 1.41], which is positive and significant. In the eastern region, even without considering the relevant factors, rural revitalization continues to positively influence overall agricultural production value.

Agricultural technology and science (lnstn) significantly influences the consequences of rural revitalization on the overall agricultural production value. The impact of rural revitalization on the total value of agricultural production was 0.95, while the influence of agricultural technology and science was 0.70, both statistically significant within the 95% confidence interval. This shows that the rural revitalization policy may enhance the advancement of agricultural science and technology, thereby facilitating an increase in overall agricultural production value. However, compared with agricultural industrialization, its role is weaker and may be limited by the efficacy of scientific and technical change as well as its dissemination and implementation.

Agricultural industrialization (lnen) is the primary method of rural revitalization to enhance overall agricultural production value. The consequences of rural revitalization on industrial agriculture were 1.72, and the consequences of agricultural industrialization on the overall agricultural production value were 0.37, both of which were significant within a 95% confidence interval. The rural revitalization initiative in the eastern region largely elevates the agricultural output value by promoting agricultural industrialization.

The modification of industrial structure (lnis) influences the consequences of rural revitalization on overall agricultural production value. The consequence of rural revitalization on industrial structure is 0.99, while the influence of industrial structure on total agricultural production value is 0.38, both statistically significant at the 95% confidence level.

5.5.2. The Middle

The direct consequence of rural revitalization on total agricultural production value is 2.32 and is statistically significant at the 95% confidence level, suggesting that the rural revitalization program positively influences the total value of agricultural production in the middle region.

The consequence of rural revitalization on agricultural industrialization is 4.81, and the effect of industrialization on the total value of agricultural production is 0.20, which is significant. This shows that the central region mainly depends on enhancing agricultural industrialization to increase the overall agricultural production value; however, its driving effect is relatively weak.

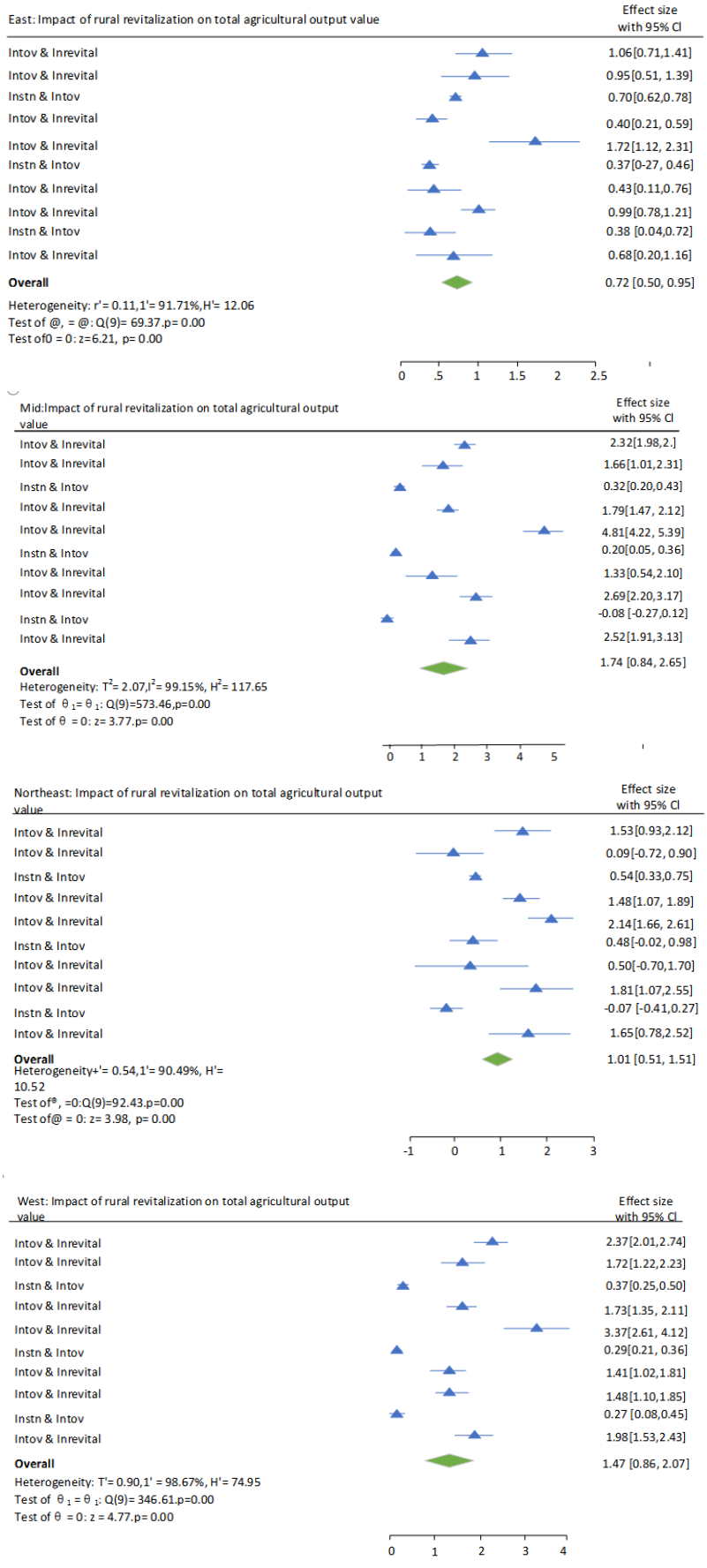

Figure 4. Regional heterogeneity results of rural revitalization on total value of agricultural production.

The consequences of rural revitalization on the industrial structure is 2.69, while the influence of the industrial structure on the total agricultural production value is 2.52, both of which are statistically significant. The rural revitalization program in the central area has successfully facilitated the optimization of industrial structure, enhanced the growth of total agricultural production value, and yielded significant outcomes in the integration of key agricultural sectors with other industries.

The consequence of rural revitalization on agricultural science and technology is 1.66, but the effect of agricultural science and technology on the overall agricultural production value is 0.32, indicating significance but with limitations. This signifies that agricultural science and technology have not fully transformed into the driving force of agricultural economic growth in the central region.

5.5.3. The Northeast

From the perspective of the northeast region, the direct effect of rural revitalization on overall agricultural production value was 1.53. The findings are significant within a 95% confidence interval, suggesting that rural revitalization exerts a positive influence on the total value of agricultural production, independent of high participation factors, such as agricultural science and technology, agricultural industrialization, and industrial structure.

Agricultural industrialization (lnen) is an important channel for rural revitalization, aimed at enhancing overall agricultural production value. The consequence of rural revitalization on agricultural industrialization was 2.14, whereas the influence of agricultural industrialization on the overall agricultural production value was 0.48, both of which were significant within the 95% confidence interval. Rural revitalization in the northeast primarily enhances overall agricultural production value by advancing agricultural industrialization, and its impact surpasses that of the eastern region.

In contrast, the roles of agricultural technology (lnstn) and industrial structure (lnis) are less significant. The impact of agricultural science and technology on the path of rural revitalization on the total value of agricultural production shows an intrinsic effect. The influence of industrial structure modification on the overall agricultural production value is negligible, indicating that agricultural development in northeast China is less reliant on scientific and technical innovation and the enhancement of the industrial structure, and there is room for future incremental improvement.

5.5.4. Western Regions

The total value of agricultural production was substantially positively impacted by rural revitalization, with a direct effect of 2.37. This suggests that the rural revitalization policy in Western China has the potential to stimulate direct agricultural economic development.

The consequences of rural revitalization on agricultural science and technology were 1.72, while the consequences of agricultural science and technology on the total value of agricultural production were 0.37. Both these effects are substantial. This shows that the growth in the total value of agricultural production in rural revitalization has been partially facilitated by agricultural science and technology. However, its driving effect is relatively weak, and the transformation of agricultural scientific and technological achievements needs to be strengthened.

The effect of rural revitalization on agricultural industrialization was 3.37, and the impact of agricultural industrialization on the total value of agricultural production was 0.29, both of which were statistically significant. This shows that agricultural industrialization is a critical method for fostering agricultural economic development and rural revitalization. However, its indirect effect is lower than its direct effect, indicating that agricultural industrialization has constrained agricultural economic growth.

The consequence of rural revitalization on industrial structure is 1.48, and the impact of industrial structure on the total value of agricultural production is 0.27, both of which are significant. This shows that the rural revitalization policy facilitates the enhancement of the industrial structure in the western region and further promotes the growth of the total value of agricultural production. However, the driving effect of industrial structure adjustment creates room for improvement.

Overall, the rural revitalization of each region is positive and significant to the total value of agricultural

production, but the focus is on the impact path. The eastern region mainly relies on agricultural industrialization, while the central region relies on industrial structure optimization. The northeast region has the strongest effect on agricultural industrialization, but the influence of science, technology, and industrial structure is limited. Rural revitalization in the West exerts the most significant direct influence on the overall value of agricultural products. However, the modification of agricultural science, technology, and industrial structures has increased the potential for economic advancement. Therefore, all regions should combine their characteristics, optimize innovation in agricultural science, enhance industrialization, optimize the industrial structure, and facilitate sustainable agricultural growth.

Regional heterogeneity stems from structural differences in fiscal capacity, resource endowments, and industrial bases [61]. Eastern provinces possess stronger fiscal resources and infrastructure enabling rapid industrialization, while western regions face resource constraints and higher transaction costs from terrain dispersion. Eastern processing clusters generate immediate policy effects, whereas western smallholder systems require longer transformation. These disparities necessitate differentiated regional policies.

6. Policy Recommendations and Global Applicability

We acknowledge measurement limitations. Technological innovation uses R&D personnel rather than outputs, underestimating efficiency. Agricultural industrialization uses firm counts rather than value-added, reflecting breadth not intensity. Most critically, industrial structure optimization uses provincial GDP ratios, an economy-wide rather than rural-specific measure, potentially conflating urban-rural dynamics. Results should be interpreted cautiously as aggregated rather than precise rural-specific estimates.

The empirical analysis demonstrates the beneficial effect of rural revitalization on the overall production value of the agricultural and diverse industrial sectors (planting, forestry, animal husbandry, and fishery). Meanwhile, agricultural industrialization, technological innovation, and agricultural industrial structure optimization significantly contribute to rural revitalization initiatives aimed at enhancing agricultural economic growth, informed by the study's findings on overall impacts and regional variability. The subsequent policy proposals aim to augment the rural revitalization strategy's role in fostering agricultural economic growth and refining the regional development model.

6.1. Enhancing the Effectiveness of Rural Revitalization Strategies in Promoting Agricultural Growth

(1) Augmented assistance for technological innovation and promoting the advancement of smart agriculture

The government should augment financial assistance for advancements in agricultural research and technology. Collaboration among scientific research institutes, universities, and agricultural enterprises should be promoted to enhance the research and development of intelligent agricultural technology while advancing agricultural mechanization and digital agriculture through subsidies, tax incentives, and additional policies. Particularly in the eastern region, the implementation of the agricultural Internet of Things, big data, artificial intelligence, and other technologies must be expedited to enhance agricultural production efficiency and resource utilization, thereby establishing a high-value-added agricultural and industrial system.

(2) Enhancing the agricultural supply chain and increasing agricultural industrialization

Given the significant reliance on agricultural industrialization in the central and western areas, the agricultural industry chain necessitates enhancement, alongside the advancement of deep processing of agricultural goods. Cold chain logistics, brand building, and other links should be promoted to enhance the value-added of agricultural goods. Simultaneously, we will encourage leading enterprises and cooperatives to drive small farmers to participate in agricultural industrialization, enhance market competitiveness, form a stable supply system for agricultural products, and raise farmers' income.

(3) Improve regional agricultural infrastructure

and mitigate urban-rural and regional inequalities

The government ought to augment investment in agricultural infrastructure in the central and western areas, enhance essential amenities,including farmland water conservancy, road transportation, warehousing, and logistics, and improve agricultural production conditions and market circulation efficiency. Furthermore, we must improve the growth of the rural financial services sector, increase finance accessibility for farmers and agricultural companies, facilitate the advancement of the agriculture industry, and narrow the regional development gap.

(4) Promote rural revitalization according to local conditions and develop differentiated development strategies

Strategies for rural revival and development should be tailored to the resource endowment and economic basis of various regions. In the eastern area, we must prioritize the advancement of smart agriculture and technological innovation to enhance the competitiveness of modern agriculture. In the central and western areas, industrial integration must be fundamental, fostering the synchronized advancement of agriculture alongside processing,tourism, e-commerce, and other industries; building a diversified rural economic system; and achieving sustainable agricultural development.

(5) Strengthen the training of agricultural personnel and improve the quality and skills of farmers

The advancement of agricultural modernization is inextricably linked to the assistance of highly skilled individuals. The government ought to strengthen agricultural vocational education and skill training to improve farmers' ability to apply new technologies and new equipment.Young talents and college graduates should be encouraged to devote themselves to agriculture, promote the specialization of agricultural business subjects, improve agricultural production efficiency and innovation ability, and provide long-term talent security for rural revitalization.

6.2. Applicability and Transferability to Global South Contexts

China's rural revitalization strategy offers an applicable model for Global South nations. Through coordinated integration of industry, technology, and institutional capacity, China has overcome challenges common to fragmented rural development. The synergistic effects observed parallel ongoing initiatives: Africa's agricultural corridors (Ethiopia's Agricultural Growth Program, Tanzania's SAGCOT) emphasize similar infrastructure and value chain integration, while India's rural clusters (Gujarat dairy cooperatives, Maharashtra horticulture) mirror the industrialization mechanisms identified. Regional heterogeneity findings reveal that resource-constrained regions require differentiated policy intensities. Integrated strategies yield multiplicative benefits when tailored to local endowments.

6.2.1. Lessons from the Chinese Experience

For agricultural-based economies in Africa, Southeast Asia, and Latin America—regions often characterized by significant urban-rural disparities—the Chinese rural revitalization experience offers several practical insights:

(1) Agricultural industrial upgrades China's emphasis on agricultural processing, logistics infrastructure, and branding has successfully increased the value-added potential of its agricultural products. This offers a viable roadmap for countries reliant on primary product exports to enhance their agricultural value chains and diversify their rural economies.

(2) Digital and Precision Agriculture. The adoption of digital technologies including precision farming illustrates the transformative role of technological innovation in improving productivity and resource efficiency. These practices can serve as models for countries such as India, Brazil, and Kenya, where the modernization of agricultural practices is a priority.

(3) Integrated Rural Development Strategies. China's regionally tailored rural revitalization programs promote balanced territorial development and facilitate the integration of urban and rural areas. This approach is particularly relevant for Latin American countries facing pronounced urban-rural development gaps, providing a reference for achieving inclusive rural growth.

6.2.2. Policy Recommendations for Developing Countries in the Global South

Building on China's rural revitalization practices, the following policy recommendations are proposed for developing countries:

(1) Localization of rural revitalization frameworks: Countries in the global south should develop rural revitalization strategies tailored to their specific agricultural conditions and resource bases. Drawing on China' s experience, China should integrate policy instruments for industrial upgrading, technological innovation, and institutional reform. Participation in multilateral initiatives, including the Belt and Road Initiative, could facilitate access to Chinese expertise in agricultural facilities, smart farming, and agro-industrial development.

(2) Establishing Collaborative and Inclusive Rural Governance Systems. Inspired by China' s rural governance mechanisms, developing countries should promote inclusive governance models that encourage the participation of cooperatives, farmer organizations, and non-governmental organizations (NGOs). Such models can enhance community self-governance and promote transparency and accountability in rural development programmes. Coordinated efforts among governments, private enterprises, and civil society are essential for improving the infrastructure and public services in rural areas.

(3) Expanding access to rural financial services: Building on China' s experience with inclusive and digital finance, Global South countries should enhance rural financial infrastructure to support smallholder farmers and rural enterprises. The promotion of micro-credit schemes, agricultural insurance, and risk-sharing mechanisms can alleviate financing barriers. Digital financial technologies can extend financial services to remote and under-served rural communities, facilitating greater involvement in contemporary agricultural value chains.

Although this analysis is written in an economic and technological context, its implementation at a grassroots level needs social aspects as well [62]. Future studies should aim to include social aspects in their research so that comprehensive advice is provided [63].

In addition to the issues of measurements explained above, this research also has limitations in methodology and its scope. In fact, System GMM corrects endogeneity issues, but it does not control for possible unobservable variables that may affect research results, such as overall implementation quality in regions. Also, it is not possible to examine long-term sustainability within the 2012 to 2021 period, while pooling provinces obscures heterogeneity in regions. Despite these limitations, the findings provide robust evidence for integrated rural development strategies and offer transferable insights for agricultural modernization in developing economies.

Author Contributions

Conceptualization, H.-O.Y. and N.M.b.A.M.; methodology, H.-O.Y. and N.M.b.A.M.; formal analysis, H.-O.Y.; investigation, H.-O.Y.; data curation, H.-O.Y.; writing—original draft preparation, H.-O.Y.; writing—review and editing, N.M.b.A.M.; visualization, H.-O.Y. and N.M.b.A.M.; supervision, N.M.b.A.M.; validation, N.M.b.A.M. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent Statement

Not applicable.

Data Availability Statement

Data are available from the National Bureau of Statistics of China at http://www.stats.gov.cn/. The processed dataset is available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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