New quality productivity and high-quality agricultural development: Coupling and coordinating space-time analysis and policy effect evaluation

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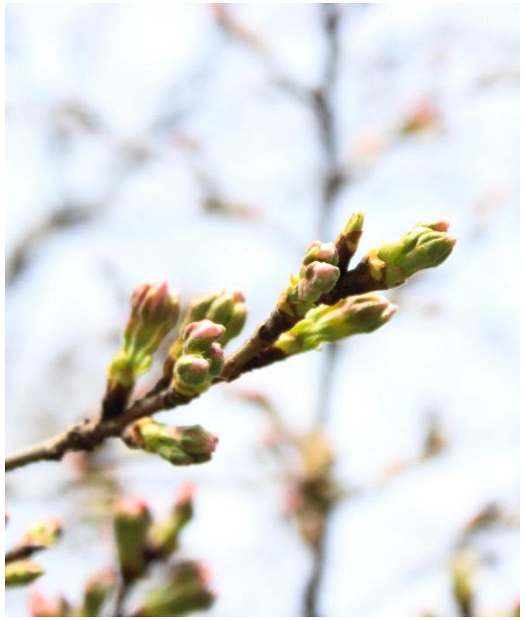


1. Introduction

1.1 Research background

1.High-quality agricultural development: The report of the 20th National Congress of the Communist Party of China states that accelerating the building of a strong agricultural country and promoting high-quality agricultural development are the core tasks for ensuring food security, rural revitalization, and modernization.

2. Practical challenges: Intensified constraints of resources and the environment, widening regional development gaps, and insufficient industrial competitiveness pose severe challenges to the transformation and upgrading of agriculture.

3. New quality Productivity: Centered on technological innovation, green transformation and digital empowerment, it provides a brand-new source of power and injects new impetus into the high-quality development of agriculture.

4. Coupling and Coordination: The coupling and coordination relationship between new quality productivity and high-quality agricultural development is the key to promoting agricultural modernization, optimizing the industrial structure, and facilitating coordinated regional development.

1.2 Literature review

1. Research on new quality productivity

Lu Jiang and Guo Ziang (2024) proposed a new qualitative productivity assessment method quantified from three dimensions: technology, green, and digital, which has been widely recognized. Han Wenlong and Zhang Ruisheng (2024) further enriched the measurement framework of new quality productivity from the perspective of substantive and permeable elements. New quality productivity emphasizes enhancing the efficiency of agricultural development through technological innovation, green transformation and digital empowerment, and it is the core driving force for promoting high-quality agricultural development.

1.2 Literature review

2. Research Progress on High-Quality Agricultural Development

High-quality agricultural development aims to enhance agricultural efficiency and sustainability and meet the demands of food security and ecological protection. Liu Zhongyu et al. (2021) constructed an evaluation system covering five dimensions including innovation, coordination and green development, and adopted the entropy weight method to avoid subjective bias. Huang Xiujie et al. (2024) analyzed multiple dimensions including product quality, industrial benefits, and production efficiency, and depicted the current situation and challenges of high-quality agricultural development in China. Wang Shangao (2024) evaluated the green total factor productivity of agriculture through the DEA method and proposed a new perspective for quantifying the high-quality development of agriculture.

1.2 Literature commentary

3.Research on the Coupling and Coordination of New Quality Productivity and High-Quality Agricultural Development

Most of the existing literature focuses on the analysis of a single dimension or a certain field, lacking quantitative research on the coupling and coordination of the two. Furthermore, the significant differences in the development levels of various regions and the underlying obstructive factors have not been fully explored, which has imposed certain limitations on policy-making and the optimal allocation of resources.

This paper constructs a new quality productivity assessment framework covering three dimensions: technology, green, and digital. Then, it measures the coupling coordination degree of the two and combines spatial analysis methods to reveal their spatio-temporal evolution characteristics, providing new theoretical support for the high-quality development of agriculture in China.

1.3 Significance of research

1.Theoretical value:

The systematic analysis of the coupling and coordination relationship between new quality productivity and high-quality agricultural development has enriched the research in related fields.

Provide the mechanism of the role of new quality productivity in the high-quality development of agriculture and offer a new theoretical framework.

2. Application Value:

Reveal the spatio-temporal evolution characteristics between new quality productive forces and high-quality agricultural development, and provide quantitative basis for policy-making.

Analyze regional differences and the main constraints to provide theoretical support for promoting the coordinated development of various regions.

2. Research and design

2.1 Construction of the evaluation index system

Table 1 Evaluation Index System of New-quality Productivity

Primary index	Secondary index	Three-level index	Index interpretation	character
Scientific and technological productivity	Innovation productivity(W1)	Innovative R&D	Number of domestic patents granted	+
		Innovative industry	High-tech industry business income (ten thousand yuan)	+
		Innovative product	Industrial innovation funds for industrial enterprises (ten thousand yuan)	+
	Technological productivity(W2)	Technology research and development	Full-time equivalent of R&D personnel in industrial enterprises (h)	+
Green productivity	Resource-saving productivity(W3)	Energy intensity	Energy consumption/GDP (%)	−
		Water use intensity	Industrial Water consumption/GDP (%)	−
	Environmentally friendly productivity(W4)	Waste utilization	Comprehensive utilization of industrial solid waste/production (%)	+
		Waste water discharge	Industrial Wastewater Discharge/GDP (%)	−
		Exhaust emission	Industrial SO2 emissions/GDP (%)	−
Digital productivity	Digital industry productivity(W5)	Electronic information manufacturing	Integrated circuit output (10,000)	+
		Telecommunication service communication	Total telecommunications business (ten thousand yuan)	+
		Internet penetration rate	Number of Internet broadband access ports (PCS)	+
	Industry figure productivity(W6)	Software service	Software revenue (people)	+
		Digital information	Cable length/Area (m)	+
		Electronic commerce	E-commerce sales (ten thousand yuan)	+

1.Evaluation index system of new quality productivity

Referring to the measurement of new quality productivity from three dimensions of scientific and technological productivity, green productivity and digital productivity proposed by Lu Jiang et al. (2024), an evaluation index system of new quality productivity was constructed.

Three first-level indicators
Six secondary indicators
Sixteen third-level indicators

2.Evaluation index system for High-Quality agricultural development

Drawing on the relevant research of Liu Zhongyu et al. (2021), an evaluation index system for high-quality agricultural development was constructed from five dimensions: the level of innovative development, the level of coordinated development, the level of green development, the level of open development, and the level of shared development.

5 first-level indicators

11 secondary indicators

28 third-level indicators

Table 2. Evaluation index system of agricultural high-quality development

Primary index	Secondary index	Three-level index	Index interpretation	character
Innovative development	Fundamentals of Innovation (W7)	Level of agricultural mechanization	Total power of agricultural machinery (10,000 kW)	+
		The proportion of agricultural financial input	Fiscal expenditure on agriculture, forestry and water conservancy	+
		The proportion of leisure agriculture demonstration counties	Total number of leisure agriculture demonstration counties/regions	+
		The proportion of typical rural entrepreneurship and innovation counties	Total number of typical counties/regions in rural entrepreneurship and innovation	+
		Labor productivity	Total output value of agriculture, forestry, animal husbandry and fishery/Number of employees in the primary industry	+
	Innovation Benefits (W8)	Land productivity	Total agricultural output value/planted area of crops	+
		Number of green food certifications	Number of green food certifications	+
		Grain yield per unit area (tons)	Grain production/grain sown area	+
		Effective irrigated area	Effective irrigated area (thousand hectares)	+
Coordinated development	Industrial Coordination (W9)	Agricultural industrial structure adjustment index	1- (Agricultural output value/Total output value of agriculture, forestry, animal husbandry and fishery)	+
	Urban and Rural Coordination (W10)	Binary correlation coefficient	Comparative labor productivity of primary industry/Comparative labor productivity of secondary and tertiary industry	+
Green development	Resource Consumption (W11)	Amount of agricultural film used per unit area	Agricultural film usage/sown area	-
		Use intensity of agricultural diesel oil	Amount of agricultural diesel oil/planted area	-
		Per capita electricity consumption	Rural electricity consumption (10,000 KWH)/ Rural population (10,000)	-
	Environmental Pollution (W12)	Fertilizer application per unit area	Fertilizer use (tons)/ Total planted area of crops (thousand hectares)	-
		Pesticide application per unit area	Pesticide use (tons)/ Total sown area of crops (thousand hectares)	-
	Environmental Protection (W13)	Forest coverage rate	Forest coverage (%)	+
Open development	Resource Optimization (W14)	Rural land transfer rate	The area of cultivated land contracted by households and the total area of circulation/sown area	+
		Proportion of investment in fixed assets in agriculture	The completed investment in fixed assets of rural households is 100 million yuan/output value of primary production	+
	Market Optimization (W15)	Proportion of market turnover of agricultural products	Market turnover of agricultural products/output value of primary production	+
		Dependence on import and export of agricultural products	Total imports and exports of agricultural products/Gross product	+
		Leading enterprises drive efficiency	Leading enterprises/rural population	+
Shared development	Standard of Living (W16)	Income level of rural residents	Per capita disposable income of rural residents	+
		Overall wealth level of rural residents	Rural Engel coefficient	-
		The life richness of rural residents	Per capita expenditure on education, culture and entertainment/per capita consumption expenditure	+
		Expenditure on medical and health care for rural residents	Health care expenditure per capita/consumer expenditure per capita	+
	Benefit Sharing (W17)	The proportion of rural residents receiving minimum living allowances	The proportion of rural residents receiving minimum living allowances	-
		Urban-rural income ratio	Urban disposable income/rural disposable income	-
		Ratio of urban and rural consumption level	Per capita consumption expenditure of urban residents/per capita consumption expenditure of rural residents	-
		Urban-rural consumption gap	Retail sales of consumer goods in towns and villages/Retail sales of consumer goods in the whole society	+

3. Entropy power law

The objective weighting method based on the information entropy theory determines the weight of each index by calculating the dispersion degree of each index, thereby avoiding the deviation of subjective weighting.

(1)The following is the calculation process of the entropy weight method:

$$x_{ij}=\frac{r_{ij}-\min_j r_{ij}}{\max_j r_{ij}-\min_j r_{ij}}$$

r_{ij} It is the original data of the i-th item under the j-th indicator, x_{ij} is the standardized value of the j-th object on the i-th indicator. If =0, it is replaced with 0.00001. m is the total number of evaluation objects, and n is the total number of evaluation indicators.

(2) Calculate the proportion of the indicators: For the i-th indicator, its proportion in the JTH evaluation object p_{ij} is calculated by the following formula:

$$p_{ij}=\frac{x_{ij}}{\sum_{k=1}^{m}x_{ik}}$$

（3）Calculate the entropy value: The entropy value ei of the i-th index is calculated by the following formula:

$$e_i = -\frac{1}{\ln m}\sum_{j=1}^{m} p_{ij} \ln(p_{ij})$$

（4）Calculate the coefficient of difference: The coefficient of difference gi for the i-th indicator is calculated by the following formula. The smaller the entropy value, the greater the coefficient of difference, indicating that the degree of variation of this indicator is greater.

$$g_i = 1 - e_i$$

（5）Calculate the weight: The weight wi of the i-th indicator is determined by the coefficient of difference of all indicators:：

$$w_i = \frac{g_i}{\sum_{i=1}^{n} g_i}$$

2.2 Coupling coordination degree model

1.Coupling coordination degree Model: To explore the interrelationship and influence between new quality productivity and high-quality agricultural development, we adopted the coupling coordination degree model for quantitative analysis. The specific calculation formula is as follows:

$$C = 2 \times \left\{ \frac{f(x) \times g(x)}{[f(x) + g(x)]^2} \right\}^{\frac{1}{2}}$$

$$T = \alpha \times f(x) + \beta \times g(x)$$

$$D = \sqrt{C \times T}$$

Among them: C represents the coupling degree; T is the comprehensive coordination index; D represents the coupling coordination degree; f (x) and g (x) respectively represent the scores of new quality productivity and high-quality agricultural development. The larger the value, the higher the corresponding degree of development. α and β are undetermined weights, reflecting the influence coefficients of new quality productivity and high-quality agricultural development. Assuming that new quality productivity and high-quality agricultural development are equally important, let α=β=0.5

2. Coupling coordination degree classification: It is divided into 10 types according to the magnitude of coupling coordination degree. The classification criteria are shown in Table 3.

Table 3 Coupling order corresponding to coupling coordination degree

D-value	phase	D-value	phase
[0.0,0.1)	Extremely dysfunctional recession	[0.5,0.6)	Grudgingly coordinated development
[0.1,0.2)	Severe dysfunctional recession	[0.6,0.7)	Primary coordinated development
[0.2,0.3)	Moderate dysplasia	[0.7,0.8)	Intermediate coordinated development
[0.3,0.4)	Mild dysplasia	[0.8,0.9)	Sound and coordinated development
[0.4,0.5)	Near dysfunctional recession	[0.9,1.0]	High-quality and coordinated development

2.3 Nuclear density estimation

1. Principle of kernel density estimation: Given a set of sample data, the density estimation function of kernel density estimation $f_h(x)$ is usually expressed as:

$$f_h(x) = \frac{1}{n}\sum_{i=1}^{n} K_h(x - x_i)$$

Among them, h is the bandwidth parameter (also known as the smoothing parameter), which determines the width and smoothness of the kernel function.

2. The core idea is: to expand each data point into a small density peak through a smooth kernel function (usually a symmetrical and non-negative function, such as the Gaussian function), and then superimpose the density peaks of all data points to obtain the overall density estimation.

2.4 Moran Index

Moran's I: In this study, the Global Moran's I was used to measure the spatial correlation degree of the coupling coordination between new quality productivity and high-quality agricultural development. The calculation formula of the global Moran index is as follows:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{s^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}$$

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})}{n}$$

2.5 Analysis of obstacle factors

Obstacle factor analysis: To effectively promote the coupled and coordinated development between the two, the obstacle degree model can be utilized to identify and diagnose the obstacle factors that affect their coupled and coordinated development. The obstacle degree model is as follows:

$$I_{ij} = 1 - Y_{ij}$$

$$h_j = \left(\frac{F_j I_{ij}}{\sum_{j=1}^{m} F_j I_{ij}} \right) \times 100\%$$

$$H_j = \sum h_j$$

2.6 Dual machine learning model

This paper adopts a dual machine learning model to evaluate the effect of rural revitalization policies on the growth of the coupling coordination degree between new quality productivity and high-quality agricultural development. Firstly, we constructed a partially linear dual machine learning model, aiming to reduce the complexity of the model and improve the prediction accuracy.

$$Y = g_0(D,X) + U$$
$$D = m_0(X) + V$$

Among them, Y is the explained variable, D is the treatment variable, which is a dummy variable with a value of 0 or 1, X is the covariate, g(x) and m(x) are functions of unknown form, and U and V are perturbation terms. The model assumption is: $E(U|D,X) = 0, E(V|X) = 0$. The covariate X influences the treatment variable D by the propensity score m(x).

2.6 Data source

1. Data source: The original data are derived from the annual "China Statistical Yearbook", "China Education Expenditure Statistical Yearbook", "China Environmental Statistical Yearbook", "China Electronic Information Industry Statistical Yearbook", "China Rural Statistical Yearbook", "China Science and Technology Yearbook", "China Agricultural Statistical Yearbook", "China Tertiary Industry Statistical Yearbook", as well as statistical yearbooks of various provinces and cities and environmental bulletins, etc. A small amount of missing data is filled by interpolation.

2. Data Scope: Given the availability of data, this paper takes 30 provinces in China (excluding Tibet, Hong Kong, Macao and Taiwan regions for the time being) as the research sample, and the research period is from 2010 to 2022.

3. Empirical analysis

3.1 Coupling coordination

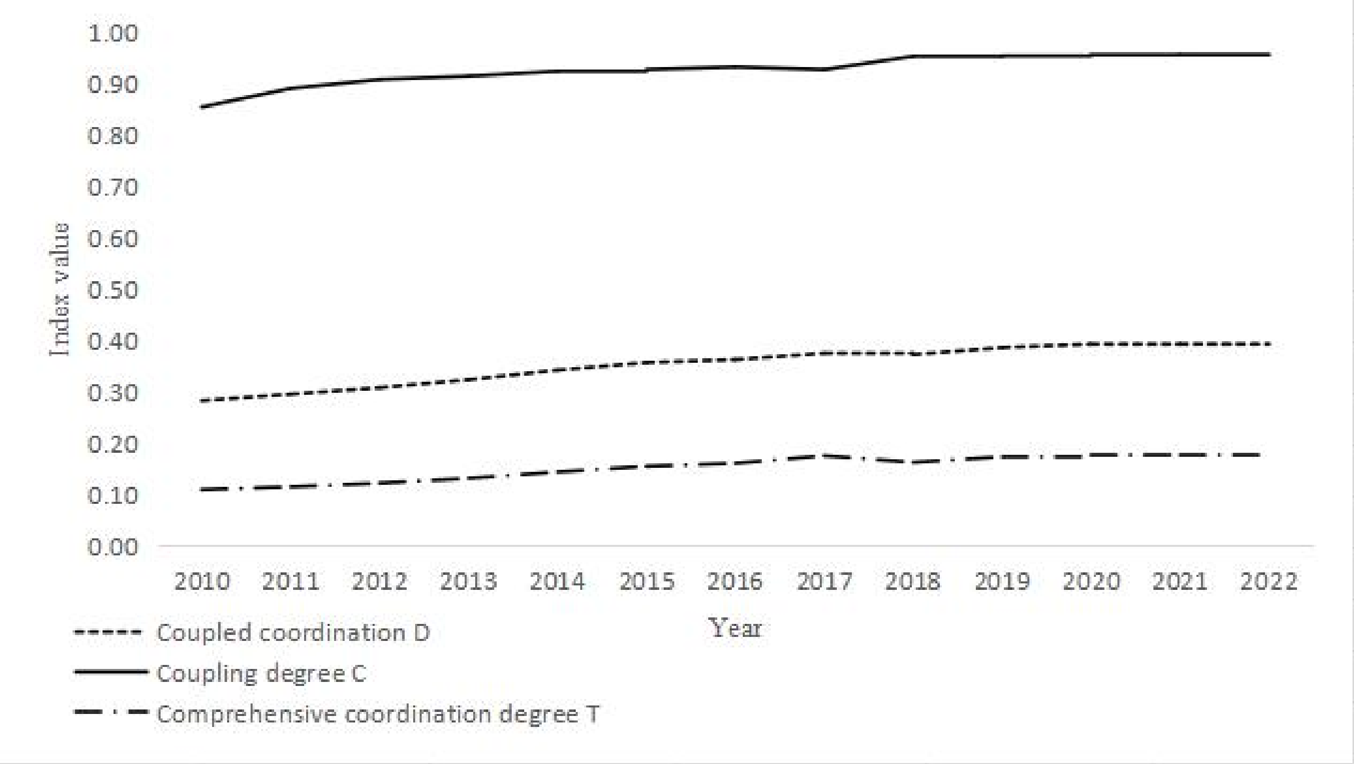
Table 4 Coupling coordination degree

region	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Beijing	0. 39	0. 40	0. 43	0. 44	0. 45	0. 46	0. 48	0. 50	0. 53	0. 57	0. 58	0. 61	0. 63
Tianjin	0. 31	0. 32	0. 33	0. 34	0. 35	0. 36	0. 36	0. 36	0. 39	0. 42	0. 44	0. 45	0. 46
Hebei	0. 32	0. 32	0. 32	0. 34	0. 34	0. 36	0. 36	0. 38	0. 40	0. 42	0. 44	0. 43	0. 45
Shanxi	0. 26	0. 26	0. 27	0. 28	0. 28	0. 28	0. 28	0. 29	0. 31	0. 33	0. 34	0. 34	0. 35
Inner Mongolia	0. 25	0. 25	0. 25	0. 27	0. 28	0. 29	0. 29	0. 29	0. 31	0. 33	0. 34	0. 33	0. 35
Liaoning	0. 31	0. 31	0. 32	0. 34	0. 35	0. 35	0. 36	0. 36	0. 38	0. 39	0. 40	0. 40	0. 41
Ji Lin	0. 28	0. 28	0. 29	0. 30	0. 30	0. 31	0. 31	0. 33	0. 32	0. 34	0. 35	0. 35	0. 37
Heilongjiang	0. 31	0. 31	0. 32	0. 33	0. 33	0. 34	0. 34	0. 34	0. 35	0. 37	0. 38	0. 37	0. 37
Shanghai	0. 38	0. 39	0. 41	0. 42	0. 45	0. 46	0. 47	0. 49	0. 53	0. 55	0. 57	0. 60	0. 63
Jiangsu	0. 43	0. 45	0. 47	0. 48	0. 49	0. 51	0. 52	0. 54	0. 56	0. 59	0. 62	0. 65	0. 67
Zhejiang	0. 38	0. 39	0. 41	0. 42	0. 43	0. 45	0. 46	0. 47	0. 50	0. 54	0. 56	0. 57	0. 59
Anhui	0. 30	0. 31	0. 32	0. 34	0. 35	0. 36	0. 37	0. 39	0. 41	0. 43	0. 45	0. 45	0. 47
Fujian	0. 32	0. 32	0. 34	0. 35	0. 36	0. 37	0. 38	0. 39	0. 42	0. 43	0. 44	0. 46	0. 47
Jiangxi	0. 28	0. 28	0. 29	0. 29	0. 30	0. 32	0. 32	0. 34	0. 36	0. 38	0. 40	0. 39	0. 40
Shandong	0. 40	0. 41	0. 43	0. 45	0. 45	0. 47	0. 47	0. 49	0. 51	0. 52	0. 54	0. 55	0. 57
Henan	0. 33	0. 33	0. 34	0. 36	0. 37	0. 39	0. 39	0. 40	0. 42	0. 44	0. 46	0. 46	0. 47
Hubei	0. 30	0. 31	0. 32	0. 34	0. 35	0. 36	0. 37	0. 38	0. 40	0. 42	0. 43	0. 44	0. 46
Hunan	0. 30	0. 30	0. 31	0. 33	0. 34	0. 35	0. 36	0. 37	0. 40	0. 42	0. 44	0. 44	0. 46
Kwangtung	0. 40	0. 41	0. 43	0. 45	0. 46	0. 48	0. 49	0. 51	0. 55	0. 57	0. 60	0. 61	0. 63
Guangxi	0. 26	0. 26	0. 28	0. 29	0. 30	0. 31	0. 31	0. 32	0. 34	0. 37	0. 39	0. 37	0. 39
Hainan	0. 26	0. 26	0. 26	0. 27	0. 28	0. 29	0. 30	0. 30	0. 31	0. 33	0. 34	0. 35	0. 36
Chongqing	0. 28	0. 29	0. 29	0. 31	0. 32	0. 33	0. 34	0. 35	0. 37	0. 39	0. 42	0. 42	0. 44
Sichuan	0. 30	0. 30	0. 32	0. 33	0. 34	0. 35	0. 36	0. 38	0. 41	0. 43	0. 45	0. 44	0. 45
Guizhou	0. 21	0. 22	0. 24	0. 25	0. 26	0. 28	0. 29	0. 30	0. 32	0. 34	0. 36	0. 34	0. 35
Yunnan	0. 26	0. 27	0. 28	0. 29	0. 31	0. 32	0. 33	0. 34	0. 36	0. 39	0. 40	0. 39	0. 40
Shaanxi	0. 28	0. 28	0. 29	0. 31	0. 31	0. 32	0. 33	0. 33	0. 35	0. 38	0. 40	0. 39	0. 40
Gansu	0. 24	0. 24	0. 25	0. 27	0. 28	0. 29	0. 30	0. 32	0. 34	0. 36	0. 38	0. 40	0. 40
Qinghai	0. 18	0. 19	0. 20	0. 20	0. 21	0. 21	0. 23	0. 23	0. 24	0. 26	0. 26	0. 26	0. 27
Ningxia	0. 20	0. 20	0. 22	0. 23	0. 24	0. 24	0. 24	0. 24	0. 26	0. 29	0. 32	0. 32	0. 34
Xinjiang	0. 24	0. 24	0. 25	0. 26	0. 26	0. 27	0. 27	0. 28	0. 30	0. 32	0. 33	0. 32	0. 33

1. From the perspective of time, the coupling and coordination of each province has improved.

2. The speed of improvement is not balanced, and many provinces are still in a medium level of coupling and coordination.

3. Regional differences are manifested in the relatively high coupling and coordination between the eastern and coastal areas, while the coupling and coordination between the western and inland areas is relatively low.



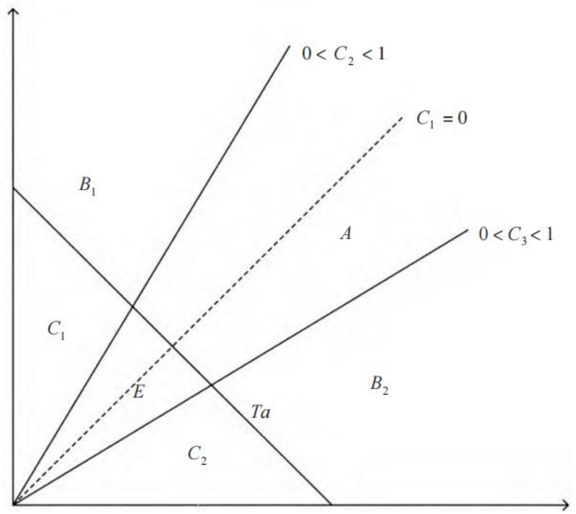
1. Coupling coordination Dimension The value is steadily rising, and the whole is gradually improving.

2. Coupling degree Centigrade The large value and steady improvement indicate the new quality productivity. - The deviation between the high-quality development of agriculture is relatively small.

3. Degree of coordination T The value is small and the growth is slow, and the overall coordination is relatively low.

3.2 Changes in coupling types

According to the calculation formula and model of coupling coordination, we Right Provinces have been classified. The dotted line represents the ideal state of coupling, the ray represents the average coupling of all cities, and the solid line with a negative slope represents the average coordination of all cities. Cities are divided into four categories: high coupling and coordination. A Type, with low coordination but high coupling E Type, low coupling but high coordination B. Type, and the degree of coupling and coordination is low Centigrade Type. B. Type and Centigrade Type cities are further distinguished according to the relative size of new productivity and high-quality agricultural development.

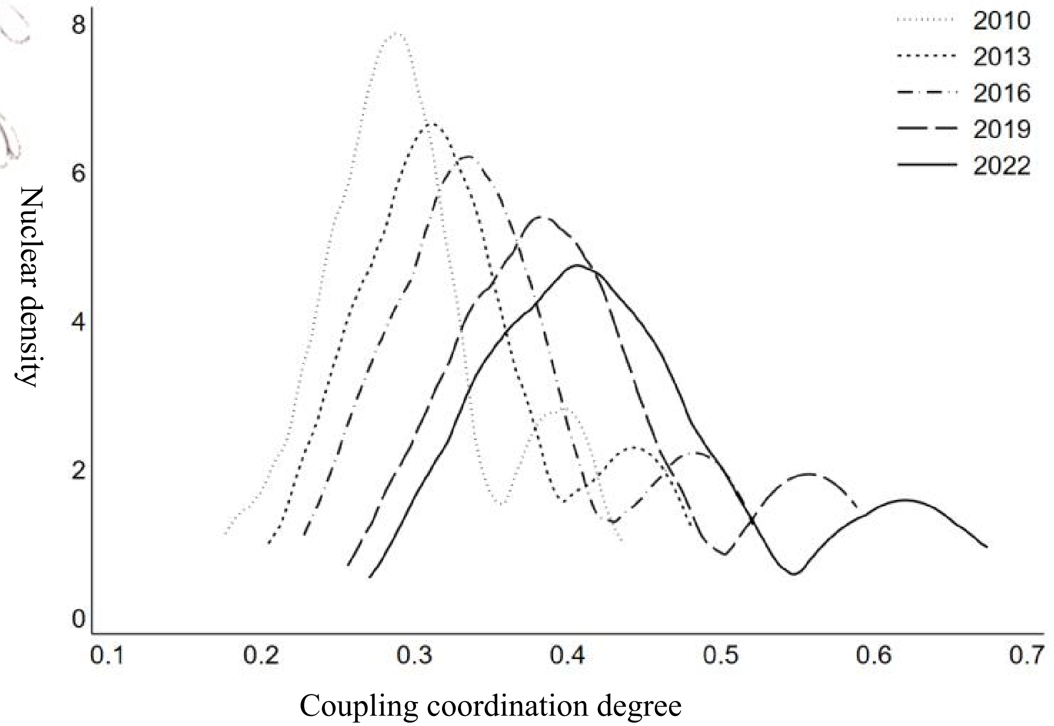


The classification results are shown in the table. Five As shown.

Table 5 Number of cities with different regional coupling types (unit: unit)

Type	Coupling type	The year 2010	The year 2022
A	Double height type	0	11
B_1	Low coordination degree and high development degree of agriculture high-quality development lag type	6	3
B_2	Low coordination degree high development degree new quality productivity lag type	1	0
C_1	Double low agricultural high-quality development lag type	12	3
C_2	Double low quality productivity lag type	1	1
E	Low development degree high coordination degree type	10	12

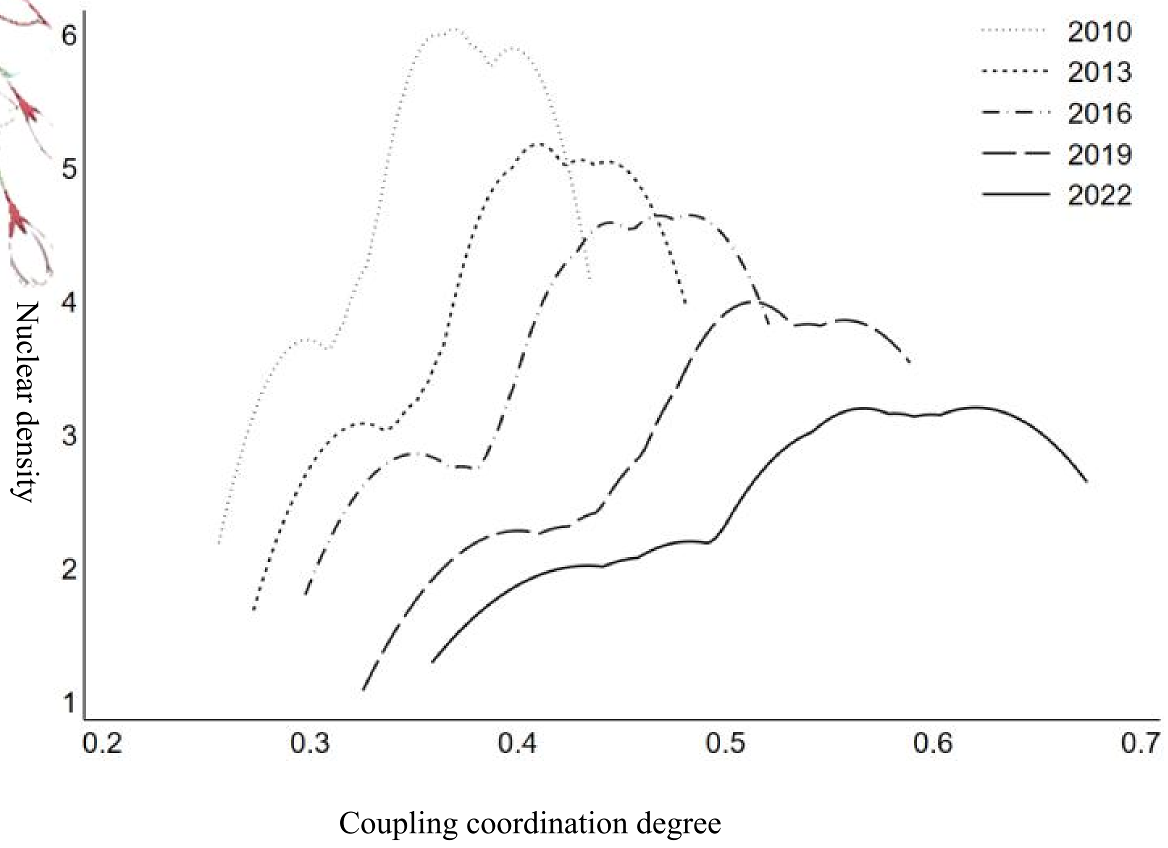
3.3 New quality productivity - Nuclear density distribution of agricultural high-quality development coupling and coordination



Whole country

1.The overall coupling coordination degree across the country shows an upward trend.

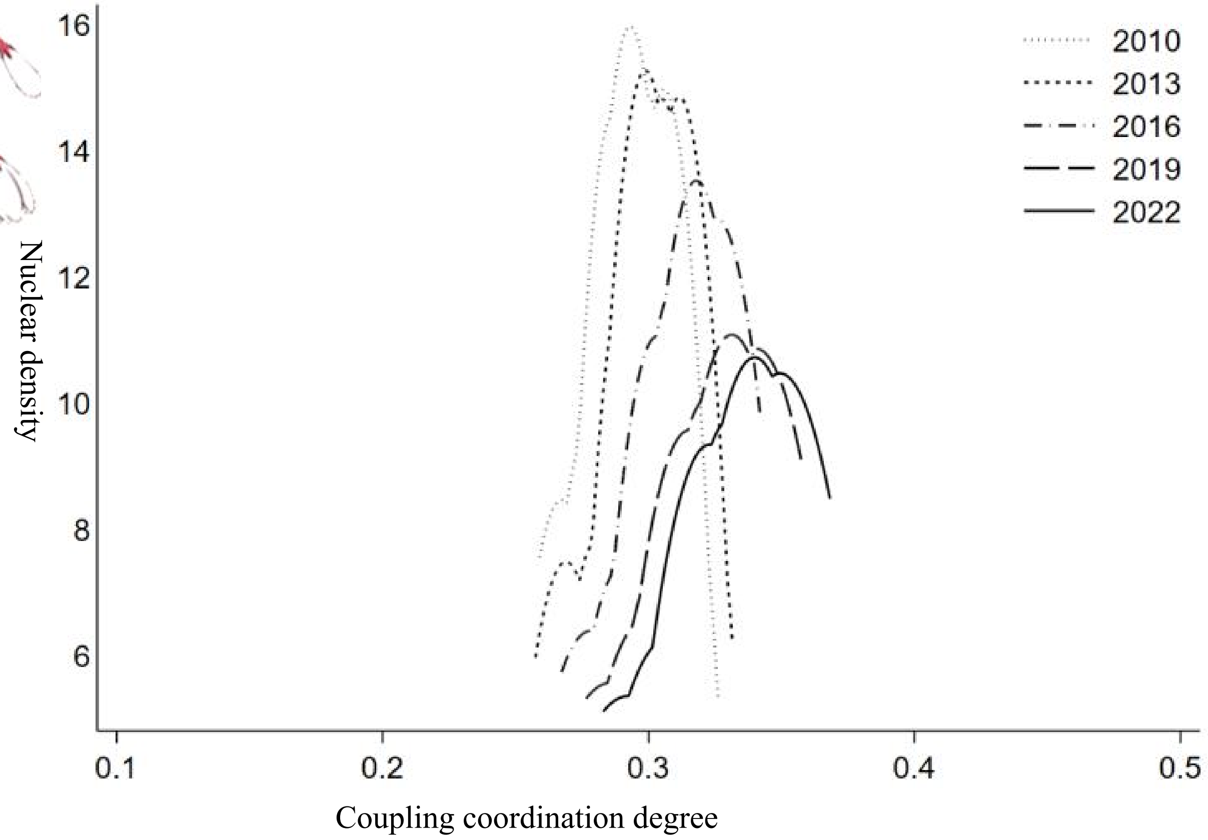
2. The rapid development or high concentration of resources in advanced regions indicates a significant disparity in regional distribution



Eastern part

1. The development of provinces with high coupling and coordination is deviating from the average level, and the polarization phenomenon has increased.

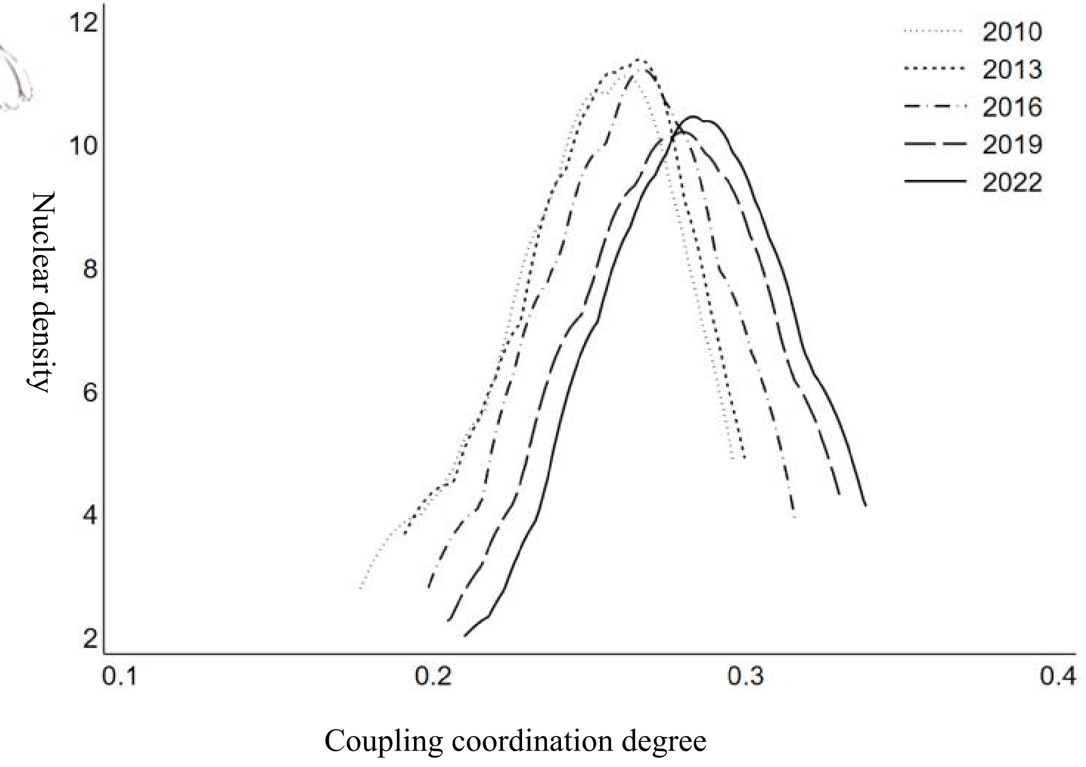
2. The degree of concentration is not high, but the overall level of coupling coordination is higher.



Central section

1. The coordination in most areas is relatively concentrated, indicating that the coordinated development is relatively balanced.

2. The overall coupling and coordination lags behind that of the whole country and the east.



Western part

1. The distribution of coupling coordination is concentrated, and most regions develop more evenly in these years.

2. The overall degree of coupling and coordination lags behind that of the whole country, the east and the central region.

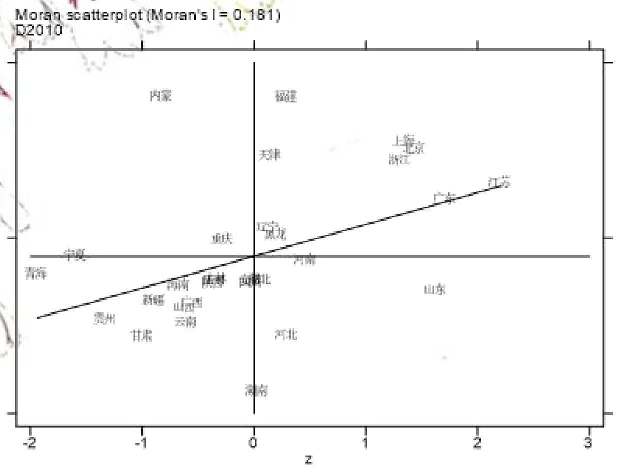
3.4 Spatial self-correlation analysis

Table 6 Moran index of coupling coordination degree of new quality productivity-agricultural high-quality development from 2010 to 2022

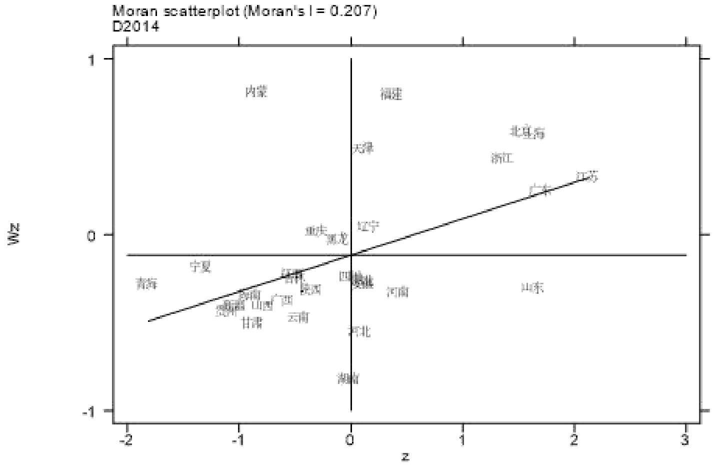
Year	I_1	I_2
2010	0.178**	0.120***
2011	0.193***	0.120***
2012	0.195***	0.116***
2013	0.192***	0.113***
2014	0.205***	0.117***
2015	0.188***	0.114***
2016	0.189***	0.108***
2017	0.171**	0.098***
2018	0.187**	0.103***
2019	0.194***	0.102***
2020	0.181**	0.102***
2021	0.202***	0.100***
2022	0.206***	0.103***

Note: *, **, *** indicate significance at the 10%, 5%, and 1% levels, respectively, the same below.

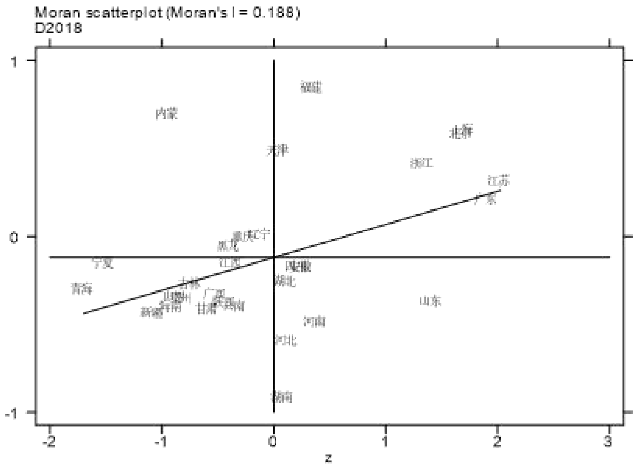
Weight W1 is the reciprocal of the GDP difference, and weight W2 is the reciprocal of the distance. Both the I1 value and the I2 value are positive and have passed the significance test, indicating that the coupling coordination degree shows a positive spatial correlation as a whole, and there is an agglomeration effect among adjacent provinces.



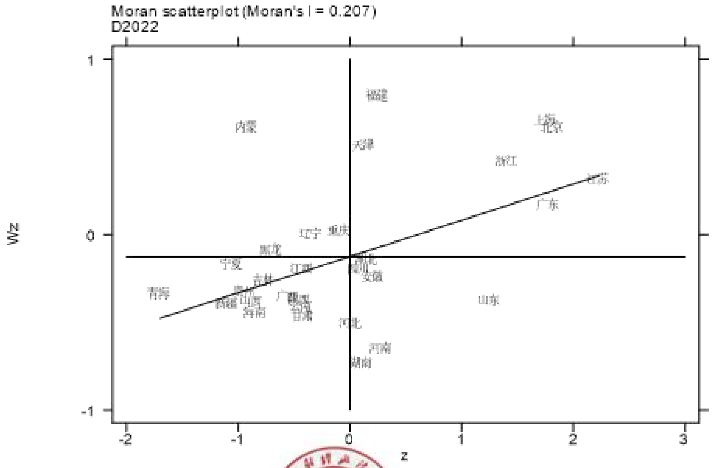
2010



2014



2018



2022

1.Overall, the number of provinces in the first and third quadrants is greater than that in the second and fourth quadrants, indicating a relatively high spatial positive correlation in the distribution of the coupling coordination degree between China's new quality productivity and high-quality agricultural development.

2. More provinces have moved away from the "low-low" agglomeration areas, and new quality productive forces and high-quality agriculture have developed, which has improved the situation of "low-low" agglomeration.

3.5 Analysis of obstacle factors

Follow 2010 Year to 2022 In the year, the main obstacles affecting the coupling and coordination of new qualitative productivity and agricultural high-quality development include industrial digital productivity (W4), innovative productivity (W1 ULZ 000105), innovative benefits （ W8), the foundation of innovation (W7) and digital industry productivity (W3) .

Table 7 Obstacle degree of coupling coordination degree between new quality productivity and agricultural high-quality development (unit :%)

Year		1	2	3	4	5
2010	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.45	7.08	6.76	5.28	4.68
2011	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.51	7.13	6.67	5.29	4.86
2012	Obstacle factor	W4	W1	W8	W8	W7
	Obstacle degree	9.60	7.23	6.64	5.29	4.97
2013	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.68	7.33	6.71	5.37	4.58
2014	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.69	7.39	6.73	5.38	5.11
2015	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.60	7.43	6.67	5.39	5.17
2016	Obstacle factor	W4	W1	W8	W3	W7
	Obstacle degree	9.54	7.5	6.60	5.29	5.27
2017	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.51	7.55	6.66	5.34	5.30
2018	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.59	7.61	6.64	5.29	5.19
2019	Obstacle factor	W4	W1	W8	W7	W3
	Obstacle degree	9.68	7.71	6.65	5.31	5.02
2020	Obstacle factor	W4	W1	W8	W7	W14
	Obstacle degree	9.91	7.70	6.53	5.25	5.06
2021	Obstacle factor	W4	W1	W8	W3	W7
	Obstacle degree	9.67	7.35	6.40	5.84	5.33
2022	Obstacle factor	W4	W1	W8	W3	W7
	Obstacle degree	9.56	7.33	6.26	6.17	5.39

4. Policy evaluation

4.1 Benchmark regression

Table 10 Regression Results

Variable	Difference-in-differences model The coupling and coordination degree between new quality productivity and high-quality agricultural development		Dual machine learning The coupling and coordination degree between new quality productivity and high-quality agricultural development	
D	0.0268***	0.0179***	0.0605***	0.0619***
P value	0.008	0.001	0.000	0.000
Control the primary term	Yes	Yes	Yes	Yes
Control the quadratic term	No	Yes	No	Yes
Time-fixed effect	Control	Control	Control	Control
Provincial fixed effect	Control	Control	Control	Control
Sample size	390	390	390	390

Note: *** indicates $p < 0.01$, ** indicates $p < 0.05$, * indicates $p < 0.1$. The following table is the same.

4.2 Robustness test - Replace the machine learning algorithm

In order to avoid the impact of model setting bias on the conclusion, this paper is to verify the robustness of the model; replace the machine learning algorithm, change the random forest algorithm to lassocv regression, gradboost and svm, and explore the possible impact of the prediction algorithm on the conclusion of this article.

Table 11 Robustness Test - Replace the Machine learning Model

Variable	Lassocv	Gradboost	Svm
D	0.0764***	0.0120***	0.0658***
P value	0.000	0.003	0.000
Control the primary term	Yes	Yes	Yes
Control the quadratic term	Yes	Yes	Yes
Time-fixed effect	Control	Control	Control
Provincial fixed effect	Control	Control	Control
Sample size	390	390	390

4.2 Robustness test - Adjust the research sample

Considering that there may be large differences in the degree of development between provinces and cities in China, this paper excludes the top 10% and the bottom 10% of the provinces with economic development among the 30 provinces, and divides them into the top 10% and the bottom 10% of the per capita gross regional GDP, and conducts regression analysis of the remaining cities;

In addition, considering that samples with a long time difference will have a certain impact on regression, this paper adjusts the time interval to four years before and after the implementation time of the policy.

Table 12 Robustness Test - Adjusting the research samples

Variable	Exclude some cities	Adjust the research interval
D	0.0422***	0.0400***
P value	0.000	0.000
Control the primary term	Yes	Yes
Control the quadratic term	Yes	Yes
Time-fixed effect	Control	Control
Provincial fixed effect	Control	Control
Sample size	390	390

4.2 Robustness test - Shrinkage processing

Because the abnormal value in the regression sample may cause the estimated results to be biased, this paper conducts both the control variable set and the dependent variable in the reference regression. One percent And Five percent The shrinkage processing of the sub-bit point replaces the extreme value in the data, and conducts regression analysis again. The specific results are shown in the following table.

Table 13 Robustness Test - Tail Reduction Treatment

Variable	1%Shrink tail	5%Shrink tail
D	0.0400^{***}	0.0397^{***}
P value	0.000	0.000
Control the primary term	Yes	Yes
Control the quadratic term	Yes	Yes
Time-fixed effect	Control	Control
Provincial fixed effect	Control	Control
Sample size	390	390

4.3 Space heterogeneity test

In reality, China's regional economic development is unbalanced, and the impact of economic growth in different regions and provinces is different. In order to study this difference, this paper divides the sample cities into six regions of North China, Northeast China, East China, Central South China, Southwest China and Northwest China and group return. The results are shown in the table below.

Table 14 Spatial Heterogeneity Analysis

Variable	North China region	Northeast Region	East China region	Central and South China	Southwest Region	Northwest Region
D	0.0506***	0.0263**	0.0299**	0.0405***	0.0492***	0.0556***
P value	0.0025	0.014	0.010	0.005	0.001	0.004
Control the primary term	Yes	Yes	Yes	Yes	Yes	Yes
Control the quadratic term	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Control	Control	Control	Control	Control	Control
Provincial fixed effect	Control	Control	Control	Control	Control	Control

5. Conclusions and suggestions

5.1 Conclusion

1. The coupling relationship is gradually strengthened.

The coupling relationship between new quality productivity and high-quality agricultural development is gradually strengthened, and the coordination is constantly improved. Some provinces still exist. " Low-quality coordination " Phenomenon, we need to pay attention to the agricultural development strategies of these areas.

2. Spatial distribution features are prominent

The degree of coupling coordination shows a positive correlation, forming " Tall - Tall " And " Low - Low " The spatial gathering pattern. High-coordination areas are mainly distributed on the eastern coast, while low-coordination areas are mainly distributed in the west and northeast.

3.The impact of obstacle factors is significant

Digital productivity, innovation productivity and innovation efficiency are the main obstacles. Digital transformation urgently needs to be strengthened to promote coordination.

4. The policy has a remarkable effect.

The implementation of the rural revitalization policy has significantly improved the coupling and coordination between new quality productivity and high-quality agricultural development. The policy has achieved positive results in promoting agricultural modernization and rural revitalization.

5. Two Policy suggestions

1. Increase the construction of digital agricultural infrastructure

Strengthen 5G , the application of the Internet of Things, big data and other technologies in agriculture to improve the level of digital agriculture. Support the transformation of digital agriculture in the western and northeast regions to improve production efficiency and quality.

2.Optimize innovation policy support

Increase innovation support for the integration of green and science and technology, and promote the transformation and application of agricultural scientific and technological achievements. Build a green technology innovation platform to promote the development of the green industry chain.

3.Strengthen regional coordinated development

Formulate differentiated regional policies to support infrastructure construction and quality improvement of agricultural production. Support local agricultural leading enterprises and promote the upgrading of the agricultural industry chain.

Thank you

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