

Research on the Coupling Coordination of Digital Economy and High-Quality Agricultural Development in Hefei

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Abstract

Utilizing a series of statistical model methods and statistical data from Hefei for the period 2005-2023, this study analyzes the level of high-quality agricultural development, the development level of the digital economy, and the coupling coordination degree between the digital economy and high-quality agricultural development in Hefei. The results indicate that from 2005 to 2023, both the level of high-quality agricultural development and the development level of the digital economy in Hefei showed steady improvement, and the coupling coordination degree between the two systems continuously increased.

Keywords

High-quality agricultural development; Digital economy; Coupling coordination; Hefei

1. Introduction

Improving the level of high-quality agricultural development is the primary task for advancing agricultural and rural modernization and implementing the rural revitalization strategy. In recent years, Hefei's agricultural industry has experienced rapid development, with 400,000 mu of high-standard farmland constructed, the output value of agricultural product processing exceeding 200 billion yuan for the first time, and achieving a breakthrough with the first agricultural enterprise reaching a 10-billion-yuan scale. However, with the continuous advancement of urbanization, Hefei's agricultural development faces challenges such as tightening resource and environmental constraints and insufficient industrial integration, which restrict high-quality agricultural development.

Digital economy refers to the use of information technology to drive productivity growth and optimize economic structure [1]. It is a typical economic concept distinguished from a technological perspective [2]. In addition to the information and communication technology industry, the digital economy has given rise to new

business forms, such as the platform economy, sharing economy, and online finance, which are also included in the scope of the digital economy [3]. The digital economy is characterized by its penetrative and integrative nature, enabling integrated development with traditional industries, which similarly constitutes a component of the digital economy [4]. The connotation and composition of the digital economy continue to expand. There is no unified indicator system for measuring the development of the digital economy. Existing measurement systems for the digital economy cover a wide range of aspects. For instance, Liu et al. evaluated the development level of the digital economy in various provinces of China using indicators from three dimensions: informatization, the internet, and digital transactions [5]. Zhang et al. constructed an evaluation indicator system for China's digital economy development from dimensions such as information and communication infrastructure, ICT application, enterprise digital development, and the information and communication technology industry [6]. Wan et al. built a digital economy evaluation indicator system comprising three major dimensions—digital input, digital governance environment, and digital output—with a total of 70 measurement indicators from an economic perspective of input and output [7].

As a new economic form, the digital economy plays a significant role in enhancing the efficiency of agricultural production factors and optimizing the industrial structure, and has become a new driving force for agricultural transformation, upgrading, and high-quality development. The “Decision of the Standing Committee of the Anhui Provincial People's Congress on Further Promoting the High-Quality Development of the Digital Economy” emphasizes the need to accelerate the integrated development of the digital and real economies, intensify efforts to develop smart agriculture, and continuously generate new quality productive forces in agriculture. Therefore, measuring the levels of digital economy and high-quality agricultural development in Hefei and clarifying the coupling and synergistic relationship between them is of great significance for promoting high-quality agricultural development in Hefei.

2. Measurement and Analysis of High-Quality Agricultural Development Level in Hefei

2.1. Indicator Selection

Centering on the core connotation of high-quality agricultural development and considering data availability, a total of 5 secondary indicators and 14 tertiary indicators were selected. As can be seen from Table 1, the innovation dimension is the core driving force for enhancing high-quality agricultural development, selecting indicators such as the level of agricultural mechanization, labor productivity, land productivity, and grain yield per unit area. The coordination dimension focuses on the structural balance within agriculture and with the external environment, reflected through indicators like the agricultural industrial structure adjustment index

and the proportion of grain sown area. The green dimension reflects the resource and environmental sustainability of agricultural production, characterized by inverse indicators such as fertilizer application intensity, pesticide application intensity, and agricultural plastic film use intensity. The openness dimension measures the depth of agriculture's integration into the modern economic system, indicated by the degree of agricultural marketization and the level of non-agricultural employment. The sharing dimension focuses on the fairness and inclusiveness of agricultural development outcomes, selecting indicators such as the affluence level of rural residents, the urban-rural income ratio, and the urbanization rate.

Table 1. Hefei Agricultural High-Quality Development Evaluation Indicator System

Sub-item Indicator	Basic Indicator	Indicator Meaning
Innovation	Agricultural Mechanization Level	Total Agricultural Machinery Power / Total Sown Area of Crops (10,000 kW/hectare)
	Agricultural Labor Productivity	Gross Output Value of Farming, Forestry, Animal Husbandry, and Fishery / Number of Employed Persons in the Primary Industry (10,000 yuan/person)
	Land Productivity	Gross Agricultural Output Value / Total Sown Area of Crops (10,000 yuan/hectare)
Coordination	Grain Yield per Unit Area	Grain Output / Sown Area of Grain Crops (ton/hectare)
	Agricultural Industrial Structure Adjustment Index	$1 - (\text{Gross Agricultural Output Value} / \text{Gross Output Value of Farming, Forestry, Animal Husbandry, and Fishery}) (\%)$
Green	Proportion of Sown Area for Grain Crops	Sown Area of Grain Crops / Total Sown Area of Crops (%)
	Fertilizer Application Intensity	Total Agricultural Fertilizer Application (Converted to Pure) / Total Sown Area of Crops (ton/hectare)
	Pesticide Application Intensity	Total Pesticide Usage / Total Sown Area of Crops (ton/hectare)
Openness	Agricultural Plastic Film Use Intensity	Total Agricultural Plastic Film Usage / Total Sown Area of Crops (ton/hectare)
	Agricultural Marketization Degree	Output Value of Agricultural Services (Support Activities) / Gross Output Value of Farming, Forestry, Animal Husbandry, and Fishery (%)
	Non-agricultural Employment Level	$1 - (\text{Number of Employed Persons in the Primary Industry} / \text{Total Number of Employed Persons}) (\%)$
Shared	Affluence Level of Rural Residents	Rural Residents' Engel's Coefficient (%)
	Urban-Rural Income Ratio	Disposable Income of Urban Residents / Per Capita Disposable Income of Rural Residents (%)
	Urbanization Rate	Urban Population / Resident Population (%)

2.2. Results Analysis

The entropy method was employed to measure the level of high-quality agricultural development in Hefei. As can be seen from Table 2, the comprehensive score for high-quality agricultural development in Hefei increased from 0.318 in 2005 to 0.771 in 2023, showing a strong and continuous upward trend overall. This indicates that the overall development quality of agriculture in Hefei has substantially improved. Behind this positive trend lies the synergistic effect of multiple policies and innovative measures. In the innovation dimension, leveraging its advantages in scientific and technological resources, Hefei continuously promoted agricultural mechanization and technological progress, enhancing labor productivity and land output rate. In the coordination dimension, by optimizing the agricultural industrial structure, it developed various forms of specialty agriculture while ensuring food security, promoting industrial integration. In the green dimension, benefiting from the promotion of ecological agriculture models and the implementation of actions to reduce and enhance the efficiency of fertilizer and pesticide use, the sustainability of agricultural production continuously improved. In the openness and sharing dimensions, the acceleration of urban-rural integrated development, the increase in the level of rural marketization, and the broadening of farmers' income channels jointly promoted the inclusive sharing of development outcomes.

Table 2. Empirical Analysis Results

Year	Comprehensive score of high-quality agricultural development	Comprehensive score of digital economy	Coupling coordination degree
2005	0.223	0.015	0.240
2006	0.318	0.042	0.340
2007	0.264	0.043	0.326
2008	0.344	0.060	0.379
2009	0.365	0.078	0.411
2010	0.382	0.062	0.392
2011	0.312	0.090	0.409
2012	0.341	0.227	0.527
2013	0.351	0.151	0.480
2014	0.486	0.184	0.547
2015	0.536	0.249	0.604
2016	0.542	0.321	0.646
2017	0.576	0.361	0.675
2018	0.602	0.527	0.751
2019	0.645	0.703	0.821
2020	0.653	0.851	0.863
2021	0.699	0.612	0.809
2022	0.735	0.670	0.838

2023	0.771	0.707	0.859
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3. Measurement and Analysis of Digital Economy Development Level in Hefei

3.1. Indicator Selection

Referencing the construction of digital economy indicator systems in existing literature and considering data availability, a total of 3 secondary indicators and 7 tertiary indicators were selected. As can be seen from Table 3, the digital infrastructure dimension focuses on the hardware support and connectivity capacity for digital economy development, selecting indicators such as internet penetration rate and mobile phone penetration rate. The digital industrialization dimension focuses on the scale and development level of the information industry itself, selecting indicators such as the foundation of the postal industry, the foundation of the telecommunications industry, and the foundation of the information industry. The industry digitization dimension focuses on the enabling and transformative effects of digital technology on traditional industries, selecting indicators such as R&D expenditure and the number of patents granted.

Table 3. Hefei Digital Economy Development Evaluation Indicator System

Sub-item Indicator	Basic Indicator	Unit of Measurement
Digital Infrastructure	Internet Penetration Rate	Fixed Broadband Internet Subscribers / Resident Population (%)
	Mobile Phone Penetration Rate	Number of Mobile Phone Subscribers at Period-end / Resident Population (%)
Digital Industrialization	Postal Industry Foundation	Total Postal Business Volume / Resident Population (10,000 yuan/10,000 persons)
	Telecommunications Industry Foundation	Total Telecommunication Business Volume / Resident Population (10,000 yuan/10,000 persons)
	Information Industry Foundation	Employed Persons in Information Transmission, Software, and IT Services / Total Employed Persons (%)
Industry Digitization	R&D Expenditure	R&D Expenditure of Industrial Enterprises above Designated Size (100 million yuan)
	Number of Patents Granted	Number of Invention, Utility Model, and Design Patents Granted (unit)

3.2. Results Analysis

The entropy method was employed to measure the development level of the digital economy in Hefei. As can be seen from Table 2, from 2005 to 2023, the development level of the digital economy in Hefei exhibited a distinct trend characterized by "steady accumulation in the early stage, a rapid leap in the middle stage, and sustained improvement after a short-term adjustment."

During the initial phase from 2005 to 2012, the development level started from a low base and experienced slow growth. This reflects that the digital infrastructure during this period was in a phase of large-scale investment and construction, and the widespread adoption of the internet and mobile networks had not yet fully translated into scaled industrial momentum.

Starting in 2013, the digital economy entered a phase of rapid ascent. This leap was primarily driven by strong policy initiatives such as the "Broadband China" strategy and the commercial deployment of 4G, coupled with Hefei's forward-looking industrial layout in core digital sectors like integrated circuits and new displays. These factors led to a simultaneous and significant enhancement in both the foundation of digital industrialization and the innovation capacity of industry digitization.

Notably, the noticeable dip in the score observed in 2021 was partly attributable to a change in statistical methodology. Specifically, the calculation of total telecommunications business volume and total postal business volume was switched to constant prices of the base year 2020. This adjustment removed the impact of price changes, allowing the data to more accurately reflect the physical volume of activity. This technical modification objectively led to a decrease in the indicator values. However, the subsequent rapid rebound and attainment of new record highs in the scores strongly demonstrate the robust resilience of Hefei's digital economy.

4. Coupling Coordination Analysis between Digital Economy and High-Quality Agricultural Development in Hefei

4.1. Model Selection

This study employs the coupling coordination degree model to measure the coupling coordination relationship between the digital economy and high-quality agricultural development in Hefei. The coupling coordination degree model is a concept originating from physics that has subsequently been widely adopted as a research method in fields such as social sciences, geography, and environmental science. It aims to precisely quantify the interaction relationship and synergistic development level between two or more systems. Its core value lies in the fact that it can not only determine whether a relationship exists between systems but also provide an in-depth diagnosis of whether this relationship constitutes low-level mutual hindrance or high-level positive interaction.

The analytical framework of this model typically involves three key steps: First, construct a comprehensive evaluation indicator system that fully reflects the intrinsic characteristics of each system. Methods such as the entropy method are then used to scientifically determine indicator weights and calculate the respective comprehensive development level indices for each system. Second, introduce the concept of "coupling degree" to measure the intensity of interdependence and mutual influence between systems. A higher coupling degree indicates a stronger interactive force between the systems.

However, a high coupling degree might also signify intense conflict. Therefore, the most crucial step is calculating the “coordination degree”. This metric builds upon the coupling degree by incorporating the systems' development levels, enabling a comprehensive assessment of whether the interaction is harmonious and oriented towards mutually beneficial and win-win development. This effectively distinguishes between “high-level synergy” and “low-level lock-in”.

4.2. Results Analysis

As shown in Table 2, from 2005 to 2023, the coupling coordination degree between the digital economy and high-quality agricultural development in Hefei underwent a significant leap from low-level coordination to high-level synergy, overall exhibiting a three-stage evolutionary characteristic of “initial stage—breakthrough stage—deepening stage”.

During the initial stage from around 2005 to 2013, the coordination degree was at a low level and grew slowly. This indicates that during this period, the digital economy and agriculture largely developed independently. The application of digital technology in the agricultural sector was still in a sporadic pilot phase, and the interaction and synergistic effects between the two systems were relatively weak.

Subsequently, until around 2020, the coordination degree entered a phase of rapid improvement—the breakthrough stage. This was primarily attributable to the improvement of Hefei's digital infrastructure, such as 4G/5G networks and rural broadband, and the expansion of the digital industrialization scale, which provided a solid foundation for digital technology to empower agriculture. Concurrently, the widespread penetration of applications like smart agriculture, rural e-commerce, and digital inclusive finance significantly enhanced the digital level of agricultural production, operation, and management, shifting the interaction between the two systems from shallow integration to deep integration.

It is worth noting that the growth plateau or slight fluctuations observed in the coordination degree curve around 2021 were related, on one hand, to the statistical caliber adjustments for the digital economy. On the other hand, it also reflected structural adjustments during the deep integration process. Specifically, the marginal benefits of early, easily imitated, and promoted models, such as e-commerce sales, were diminishing. Meanwhile, deeper applications requiring higher technological integration and greater investment, such as intelligent agricultural machinery and agricultural big data platforms, were in a critical phase of tackling challenges and forming capacity.

Since the beginning of the “14th Five-Year Plan” period, the coordination degree has continuously moved towards higher levels. This marks the entry of the two systems into a deepening stage characterized by positive interaction. The digital economy is no longer just a tool in the agricultural sector but has become a core production factor generating new business forms and models. Simultaneously, the demands of

high-quality agricultural development provide vast scenarios for the innovation and application of digital technologies. The two have formed a new pattern of synergistic development characterized by mutual promotion and symbiotic prosperity.

5. Conclusions

First, from 2005 to 2023, the comprehensive score for high-quality agricultural development in Hefei increased from 0.318 to 0.771, showing a strong and continuous upward trend overall, indicating that the overall development quality of agriculture in Hefei has been substantially improved. This positive trend is the result of the synergistic efforts of multiple policies and innovative measures.

Second, from 2005 to 2023, the development level of the digital economy in Hefei overall exhibited a distinct trend of “steady accumulation in the early stage, rapid leap in the middle stage, and continuous improvement after short-term adjustment”. In the early stage from 2005 to 2012, the base development level was low and growth was slow. A noticeable adjustment occurred in the score in 2021; however, the score quickly recovered thereafter and reached new highs, strongly demonstrating the strong resilience of Hefei’s digital economy.

Third, from 2005 to 2023, the coupling coordination degree between the digital economy and high-quality agricultural development in Hefei experienced a significant leap from low-level coordination to high-level synergy, overall exhibiting a three-stage evolutionary characteristic of “starting - breakthrough - deepening”.

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