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DIGITIZING THE HEARTLAND: A STUDY ON AGRICULTURAL AND RURAL MODERNIZATION IN THE DIGITAL AGE

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Abstract: The 20th National Congress of China underscored the imperative of prioritizing agriculture and rural development as a cornerstone of national progress. This call for accelerated rural development aligns with the broader vision of revitalizing rural areas in terms of industries, human capital, culture, ecology, and organizational structures. In 2023, the No.1 Document of the Central Committee reiterated the critical importance of addressing the fundamental issues of agriculture, rural areas, and farmers while advancing the modernization of these sectors. The confluence of these policy directives reflects the conviction that a strong nation hinges on a robust agricultural sector, and conversely, a strong agricultural foundation is pivotal to the emergence of a modern, formidable state. The modernization of agriculture and rural areas is not only a key national priority but also the linchpin for achieving socialist modernization. Establishing a resilient agricultural sector forms the bedrock for constructing a robust contemporary nation.

Simultaneously, the rapid ascent of the digital economy is fueling a new growth engine for China's economy. The digitization of industries and the industrialization of digital processes are spearheading transformative changes across various economic domains, driving high-quality economic development in China. This prompts the question: Can the digital economy's development act as a catalyst for the modernization of agriculture and rural areas? If so, how precisely does the digital economy advance the modernization of these vital sectors? Exploring the profound impact of the digital economy on agricultural and rural modernization holds significant practical relevance as China endeavors to solidify its status as a modern socialist nation.

Keywords: Agriculture Modernization, Rural Development, Digital Economy, Socialist Modernization, High-Quality Economic Development

1. Introduction

The report of the 20th National Congress of China pointed out that it is necessary to give priority to the development of agriculture and rural areas, accelerate the construction of a powerful agricultural country, and promote the revitalization of industries, talents, culture, ecology and organizations in rural areas. In 2023, the No.1 Document of the Central Committee once again emphasized the need to stick to the basic issues of agriculture, rural areas and farmers and accelerate the modernization of agriculture and rural areas. A strong country must be strong in agriculture, and only a strong country is strong in agriculture. Realizing agricultural and rural modernization is the only way to realize socialist modernization, and building a strong agricultural

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country is the foundation of building a strong modern country. At the same time, the rapid development of digital economy is stimulating the new driving force of China's economy. Digital industrialization and industrial digitalization are leading digital changes in various fields of China's economy and promoting the high-quality development of China's economy. So, can the development of digital economy promote the modernization of agriculture and rural areas? How does the development of digital economy promote the modernization of agriculture and rural areas? It is of great practical significance for China to build a strong socialist modernization country by deeply exploring the influence of digital economy on agricultural and rural modernization.

2. Literature Review

At present, scholars' research on the impact of digital economy on agricultural and rural modernization mostly focuses on the following aspects:

First, the digital economy promotes the income increase of rural residents and the modernization of residents' lives. Zhao Jiajia et al. (2023) [1] using county-level data and CFPS survey data, it is found that the development of digital economy can significantly encourage rural residents to innovate and start businesses, and digital economy can encourage rural residents to start businesses by promoting the effective use of information, alleviating credit constraints, enhancing the willingness to take risks and improving the overall credit level of society, thus promoting rural residents to start businesses and increase their income. Zhang Liang et al. (2023) [2] made an empirical study by using China Land Economic Survey Data, which confirmed the positive role of digital economy development in increasing rural residents' income. Pan Xiquan (2023) [3] takes 26 county-level areas in Zhejiang mountainous area as the research object and finds that rural digital construction can improve the living standards of rural residents, narrow the income gap between urban and rural residents, and increase the income of rural residents by improving digital infrastructure and digital governance, which reflects the important role of digital economy in promoting the modernization of rural life.

Second, the digital economy promotes the high-quality development of rural industries and the modernization of agriculture. Li Xiaohong et al. (2023) [4] based on provincial panel data and PVAR model, it is found that there is a benign interactive relationship between rural digital development and rural industrial structure upgrading. With the continuous integration of digitalization and rural real economy, rural economy develops steadily. Qin Zhaohui et al. (2023) [5] also used provincial panel data to calculate the index of digital economy and rural industry high-quality development, and found that the driving effect of the digital economy on the high-quality development of rural industry is non-linear, and its impact mechanism is to promote the high-quality development of rural industry and the modernization of agriculture and rural areas by improving the mismatch of labor factors.

Third, digital economy promotes rural ecological optimization and modernization of rural ecological environment. Cheng Li et al. (2023) [6] studied the rural environmental governance in the Yangtze River Economic Belt by using the two-way fixed effect model and the regulatory effect model, and found that the digital economy can significantly promote the effective implementation of rural environmental governance policies and promote the modernization of ecological environment in rural areas. Yang Xue et al. (2023) [7] found that the digital

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development in rural areas can reduce agricultural carbon emissions through scale operation, structural optimization and scientific and technological progress, and its inhibitory effect on agricultural carbon emissions is more significant in the central and western regions and major grain-producing areas, which confirms the role of digital economy in promoting the modernization of rural ecological environment.

3. Research design

3.1 Variable selection

Based on the relevant data of 30 provinces and municipalities directly under the Central Government (except Tibet) in Chinese mainland from 2011 to 2021, this study calculates the index of digital economy and agricultural and rural modernization, and studies the impact of digital economy on agricultural and rural modernization. The data are all from the China Statistical Yearbook, Provincial Statistical Yearbook, China Labor Statistical Yearbook and National Bureau of Statistics.

a) Explained variable: Agricultural and rural modernization level (Rur). Based on the practices of Chen Huiqing et al. (2022) [8] and Ye Xingqing et al. (2023) [9], this paper constructs an index evaluation system of agricultural and rural modernization from five aspects: rural agricultural modernization, rural ecological modernization, rural cultural modernization, rural governance modernization, and farmers' life modernization. On the basis of standardizing the original data, the entropy method is used to assign weights, and the agricultural and rural modernization level index of different provinces is calculated, and the natural logarithm is taken. Among them, the selection of each index is shown in Table 1.

b) Core explanatory variable: Digital economy level (Dig). This paper draws on the practice of Zhao Tao et al. (2020) [10] to construct the digital economy level index, which is assigned using the entropy method after standardizing the raw data and taking its natural logarithm. The selected indicators are shown in Table 1 below:

c) Threshold variables: Scientific and technological innovation level (Sti), rural Internet development (Int), digital inclusive financing level (Dif). The measurement index of scientific and technological innovation level is the number of patent applications authorized per 100 people; The measurement index of rural Internet development level is the natural logarithm of rural broadband access users, and some missing data are supplemented by linear interpolation method; The measurement index of digital inclusive financing level is the natural logarithm of Peking University Digital Inclusive Financing Index (Guo Feng et al., 2020) [11].

d) Control variables: Government intervention (Gov), foreign trade (Fot), industrial structure (Ais), human capital (Hum), crop planting structure (Agr), population status (Pop), rural Internet development (Int). Government intervention is measured by the proportion of general budget expenditure to regional GDP; Foreign trade is measured by the logarithmic value of the total investment of foreign-invested enterprises; The industrial structure is measured by the ratio of the added value of the tertiary industry to the added value of the secondary industry; Human capital is measured by the proportion of students in ordinary high schools to the total population; Crop planting structure is measured by the proportion of sown area of grain crops to total sown area of crops; The population situation is measured by the total dependency ratio; The development level of rural Internet is

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measured by the natural logarithm of rural broadband access users. Table 2 below shows descriptive statistics of relevant data:

Table 1: Evaluation System of Agricultural and Rural Modernization and Digital Economy Level Index

	first-class index	second-class index	attribute
Agricultural and rural modernization level	rural agricultural modernization	Proportion of effective irrigated area to total sown area	+
		Per capita grain output	+
		Total power of agricultural machinery	+
		Expenditure on agriculture, forestry and water affairs of local finance	+
		Gross output value of agriculture, forestry, animal husbandry and fishery	+
	rural ecological modernization	Application amount of chemical fertilizer per-unit sown area	-
		Forest coverage rate	+
		Harmless treatment rate of domestic garbage	+
		Local fiscal expenditure on environmental protection	+
	rural cultural modernization	Per capita possession of public library collections	+
		Local financial expenditure on culture, sports and media	+
		Local financial expenditure on education	+
		Local fiscal expenditure on science and technology	+
		Telephone penetration rate	+
	rural governance modernization	Pension insurance participation rate	+
		Local financial expenditure on urban and rural community affairs	+
		Number of village committees per 10,000 people in villages	+
		Local finance expenditures on social security and employment	+

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		Number of doctors and health workers per 10,000 people in villages	+
	farmers' life modernization	Engel coefficient	-
		Proportion of administrative villages with centralized water supply	+
		Rural electricity consumption	+
		The proportion of wage income of rural residents to total income	+
		Proportion of rural residents' expenditure on education, culture and entertainment to total expenditure	+
Digital economy level	Internet popularity	Number of Internet broadband access households per 100 people	+
	Internet-related employment situation	Proportion of employed persons in information transmission, software and information technology services	+
	Output of Internetrelated industries	Total telecommunications services per capita	+
	Telephone popularity	Telephone penetration rate	+
	Development level of digital inclusive finance	Peking University Digital Inclusive Financing Index	+

Table 2: Descriptive statistics

Variable	Mean	SD	Min	Max
Agricultural and rural modernization level(Rur)	3.229	0.342	2.299	4.095
Digital economy level(Dig)	4.371	0.991	0.296	6.271
Scientific and technological innovation level(Sti)	0.131	0.154	0.009	0.908
Rural Internet development(Int)	7.189	1.559	1.609	9.655
Digital inclusive financing level(Dif)	5.283	0.669	2.909	6.129

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Government intervention(Gov)	0.115	0.032	0.058	0.245
Foreign trade(Fot)	11.386	1.437	7.948	15.326
Industrial structure(Ais)	1.342	0.732	0.527	5.244
Human capital(Hum)	0.018	0.004	0.006	0.027
Crop planting structure(Agr)	0.658	0.147	0.355	0.971
Population status(Pop)	0.381	0.074	0.193	0.578

3.2 Model design

In order to analyze the impact of digital economy development on agricultural and rural modernization, this paper constructs the following model:

$$Rur_{it}=\alpha_1 Dig_{it}+\alpha_z C_{it}+\alpha_0+\mu_i+\sigma_t+\varepsilon_{it} \quad (1)$$

In the above formula, Rur_{it} is the agricultural and rural modernization level of i province in t year, and Dig_{it} is the digital economic development level of i province in t year. C_{it} is the control variable of i province in t year, μ_i is the fixed effect of province, σ_t is the fixed effect of year, ε_{it} is the random disturbance term, and α_1 is the influence coefficient of digital economy development on agricultural and rural modernization.

Since the impact of digital economy development on agricultural and rural modernization may be non-linear, this paper analyzes its threshold effect. In this paper, Hansen's (1999) [12] method is used for reference to construct a panel threshold regression model. The single threshold model and double threshold model are as follows:

$$Rurit=\rho 1 Digit\cdot I(qit\leq\theta 1)+\rho 2\ Digit\cdot I(qit>\theta 1)+\rho zCit+\rho 0+\mu i+\sigma t+\varepsilon it \quad (2)$$

$$Rurit=\delta 1 DigitI(qit\leq\theta 1)+\delta 2 DigitI(\theta 1< qit\leq\theta 2)+\ \delta 2 DigitI(qit>\theta 2)+\ \delta zCit+\delta 0+\mu i+\sigma t+\varepsilon it \quad (3)$$

Where q_{it} denotes threshold variables, θ_1 and θ_2 denote threshold values, I (·) denotes indicative functions, and other variables have the same meanings as above.

4. Analysis of empirical results

4.1 Benchmark regression result analysis

After Hausman test, this paper takes the fixed effect model as the benchmark regression model, and Table 3 shows the regression results of the impact of digital economy development on agricultural and rural modernization. Columns (1), (2) and (3) in the table are the regression results of adding individual fixed effects, control variables and time-fixed effects in turn. It can be seen from the results that the promotion of digital economy to agricultural and rural modernization has always remained at a significant level of 1%, that is, digital economy can significantly promote the development of agricultural and rural modernization. In addition, among the control variables, government intervention plays an equally significant role in promoting the modernization of agriculture and rural areas, which may be due to the government's support accelerating the construction of rural areas in various aspects and promoting the modernization of local economy, culture, ecology and other fields.

Table 3: Benchmark regression results

	(1)	(2)	(3)

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	Rur	Rur	Rur
Dig	0.158***	0.089***	0.066***
	(0.006)	(0.009)	(0.018)
Gov		1.418***	1.278**
		(0.445)	(0.523)
Fot		0.042	0.021
		(0.027)	(0.015)
Ais		0.107***	0.017
		(0.033)	(0.036)
Hum		-0.515	3.269
		(4.990)	(3.928)
Agr		-0.469	-0.275
		(0.279)	(0.243)
Pop		0.443*	-0.424
		(0.245)	(0.282)
Int		0.030	-0.017
		(0.018)	(0.017)
_cons	2.538***	1.986***	2.736***
	(0.027)	(0.295)	(0.270)
year	No	No	Yes
province	Yes	Yes	Yes
R^2	0.782	0.870	0.931
Note: ***, * *, * represent the significance at 1%, 5% and 10% levels respectively, and clustering robust standard errors are in brackets, the same below.			

4.2 Robustness tests

4.2.1 Replace the explained variable

In order to ensure the robustness of benchmark regression results, this paper replaces the explained variables. In this paper, the new agricultural and rural modernization level (Rur2) is calculated by using the weighting method of Liu Jun et al. (2020) [13] to replace the explained variables obtained by entropy method above, and the fixed effect model is used for regression. Column (1) of Table 4 shows the regression results after replacing the

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explained variables. From the results, it can be seen that the digital economy still plays a significant role in promoting agricultural and rural modernization, which is consistent with the benchmark regression results.

4.2.2 *Replace the core explanatory variables*

In order to further verify the effectiveness of the benchmark regression results, a new digital economy level (Dig2) is obtained by using the weighting method of Liu Jun et al. (2020) [13] to replace the core explanatory variables calculated by entropy method above, and then regression is carried out. Column (2) of Table 4 shows the regression results after replacing the core explanatory variables, which are consistent with the baseline regression results.

4.2.3 *Endogeneity test*

This paper draws lessons from the methods of Huang Qunhui et al. (2019) [14] and Zhao Tao et al. (2020) [10], and adopts the historical data of posts and telecommunications in 1984 as the instrumental variable of digital economy level. Since the selected instrumental variables are cross-sectional data, this paper draws on Nunn N and Qian N (2014) [15] to use the interaction term between the number of telephones per 10,000 people in 1984 and the number of mobile Internet subscribers in the previous year in each province as the instrumental variable. Column (3) of Table 4 is the regression result after using instrumental variables. It can be seen that the digital economy still plays a significant role in promoting agricultural and rural modernization, and all of them are significant at the level of 1%. From the P-value and Wald F-value of Kleibergen-Paap rk LM, it can be seen that the instrumental variables passed the under-identification test and the weak instrumental variable test, which indicates the reasonableness of the instrumental variables setting.

Table 4: Robustness tests

	(1)	(2)	(3)
	Rur2	Rur	Rur
Dig	0.086***		0.160***
	(0.025)		(0.040)
Dig2		0.070***	
		(0.018)	
Control	Yes	Yes	Yes
year	Yes	Yes	Yes
province	Yes	Yes	Yes
R2	0.983	0.981	0.988
Kleibergen-Paap rk LM			22.277 [0.000]
Kleibergen-Paap rk Wald F			21.795{16.38}

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Note: [] is the P value and {} is the critical value at the 10% level of the Stock-Yogo test.

4.3 Threshold effect analysis

Firstly, the significance of the threshold effect and the number of thresholds is tested. After 300 calculations by Bootstrap method, P statistics and F statistics of the threshold effect test can be obtained. Table 5 is the threshold effect test result. It can be seen from the table that there are double thresholds when the level of scientific and technological innovation and the level of digital inclusive finance are the threshold variables; When the development level of rural Internet is taken as the threshold variable, there is a single threshold.

Table 5: Threshold effect analysis

		Threshold value	F	P	Critical value		
					10%	5%	1%
Scientific and technological innovation level	Single	0.0848	40.91	0.0067	23.3310	27.7541	35.7424
	Double	0.2392	19.38	0.0767	18.3119	21.3699	28.6105
	Triple	—	14.70	0.3833	25.4224	28.5350	39.7790
Rural Internet development	Single	8.1792	37.48	0.0167	24.5590	30.6553	45.1855
	Double	—	20.31	0.1100	20.6951	25.1799	31.7785
Digital inclusive financing level	Single	4.4270	49.24	0.0000	15.3942	17.9618	29.7257
	Double	5.7911	38.74	0.0000	13.9225	16.4678	20.3965
	Triple	—	19.09	0.7033	55.2628	60.5598	74.6799

Table 6 shows the threshold regression results of this paper. Column (1) of Table 6 shows the regression results with the level of scientific and technological innovation as the threshold variable. It can be seen from the table that no matter which range the level of scientific and technological innovation is in, the promotion of digital economy to agricultural and rural modernization is significant at the level of 1%. When the level of scientific and technological innovation is lower than the threshold value of 0.0848, the impact coefficient of digital economy on agricultural and rural modernization is 0.147; When the level of scientific and technological innovation is between 0.0848 and 0.2392, the coefficient rises to 0.155; When the level of scientific and technological innovation is higher than the threshold value of
0.2392, the coefficient rises to 0.174, and its promoting effect rises step by step.

Column (2) is the regression result with the development level of rural Internet as the threshold variable. It can also be seen from the table that the promotion of digital economy to agricultural and rural modernization is always significant at the level of 1%. Further analysis shows that when the development level of rural Internet crosses

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the threshold value of 8.1792, the impact coefficient of digital economy on agricultural and rural modernization increases from 0.137 to 0.152. That is to say, the higher the development level of rural Internet, the greater the promotion of digital economy to agricultural and rural modernization.

Column (3) is the regression result with the level of digital inclusive finance as the threshold variable. It can also be seen from the table that the digital economy has always played a significant role in promoting agricultural and rural modernization. In-depth analysis shows that when the level of digital Inclusive Financing transits from a low threshold to a high threshold, the influence coefficient of digital economy on agricultural and rural modernization keeps rising, and its promotion is obviously accelerated. This result reflects the importance of promoting the development of digital inclusive finance.

Table 6: Threshold effect regression results

	(1)	(2)	(3)
	Scientific and technological innovation level	Rural Internet development	Digital inclusive financing level
	Rur	Rur	Rur
Low threshold interval	0.147***	0.137***	0.112***
	(0.018)	(0.015)	(0.014)
Middle threshold interval	0.155***		0.147***
	(0.018)		(0.014)
High threshold interval	0.174***	0.152***	0.159***
	(0.019)	(0.015)	(0.013)
Control	Yes	Yes	Yes
year	Yes	Yes	Yes
province	Yes	Yes	Yes
R^2	0.922	0.918	0.928

5. Conclusions and suggestions

This paper draws the following conclusions: First, the development of digital economy can significantly promote the modernization of agriculture and rural areas. Secondly, when the level of scientific and technological innovation and digital inclusive finance is taken as threshold variables, the promotion of digital economy to agricultural and rural modernization has double threshold effects. With the rise of scientific and technological innovation and digital inclusive finance, its promotion shows a ladder upward trend. When the level of rural Internet development is taken as the threshold variable, there is a single threshold effect in promoting agricultural

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and rural modernization by digital economy. The higher the level of rural Internet development, the better the digital economy can promote agricultural and rural modernization.

Based on the above conclusions, the following suggestions are put forward:

First, we should actively promote the development of digital economy in rural areas and improve the digital construction in rural areas. Based on the digital infrastructure in rural areas, we will give full play to the leading and promoting role of the digital economy in the modernization of agriculture and rural areas. We should improve the new digital infrastructure in rural areas, so that residents in rural areas can enjoy the dividends brought by the development of digital technology, narrow the digital divide between urban and rural areas, break down the digital barriers between urban and rural areas, accelerate the flow of factors between urban and rural areas, and promote the modernization of rural areas.

Second, we should actively encourage scientific and technological innovation and give full play to its role in promoting agricultural and rural modernization. On the one hand, we should persist in strengthening agriculture through science and technology, strengthen the application of science and technology in agricultural production, fully apply agricultural scientific and technological achievements to agricultural production, and improve agricultural production efficiency. On the other hand, we should use science and technology to lead the integration and development of rural industries, establish a demonstration village led by science and technology with intelligent equipment, green production and processing as the key according to local characteristics, promote the integration and development of the whole industrial chain in rural areas, and promote the development of rural economy.

Third, we should increase financial support for agriculture and actively promote the development of digital inclusive finance. Digital inclusive finance has the characteristics of convenience, sharing, wide coverage and high efficiency, which can lower the financing threshold of rural residents and improve their acceptance of digital finance. Local financial institutions should combine local characteristics and launch characteristic digital financial products to meet the diversified financial needs of residents at different levels, ease the financial pressure of rural residents and promote local economic development. At the same time, financial institutions should strengthen the publicity of digital Inclusive Financing, so that rural residents can better understand digital inclusive finance and improve their financial literacy.

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