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The Impact of the Digital Economy on High-Quality Development of Specialized Farmers' Cooperatives: Evidence from China

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Abstract: The development of the digital economy is profoundly changing and influencing the development mode of specialized farmers' cooperatives. It can promote the development of specialized farmers' cooperatives by optimizing resource allocation, improving production efficiency, and enhancing their external service and internal governance capacity. This paper used the panel data of 30 Chinese provinces and cities from 2017 to 2020 and applied various statistical analysis methods to investigate the role of the digital economy in promoting agricultural cooperatives and their internal mechanisms. The results show the following: (1) The development of specialized farmers' cooperatives was slightly improved in China over the studied years. Cooperatives in the eastern areas had the highest development levels, and there was a marked increase in the development of cooperatives in western regions in these years. (2) The digital economy can effectively enhance the technological innovation level and then boost the high-quality development of agricultural cooperatives. (3) The results of the threshold regression analysis show that there is only one threshold for the impact of digitalization on the development of farmers' cooperatives. (4) By analyzing the data from these regions, we found that digitalization can foster the development of rural cooperatives not only in specific regions, but also in surrounding areas. (5) The heterogeneity analysis showed that the promoting effect of digitalization on specialized farmers' cooperatives was more evident in the west of China than in the eastern and central regions. Therefore, this paper provides a reference for accelerating the development of specialized farmers' cooperatives under the background of the digital economy.

Keywords: specialized farmers' cooperatives; digital economy; high-quality development; technological innovation

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1. Introduction

High-quality development is sustainable development that combines speed and quality, gradually penetrating different areas of social life [1]. Agriculture is a source of food and the foundation of human survival. China is an agricultural country, and high-quality development of agriculture is the basis for the sustainable development of society as a whole [2,3]. Specialized farmers' cooperatives are crucial in fostering rural sustainable agricultural development [4]. As a new type of agricultural management entity, agriculture cooperatives can organize farmers to standardize production, becoming the defenders of their rights [5,6]. Dispersed farmers are organized as cooperatives, which can strengthen their dominant position in the market, reduce production costs, promote production efficiency, and transform agricultural development [7–9]. According to the annual statistical report of the rural cooperative economy in China, about 2.012 million such cooperatives have been established, showing a trend of a promising increase and enabling nearly 22 million people to lift themselves out of poverty [10]. Over 90% of China's poor villages have established specialized agricultural cooperatives, which play an essential role in alleviating poverty by increasing farmers' trust in society and providing implicit guarantees [11]. The proportion

of ordinary farmers as members of cooperatives has reached 95.8%, becoming a new modern agricultural business entity, which has led to farmers participating in domestic and foreign market competition and increased their income [12].

However, due to the influence of policies, the market, technology, talents, and other factors, specialized farmers' cooperatives face many challenges, including small scale, low operating efficiency, information asymmetry, and a lack of funds [13]. They also need help with many problems and difficulties when pushing farmers into the marketplace, such as irregular management, talent shortages, and the unreasonable structure of property rights, which restrict their growth. Significantly, the emergence of "shell cooperatives" has led to a lack of trust in cooperatives among farmers, which will limit farmers' welfare improvements and reduce allocation efficiency and rural development [14]. Farmers expect to benefit from the knowledge and resources of cooperatives. However, through extensive field research throughout China, some researchers have found that almost any organization involved in agriculture can be registered as a specialized farmers' cooperative [15]. In particular, some of them were established for short-term economic reasons, such as to meet government demands or to obtain subsidies, rather than to deliver benefits to farmers [16]. Remarkably, only some genuine cooperatives have survived [17]. Therefore, evaluating the development level of specialized farmers' cooperatives in China is essential.

In recent years, the digital economy has developed rapidly worldwide. Information technologies such as the Internet of Things, cloud computing, and big data are ever-increasingly evolving, which brings opportunities for agriculture [18,19]. The Chinese government has advocated "digital industrialization and industrial digitization as the two driving forces" and has consistently strengthened policy support for developing digitalization [19]. In particular, the digital transformation of agricultural and rural areas is an important component of the comprehensive promotion of rural revitalization [20]. The No.1 Central Document for 2022 emphasized the promotion of smart agriculture, enhanced empowerment of digital technology, and the conduction of digital rural pilots. Compared with traditional agricultural operating entities, the digital economy has advantages such as data sharing, intelligent decision-making, resource integration, optimized resource allocation, enhanced production efficiency, improved product quality, and reduced production cost [21]. These opportunities for agricultural development need to be firmly grasped. Although China has made significant progress in developing digital agriculture, it should be noted that the overall digital development of agriculture and rural areas in some provinces and cities still needs to catch up and has many challenges to overcome [22]. Some factors have hindered the development of agricultural and rural information across China, such as weak agricultural and rural digital infrastructure, fragmented data resources, low data availability, poor data development and application, poor data integration and exchange, and inadequate support for administrative services [23,24].

The 20th Party Congress Report states 'The development of the digital economy must be accelerated to facilitate the deep integration of the digital and real economies". The growth and prosperity of the digital economy are becoming important driving forces for China's agricultural growth and rural social development, creating "new areas and paths" and "new driving forces and advantages" for the development of rural areas [25]. As a type of farmers' cooperative organization, specialized farmers' cooperatives face the challenges and opportunities of transformation and upgrading [26]. The No.1 Central Document for 2022 highlighted the aim to "vigorously promote digital rural construction", with an emphasis on "smart agricultural development" and "digital empowerment". Digitalizing agricultural production can increase non-farm employment and the likelihood of land transfer, increasing rural residents' income [27]. The digital economy offers opportunities for agricultural cooperatives to improve their internal governance and external service abilities and expand their business scope [28]. However, there needs to be more evidence of the impact of digitalization on the development of specialized farmers' cooperatives. Thus, it is meaningful to investigate whether digitalization can contribute to the development of

agricultural cooperatives, and to identify the internal mechanisms of practical importance for the sustainable development of specialized farmers' cooperatives and agriculture.

This paper makes the following contributions, considering the existing literature: Firstly, we construct a comprehensive and accurate index system to measure the high-quality development of specialized farmers' cooperatives, providing evidence to evaluate the current development level of agricultural cooperatives in China. Secondly, we examine the driving factors contributing to the development of agricultural cooperatives. This paper broadens the research perspective on the development of farmers' cooperatives. Digitalization and farmers' cooperatives are incorporated into an overall theoretical analysis system. In this way, we make up for the deficiencies in the existing literature. Thirdly, considering the imbalance in regional development, we highlight the critical role of digitalization in promoting agricultural cooperatives across different regions. This paper provides evidence for each area to formulate policies according to local conditions. Finally, this study provides theoretical and practical literature for the government on the accelerated cultivation of specialized farmers' cooperatives and the construction of the digital economy.

2. Theoretical Analysis

2.1. The Digital Economy and High-Quality Development of Specialized Farmers' Cooperatives

The digital economy provides a platform for the sustainable development of specialized farmers' cooperatives in rural areas [29]. It has also increased participation rates among poor rural farmers, who have traditionally been unable to participate in modern markets. The digital economy can improve the high-quality development of specialized farmers' cooperatives in the following respects: First, the digital economy assists cooperatives in rural regions in reducing the cost of acquiring information. Farmers face a higher cost of obtaining information in traditional agricultural production. With the development of the digital economy—which has integrated information technology such as the Internet of Things, cloud computing, and big data—agricultural cooperatives can break the barrier of the rural information block [30]. Specialized farmers' cooperatives are more effective at learning advanced technology, obtaining information on agricultural production, choosing appropriate planting methods, and making the best production decisions for farmers [31].

Furthermore, the digital economy provides an opportunity for innovation in marketing models. The digital economy based on the Internet of Things, cloud computing, and big data helps specialized farmers' cooperatives to reduce the distance between regions, overcome the geographical and temporal barriers in the traditional market, and use powerful platforms and websites for online marketing [32]. Through this marketing method, specialized farmers' cooperatives can obtain the market demand and price in a timely manner, establish cooperative relationships, and expand the channels of income increase for cooperatives [33]. Thus, farm products can take the digital economy's express train, leave the countryside, and sell to every part of the country (and even abroad).

Finally, as an essential part of the digital economy, digital finance inclusion helps specialized farmers' cooperatives to reduce financing constraints and improve the availability of funds. As China's economy pursues high-quality development, comprehensive digital financial services provide more robust support for specialized farmers' cooperatives, which contribute to the rational allocation of social resources, increase the demand for crucial agricultural products, and promote the supply of high-quality agricultural products [34,35]. On this basis, we propose the first hypothesis:

Hypothesis 1 (H1). *The digital economy can foster the high-quality development of specialized farmers' cooperatives.*

2.2. Influence Mechanism

Technological innovation is considered to be the engine of the digital economy, contributing to the development of specialized farmers' cooperatives [36]. Technological innovation, generated from the development of digitalization, can reduce labor costs, increase

productivity, improve product quality, and provide more opportunities for specialized farmers' cooperatives to engage in agriculture more conveniently and efficiently [37]. First, the integration of technology and traditional agriculture has given rise to new routes of development, such as intelligent agriculture. When the digital economy is combined with the conventional agricultural production mode, it will gradually generate new demand for agricultural technology to optimize supply and demand and promote the development of farmers' cooperatives [38]. Second, digitalization fosters the public's sense of identity with technology and creates an excellent technological environment, which positively promotes the efficiency of rural cooperative organizations in China [35]. Therefore, technological innovation can increase efficiency in this process when combining the digital economy with professional agricultural cooperation. Thus, we propose the second hypothesis of this paper:

Hypothesis 2 (H2). *By fostering scientific and technological innovation, the digital economy promotes the development of specialized farmers' cooperatives.*

2.3. Spatial Spillover Effect

The development of the digital economy can break the geographical and temporal barriers in the traditional market. Thus, digitalization can promote the development of specialized farmers' cooperatives in local regions and nearby areas. Firstly, the development of agricultural cooperatives in a specific place may influence the surrounding areas through a learning mechanism, which includes the knowledge spillover path and the learning imitation path. Agricultural cooperatives play a role in their demonstration effect through standardized production. They can also promote their development through learning among organizations, which reflects the spillover effect [39]. Secondly, according to the growth polemic, regions should concentrate the most resources in developed regions and dominant areas and stimulate the development of surrounding regions to achieve the result of "the part as a whole" through spatial effects [40]. In developing cooperatives, the government concentrates most of its resources on demonstrating specialized farmers' cooperatives and hopes that, by establishing them, the growth of surrounding specialized farmers' cooperatives will be stimulated. Therefore, they can be conducive to developing and promoting specialized farmers' cooperatives in nearby provinces. On the basis of this, we propose the third hypothesis:

Hypothesis 3 (H3). *The digital economy can effectively promote the development of specialized farmers' cooperatives in surrounding areas through spatial spillovers.*

3. Methods and Data

3.1. Research Methods

3.1.1. Mediation Effect Model

Based on the analyses, we established the following model (Equation (1)) to empirically study how the digital economy contributes to the development of specialized farmers' cooperatives. According to the mediation effect model proposed by Baron and Kenny, we verified the influence path step by step [41]. The technological innovation was introduced as the regulating factor of the intermediate item, and the intermediate models (2) and (3) of technological innovation were constructed.

$$score_{it} = \alpha_0 + \alpha_1 de_{it} + \alpha_2 control_{it} + \varepsilon_{it} \quad (1)$$

$$tec_{it} = \beta_0 + \beta_1 de_{it} + \beta_2 control_{it} + \varepsilon_{it} \quad (2)$$

$$score_{it} = \gamma_0 + \gamma_1 de_{it} + \gamma_2 tec_{it} + \gamma_3 control_{it} + \varepsilon_{it} \quad (3)$$

where the subscripts i and t represent the province and the year, respectively; $score_{it}$ reflects the high-quality development level of specialized farmers' cooperatives; de_{it} represents the development degree of a country's digital economy; tec_{it} is a reflection of scientific and technological progress; control represents control variables composed of trade openness ($trade_{it}$), human capital (hc_{it}), and financial support (fs_{it}); and ε represents a random error term. Among them, Equation (1) is the overall effect of the digital economy on the development of specialized farmers' cooperatives. Equation (2) reveals the mechanism of the digital economy at an intermediate stage. Formula (3) shows the direct effect of the digital economy on the high-quality development of specialized farmers' cooperatives.

3.1.2. Threshold Model

Constrained by the input intensity of the digital economy and the level of specialized farmers' cooperatives, the relationship between the digital economy and specialized farmers' cooperatives is not linear, and there is a threshold for the impact of the digital economy on cooperatives' development [36]. In the early stages of investment in the digital economy, although the constraints on financing are low, the marginal impact is relatively small, and the effect of the digital economy on the development of cooperatives is limited [35]. With the increase in investment in the digital economy, the marginal cost of products gradually decreases as access to information and business financing constraints continue to fall. At this stage, the marginal benefits of development begin to rise due to increased enterprise productivity and innovation potential. At the same time, the digital economy acts as a tool and platform to integrate technological and financial resources, enabling companies to access resources sustainably and efficiently [42]. In this way, the impact of the digital economy on specialized farmers' cooperatives dynamically expands. The imbalance in the level of the digital economy has led to the imbalanced development of agricultural cooperatives in China. Thus, a threshold model with the digital economy as a threshold variable was established.

$$score_{it} = \alpha_0 + \alpha_1 tec_{it} \cdot I(de_{it} < \gamma_1) + \alpha_2 tec_{it} \cdot I(\gamma_1 \leq de_{it} < \gamma_2) + \alpha_3 tec_{it} \cdot I(de_{it} \geq \gamma 3) + \alpha_4 control_{it} + \varepsilon_{it} \quad (4)$$

where γ is the threshold of inclusive electronic financing, and I (.) is the function of the index.

3.1.3. Spatial Durbin Model

Through knowledge exchange and learning, the production efficiency and development level of specialized farmers' cooperatives are improved, representing a spillover effect. The digital economy creates a new opportunity for China to achieve high-quality development. As a result, the development of a province also affects the development of the surrounding areas [34]. Based on this, this project studied the spatial effects of the digital economy on the high-quality development of specialized farmers' cooperatives by establishing a spatial Durbin model (SDM).

$$score_{it} = \rho W score_{it} + \eta_1 de_{it} + \eta_2 W de_{it} + \delta_{it} \quad (5)$$

where W is the spatial weight matrix, $W \times score_{it}$ is the influence of the neighbor development level of specialized farmers' cooperatives, and $W \times de_{it}$ is the spatial term of the development value of the urban digital economy.

3.2. Variable Definitions

3.2.1. Dependent Variable

The No.1 Central Document has repeatedly proposed to "promote the quality of farmer's cooperatives". Organizational production, market operation, social services, and increasing income are important ways to improve the operation ability of specialized farmers' cooperatives [43]. Liao Xiaojing et al. used micro-survey data to find that local

conditions, classified policies, and financial support are crucial to boosting the development of cooperatives in rural regions [44].

Based on the previous literature and the availability of data [45–48], this study established a set of indicators to assess the qualitative development of specialized farmers' cooperatives, including 4 first-level indicators (management ability index, profitability index, internal governance index, and sustainable development ability index), 8 second-level indicators, and 14 third-level indicators. The dimensions of each index are different. First, the standardization and evaluation method of the evaluation index was conducted, and the entropy weighting method was used to evaluate the results (the results are shown in Table 1). On this basis, the high-quality development indicators of cooperatives in various provinces were obtained. This paper draws a fundamental conclusion about cooperative institutions' development by analyzing the current situation of specialized farmers' cooperatives in China.

Table 1. The evaluation index system of the high-quality development level of specialized farmers' cooperatives.

Primary Index	Secondary Index	Computing Methods	Weight
Operation ability index	Norm management	Number of cooperatives that have passed agricultural product quality certification/Total number of cooperatives	0.126527
		Number of cooperatives with integrated production, processing, and marketing services/Total number of cooperatives	0.009746
		The number of cooperatives with a unified purchase ratio of more than 80%/Total number of cooperatives	0.066464
	Demonstration	Farmers' Cooperative Demonstration Society/Total number of cooperatives	0.036741
Profitability index	Profitability	Distributable surplus of specialized farmers' cooperatives/Specialized farmers' cooperatives' operating income	0.018446
		Number of cooperatives that extract provident funds, public welfare funds, or risk funds/Total number of cooperatives	0.043156
	Profit return	Number of cooperatives in which 60% of the distributable surplus is returned to members according to volume of transactions/Total number of cooperatives	0.030622
Internal governance index	Organization	Number of specialized farmers' cooperatives established by grassroots party organizations/Total number of cooperatives	0.080181
		Number of farmers' professional cooperative federations/Total number of cooperatives	0.097971
	Internal cooperation	Number of cooperatives carrying out internal credit cooperation/Total number of cooperatives	0.142678
Sustainable development ability index	Policy support	Number of cooperatives that received financial support in the year/Total number of cooperatives	0.073314
		Number of cooperatives undertaking national agricultural projects in the year/Total number of cooperatives	0.110421
	Market impulse	Number of cooperatives conducting rural e-commerce/Total number of cooperatives	0.073570
		Number of cooperatives carrying out leisure agriculture and rural tourism/Total number of cooperatives	0.090162

3.2.2. Core Independent Variable

The measurement of the digital economy index should be comprehensive, including not only hardware support—such as network and communication equipment—but also service scenarios, such as telecommunications services and digital finance [43]. By absorbing the indicators for the digital economy in the existing literature [49,50], this study comprehensively selected digital infrastructure, digital finance development, and digital institutional environment as the secondary indices for measuring the digital economy, containing 11 third-level indicators. The principal component analysis approach was used to extract the principal components, measure the weight of each index, and determine each province's level of digital economic development, to ensure scientificity and objectivity (see Table 2).

Table 2. The evaluation index system of the digital economy level.

Objectives	Primary Index	Secondary Index
Digital economy (de)	Digital infrastructure	Length of optical cable (kilometer)
		Number of mobile phone base stations (10,000)
		Mobile phone penetration (number of units per 100 people)
		Number of Internet broadband access ports (10,000)
		Number of Internet domain names (10,000)
	Digital finance development	Coverage of digital finance
		Depth of use of digital finance
		Digitalization degree of digital finance
		Digital inclusive finance index
	Digital institutional environment	Online mobile payment level
		Total turnover of technical contracts (CNY million)

3.2.3. Mediating Variable

Technology innovation (tec) is essential for promoting farmers' cooperatives' development, which helps extend their functions and promote integration efficiency. In this paper, the Evaluation Report of China's Regional Innovation Capability provides the overall effect of China's inter-regional technological innovation. We used this index to conduct an empirical analysis.

3.2.4. Control Variables

To control the impact of relevant factors on the development of professional farmers' cooperatives as much as possible, we chose the following variables as control variables: Trade openness (trade) is the percentage of each province's total imports and exports in the GDP. Human capital (hc) is expressed as a proportion of the university education level. Financial support (fs) is represented by the log of loans of farmers' cooperatives in each of the provinces.

3.3. Descriptive Statistics

Based on the existing data, this project selected 30 regions of China (except Tibet) from 2017 to 2020 as the research object. The data used in this paper are based on the statistical report of China's rural cooperative economy, the *China Statistical Yearbook*, and the Evaluation Report of China's Regional Innovation Capability.

Table 3 describes these variables. First, under China's rural economic and social conditions, the high-quality index (0.4456) and the low-quality index (0.0177) of farmers' cooperatives showed differences under rural economic, social, and economic conditions. Second, the maximum value of the digital economy was 3.4976, with the minimum value being 0.005, meaning that some provinces were relatively backward, and there was significant regional heterogeneity. Third, the maximum and minimum values of technological innovation were 4.0868 and 2.882, respectively, indicating that the technological innovation

in each province was relatively balanced, which may be because the provinces have paid attention to technological innovation in recent years.

Table 3. Descriptive statistics of main variables.

Variable	Obs	Mean	SD	Min	Max
score	120	0.1015	0.0697	0.0177	0.4456
de	120	2.0988	0.7729	0.0050	3.4976
tec	120	3.2839	0.3236	2.882	4.0868
trade	120	0.2500	0.2553	0.0126	1.0637
hc	120	0.1634	0.0829	0.0765	0.5049
fs	120	2.4120	10.3129	0.0000	60.8263

4. Empirical Results

4.1. Time-Series Analysis of Specialized Farmers' Cooperatives' High-Quality Development

The high-quality development levels of specialized farmers' cooperatives in 30 provinces and cities from 2017 to 2020 were calculated using the entropy method. Table 4 presents the results. First, from a national perspective, the high-quality development of agricultural cooperatives' scores rose slightly—from 0.0978 in 2017 to 0.1096 in 2020. Second, the development level of farmers' cooperatives in the eastern region was much higher than that in the central and western regions. This may be because the eastern region has a superior geographical location, long history of development, high cultural quality of workers, and a solid technical force, meaning that agriculture in the eastern region is in good condition. Third, there was a marked increase in the figure for western areas for these years, indicating that cooperatives in the western provinces developed rapidly. This may be because the government has realized that the development of agricultural cooperatives in Western China is relatively backward compared with that in Eastern China. The government increased infrastructure construction in the western region in these years to meet the development needs of specialized farmers' cooperatives. However, cooperatives in the western region still need to catch up to those in the eastern part, which indicates that the government needs to continue to promote the development of farmers' professional cooperatives in Western China to reduce differences in the area and promote balanced development among regions.

4.2. Analysis of Influence Mechanism

The result of the Hausman test in this paper was $p = 0.0000$, so we applied the fixed-effects method to reduce the potential for endogeneity bias. Models (1) and (2) are the benchmark regressions presented in Table 5. The estimated coefficient of the digital economy was positive and significant in Model (1). The estimated coefficient for the digital economy was found to be 0.018 in Model (2), which includes all control variables. Although the estimated coefficient decreased after including the control variables, the model's significance level and fitting accuracy increased significantly, indicating that the control variables were selected reasonably. The digital economy thus optimizes each province's resource allocation, reduces the cost of obtaining information, promotes innovation in marketing models, and contributes to the development of farmers' cooperatives.

Regarding the control variables, the coefficients for trade openness, human capital, and financial support were positive and significant. The results suggest that these factors are all effective ways to promote the development of farmers' cooperatives. In summary, the higher the levels of human capital, trade openness, and financial support, the higher the development of these types of institutions.

Table 4. The changes in the high-quality development levels of specialized farmers' cooperatives in various provinces.

Region	Province	2017		2018		2019		2020	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank
Eastern	Beijing	0.1587	5	0.1544	6	0.1490	5	0.1511	7
	Tianjin	0.1077	11	0.0919	12	0.1302	9	0.0355	27
	Hebei	0.0671	20	0.0685	19	0.0554	24	0.0682	21
	Shanghai	0.3151	1	0.2279	1	0.3786	1	0.4456	1
	Jiangsu	0.0879	14	0.0820	14	0.1083	12	0.1160	10
	Zhejiang	0.1548	6	0.1615	5	0.1566	4	0.1598	6
	Fujian	0.0590	23	0.0602	22	0.0684	19	0.0803	16
	Shandong	0.0614	21	0.0571	23	0.0592	23	0.0807	15
	Guangdong	0.1099	9	0.1139	10	0.0609	22	0.0544	23
	Hainan	0.1810	3	0.1690	3	0.1443	6	0.0703	20
	Eastern Mean	0.1303		0.1186		0.1311		0.1262	
Central	Shanxi	0.0351	27	0.0341	27	0.0404	26	0.0404	26
	Jilin	0.0269	29	0.0299	28	0.0340	28	0.0404	25
	Heilongjiang	0.0538	25	0.0527	26	0.0163	30	0.0177	30
	Anhui	0.0686	18	0.0695	18	0.0871	16	0.0787	17
	Jiangxi	0.1431	7	0.1411	7	0.1381	7	0.1441	8
	Henan	0.0727	15	0.0833	13	0.1001	13	0.0918	13
	Hubei	0.1391	8	0.1274	8	0.1266	11	0.1405	9
	Hunan	0.1848	2	0.1660	4	0.2199	2	0.1904	4
	Central Mean	0.0905		0.0880		0.0953		0.0930	
Western	Nei Monggol	0.0188	30	0.0222	30	0.0345	27	0.0322	28
	Guangxi	0.0925	13	0.0794	16	0.0775	17	0.0771	18
	Chongqing	0.1039	12	0.0953	11	0.0932	15	0.0958	12
	Sichuan	0.0674	19	0.0665	20	0.0937	14	0.1013	11
	Guizhou	0.1761	4	0.1881	2	0.2190	3	0.2302	3
	Yunnan	0.0473	26	0.0532	25	0.0706	18	0.0638	22
	Shanxi	0.0610	22	0.0623	21	0.0673	20	0.0719	19
	Gansu	0.0564	24	0.0734	17	0.0673	21	0.0885	14
	Qinghai	0.0720	16	0.0796	15	0.1280	10	0.1664	5
	Ningxia	0.1092	10	0.1211	9	0.1367	8	0.2792	2
	Xinjiang	0.0710	17	0.0541	24	0.0545	25	0.0486	24
	Western Mean	0.0796		0.0814		0.0948		0.1141	
National	National Mean	0.0978		0.0938		0.1048		0.1096	

Models (3)–(5) present the results of the impact mechanism. In Model (3)'s research results, we can see that the digital economy contributed to improving technological innovation in major cities in China. At the same time, for Model (4), the technological innovation index was 0.1318, reaching a significant level and showing that technological innovation is essential for developing specialized farmers' cooperatives in China. Furthermore, Model (5) added technological innovation to the model. All of the estimated coefficients were positive and passed the significance test, indicating that technological innovation is an essential path for developing Chinese specialized farmers' cooperatives. The estimated coefficient for the digital economy was 0.0139 in Model (5), which was lower than in Model (3), meaning that technological innovation mediated between the digital economy and the development of specialized farmers' cooperatives. A more detailed calculation showed the mediation effect to be 0.0015, representing 23% of the total effect. Thus, Hypotheses 1 and 2 were verified.

Table 5. Empirical results of influence mechanisms.

Variable	Model (1) Score	Model (2) Score	Model (3) Tec	Model (4) Score	Model (5) Score
de	0.0181 *	0.0180 **	0.0374 **		0.0139 *
	(1.87)	(2.48)	(2.26)		(1.90)
tec				0.1318 ***	0.1110 **
				(2.89)	(2.40)
trade		0.0759 ***	−0.0271	0.0731 ***	0.0789 ***
		(3.31)	(−0.52)	(3.25)	(3.53)
hc		0.0777 ***	−0.0747	0.0819 ***	0.0860 ***
		(2.68)	(−1.13)	(2.84)	(3.02)
fs		0.0224 ***	0.00148	0.0227 ***	0.0223 ***
		(7.88)	(0.23)	(8.11	(8.03)
_cons	0.0635 ***	−0.0221	3.221 ***	−0.4179 ***	−0.3796 **
	(3.1)	(−1.16)	(74.15)	(−2.77)	(−2.53)
N	120	120	120	120	120
R-sq	0.008	0.4665	0.3578	0.4888	0.4832

Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively; values in parentheses are *t* values.

4.3. Robustness Test

The last part mainly discusses the promoting effect of the digital economy on farmers' cooperatives. However, many problems need to be improved to develop rural cooperatives in China. Although we added some control variables, there may still be a possibility of missing-variable bias. Moreover, the development of cooperatives requires a higher level of digital economy, which may lead to the reverse. Therefore, we used the variable tool method to solve endogenous problems such as missing variables, reversal of causality, and measurement errors in the robustness test.

The number of mobile telephone base stations was chosen as an instrumental variable to further prove the models' stability, and two-stage least squares was applied to perform robustness testing. As shown in Table 6, the Kleibergen–Paap rk LM statistic passed the 1% significance level, indicating the absence of the phenomenon of tool variables. The Cragg–Donald Wald F statistic was 743.54—higher than the 10% threshold of 16.38, indicating that the models have no problem with weak instrumental variables and that the results that we obtained previously are reliable.

4.4. Analysis of Threshold Effect

We conducted threshold effect regression based on the theoretical analysis to examine the nonlinear relationship between these two main variables. The threshold variable in this section is the digital economy, and the fundamental explanatory variable is technological innovation. The empirical threshold effect test results are presented in Table 7. Our model has only one threshold effect according to the F-statistic values and *p*-values obtained via bootstrapping. Furthermore, the first threshold value is 0.5747, which divides the level of the digital economy into two phases. The influence of the threshold was verified, and some empirical conclusions were obtained, as shown in Table 7. The analysis of the *p*-values and F-statistics obtained via bootstrapping showed that the model has a unique threshold. Thus, this paper puts forward a threshold of 0.5747 and divides it into two stages of development.

Table 6. Results of robustness test.

Variable	Model (1)
	Score
de	0.0146 * (1.81)
tec	0.1099 ** (2.35)
trade	0.0792 *** (2.77)
hc	0.0863 * (1.95)
fs	0.0222 *** (4.78)
_cons	−0.4912 ** (−2.38)
Kleibergen–Paap rk LM statistic	56.164 [0.000]
Cragg–Donald Wald F statistic	743.54 {16.38}
N	120
R-sq	0.5113

Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively; () indicates a standard error statistic; [] indicates a standard error statistic; {} indicates a critical value at the 10% level.

Table 7. Threshold effect test.

Threshold Number	RSS	MSE	F-Statistic Value	*p*-Value	Critical Value		
					1%	5%	10%
Single threshold	0.0280	0.0002	37.12	0.0000	15.6693	19.4632	27.3378
Double threshold	0.0258	0.0002	9.94	0.2433	47.7927	60.5343	93.3286
Triple threshold	0.0243	0.0002	6.85	0.4600	22.2611	33.5742	62.9364

Through the test of the threshold regression model, this paper determined the influence of the threshold regression model. If the first bottom line is reached, it is possible to promote the development of rural professional cooperative organizations. After surpassing the first-order threshold, the correlation factor increased from 0.0658 to 0.0864, which was significant (see Table 8). Therefore, the higher the level of the digital economy, the greater the promotion of farmers' cooperatives' development. This may be because in areas with low levels of digital economic development, an insufficient supply of demand for technological innovation, a lack of capacity for independent innovation, a low rate of conversion of technological achievements, and imperfections in the development mechanism of technological talent, the positive impact is also weakened.

The development of the digital economy has also improved the urban infrastructural environment and facilitated the introduction of technological advances. Therefore, we can safely conclude that the impact of technological innovation on farmers' cooperatives is closely related to the development of the digital economy. When the digital economy level is low, the promotion effect is weak, but it will be enhanced when it reaches a certain extent.

Table 8. Threshold effect estimation results.

Variable	Model (1)
	Score
de < 0.5747	0.0658
	(1.46)
de ≥ 0.5747	0.0864 **
	(1.99)
trade	0.0732 ***
	(3.53)
hc	0.0577 **
	(2.12)
fs	0.0221 ***
	(8.53)
_cons	−0.2608 *
	(−1.81)
N	120
R-sq	0.4785

Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively; values in parentheses are *t* values.

4.5. Spatial Spillover Analysis

4.5.1. Spatial Correlation Test

Digital economics breaks the limitations of time and space, fosters cooperation and competition between various market economic entities, and facilitates the flow of resources between provinces. Investigating the spatial spillover effect of the digital economy on the development of specialized farmers' cooperatives is crucial. Before conducting spatial econometrics, we should examine the spatial correlation in the data. The results of the global Moran's indices from 2017 to 2020 are displayed in Table 9. As can be seen, the Moran's indices of the main variables are more significant than 0, indicating that the spatial distribution is not random but exhibits a "high-high clustering, low clustering" characteristic. Therefore, the spatial spillover effect must be addressed. Otherwise, it will lead to errors in the model results.

Table 9. Moran's indices of main variables.

Year	Score		Digital Economy		Technology Innovation	
	Moran's	Z-Value	Moran's	Z-Value	Moran's	Z-Value
2017	0.290 ***	2.815	0.279 ***	2.571	0.357 ***	3.202
2018	0.300 ***	2.732	0.300 ***	2.738	0.312 ***	2.852
2019	0.203 **	2.159	0.291 ***	2.673	0.325 ***	2.953
2020	0.114	1.363	0.297 ***	2.721	0.313 ***	2.858

Note: ** and *** indicate statistical significance at 5% and 1%, respectively; values in parentheses are *t* values.

4.5.2. Empirical Analysis of the Spatial Effect

All of the variables have spatial autocorrelation, indicating that spatial econometric models are suitable for analysis. From the conclusions of the LM and Hausman tests, we should choose a model that considers the fixed effects of both human and temporal factors. In the model estimation, we used the likelihood ratio to verify whether the spatial Durbin model would be degraded to SAR or SEM. Our tests showed that the SDM would not be degraded to other models for research. The results of the overall impact analysis of the SDM are shown in Table 10 below. The results show that the overall parameters obtained using the proposed method are positive. The 5% significance test was passed in the two dimensions of spatial correlation. Empirical analysis showed that the digital economy plays a positive role in facilitating the development of cooperative organizations, verifying the rationality of Hypothesis 3. Regional, economic, and other factors can enhance this role.

Table 10. Regression results of the spatial Durbin model.

Variable	Inverse Distance			Geographical Proximity		
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
	Direct	Indirect	Total	Direct	Indirect	Total
de	0.0644	0.6123 **	0.6767 **	0.0363	0.1432 **	0.1796 **
	(1.46)	(2.29)	(2.42)	(1.18)	(2.11)	(2.16)
tec	0.0831 **	0.5106 **	0.5938 ***	0.0752 **	0.1293	0.2045 **
	(2.21)	(2.28)	(2.59)	(2.06)	(1.53)	(2.19)
trade	0.0921 ***	0.4390 ***	0.5311 ***	0.0459 **	0.4185 ***	0.4644 ***
	(5.00)	(2.92)	(3.41)	(2.47)	(4.74)	(5.23)
hc	0.0850 ***	0.0895	0.1745	0.0863 ***	0.0876 *	0.1739 ***
	(3.76)	(0.77)	(1.53)	(4.12)	(1.83)	(3.56)
fs	0.0241 ***	0.0159	0.0400 ***	0.0224 ***	0.0044	0.0269 ***
	(10.5)	(1.46)	(3.46)	(10.52)	(0.63)	(3.48)
N		120			120	
R-sq		0.3838			0.4948	

Note: *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively; values in parentheses are *t* values.

On the other hand, using the inverse distance matrix as an example, the digital economy's direct effect is 0.0644, and its indirect effect is 0.6123; the direct effect of technological innovation is 0.0831, and its indirect effect is 0.5106. In both cases, the spillover effects are more substantial than the direct effects, indicating that, when controlling for the geographical distance factor, the digital economy is more likely to promote the development of specialized farmers' cooperatives in neighboring regions than locally. It can be concluded that the digital economy has an additional positive effect on the qualitative development of specialized farmers' cooperatives.

4.6. Heterogeneity Analysis

The development of the eastern, central, and western regions in China must be balanced. In some areas, economic growth could be faster. In many villages, farmers have a poor reputation. Compared with the east of China, the economic development of the west lags far behind. On this basis, we divided the 30 provinces and cities into three regions—eastern, central, and western—and tested their regional differences through empirical methods (see Table 11).

Table 11. Results of heterogeneity regression.

Variable	Model (1)	Model (2)	Model (3)
	Eastern	Western	Central
	Score	Score	Score
de	−0.0106	0.0374 **	0.0133
	(−0.66)	(5.01)	(1.11)
tec	0.0473	0.0571	0.0309
	(0.47)	(0.95)	(0.66)
trade	0.0714 **	−0.8878 ***	−0.3183
	(2.54)	(−4.78)	(−1.18)
hc	0.0475	0.1567 ***	−0.0236
	(0.74)	(4.79)	(−0.71)
fs	0.0234 ***	0.0213	0.0439 **
	(6.35)	(4.65)	(2.5)
_cons	−0.2035	−0.0856	−0.0317
	(−0.55)	(−0.46)	(−0.10)
N	120	120	120
R-sq	0.7506	0.1984	0.3753

Note: ** and *** indicate statistical significance at 5% and 1%, respectively; values in parentheses are *t* values.

The digital economy can improve the development level of specialized farmers' cooperatives in the western region ($\alpha = 0.0374$, $p < 0.05$), but the coefficient is not apparent in the eastern and central regions. This may be because the eastern region is more developed than the central and western regions. The upgrading of specialized farmers' cooperatives will have higher requirements on the digital economy, meaning that the impact will be minor. In addition, when farmers' professional cooperatives develop to a higher level, the positive influence of the digital economy on them has already been released, meaning that the impact of the digital economy on them declines. The results show apparent regional differences in the roles of agriculture and the rural sector in the development of China. At the same time, there are differences in the digital economy and in scientific and technological progress among the different regions of China, with significant impacts on the development of rural cooperatives. Therefore, all localities should vigorously develop cooperatives under their actual conditions and promote harmonious development among various regions.

5. Discussion

The high-quality development of specialized farmers' cooperatives is crucial to the sustainable development of agriculture and the realization of rural revitalization. Therefore, it is meaningful to comprehensively evaluate the development level of agricultural cooperatives and further investigate the driving factors that impact their development. It is of theoretical and practical significance for the government to formulate policies to promote the sustainable development of specialized farmers' cooperatives and reduce regional differences.

This paper assessed the total high-quality scores of specialized farmers' cooperatives based on existing references. We found that the national level of development was low and had only increased marginally over the studied years, indicating that the government needs to make efforts to enhance the overall development level of farmers' cooperatives in China. From the perspective of regional heterogeneity, agricultural cooperatives in the eastern areas had the highest development levels in these years, because the eastern areas were more developed than the central and western regions. This result is consistent with the viewpoint of Abate that specialized farmers' cooperatives are in locations with a developed market structure [51]. Although the government has vigorously developed farmers' professional cooperatives in the western region recently, there is still a considerable difference between the east and the west. Moreover, the development of farmers' cooperatives varied considerably between provinces, reflecting significant regional differences. Thus, governments must promote high-quality, coordinated development of farmers' cooperatives among regions and reduce the disparities in development between them.

Through the econometric analysis, we can safely conclude that digitalization has a driving effect in promoting the development of specialized farmers' cooperatives, which remains significant in the robustness test. Moreover, there was one threshold effect, indicating that the impact of the digital economy on the development of agricultural cooperatives varies at different levels of digitalization [52]. This conclusion is consistent with the idea in Catalonia that agricultural cooperatives should take advantage of digitalization [53]. When the level of digitalization is low, the promoting effect of the digital economy on cooperatives is only partial. When the level of digitalization reaches a particular value, the positive impact of the digital economy on cooperatives is gradually enhanced. Therefore, it is necessary to strengthen the construction of a digital economy in each region, and the promotion of cooperatives can be significantly improved when digitalization reaches a certain level.

From the total effect decomposition results of the spatial Durbin model, we can see that digitalization can drive the growth of specialized farmers' cooperatives in particular regions and the surrounding areas. A possible reason is that the development of digitalization facilitates cross-regional knowledge exchange and learning imitation between specialized farmers' cooperatives. Therefore, the government should give full play to the leading

role of model cooperatives, which can also increase the development of cooperatives in surrounding areas.

According to the mediation effect analysis, technological innovation is an important way for digitalization to promote the development of specialized farmers' cooperatives, indicating that innovation proposed by the digital economy provides opportunities for the development of agriculture [54]. The combination of the digital economy and innovation offers a new opportunity and environment to develop cooperatives in rural areas [55], which is consistent with the findings from the Niayes region of Senegal [56]. In addition, it is also necessary for the government to increase the degree of trade openness, education levels, and financial support, which can significantly promote the development of agricultural cooperatives.

There is evident heterogeneity in the role of the digital economy in promoting the development of specialized farmers' cooperatives. The correlation between digitalization and the high-quality development of specialized farmers' cooperatives was the lowest in the eastern region of China and the highest in the western region. On the one hand, this may be because the western areas are more backward in various factors of production, less capable of innovation and development, and less dynamic in economic growth, which not only limits the upgrading of the digital economy but also hinders the development of specialized farmers' cooperatives to some extent, causing a higher correlation between them. On the other hand, specialized farmers' cooperatives in the eastern region were more developed. The high demands of the digital economy had a minor impact on the development of cooperatives. Therefore, policymakers should formulate the cooperative development mode according to the situation of different regions.

6. Conclusions and Suggestions

6.1. Conclusions

This project used 30 regions of China (excluding Tibet) from 2017 to 2020 as the research object to examine the impact of the digital economy on the development of specialized farmers' cooperatives through various econometric methods. The conclusions are summarized as follows: Firstly, from a national perspective, the high-quality development level of agricultural cooperatives was measured, and it increased slightly from 0.0978 in 2017 to 0.1096 in 2020. From a regional perspective, the development level of specialized farmers' cooperatives in the eastern areas was always higher than in the central and western parts of China. Furthermore, the figure for the western region rose considerably to 0.1141 in 2020. Secondly, the development of specialized farmers' cooperatives in a particular province is closely related to its digital economy level. Moreover, technological innovation played a mediating role on this path, accounting for 23% of the total effect. Thirdly, there is the nonlinear feature of increasing marginal benefit between the digital economy and farmers' cooperatives. After crossing the first digital economy threshold value of 0.5747, the stimulant effect was enhanced and passed the 5% significance level. In addition, the digital economy had a positive spatial spillover effect on the development of agricultural cooperatives in surrounding regions, at the significance level of 5%. Finally, the digital economy can significantly contribute to the development of cooperatives in rural Western China, with an impact coefficient of 0.0374. However, its impact is negligible in China's eastern and central regions.

6.2. Suggestions

Here, we put forward policy advice according to the conclusions that we drew. Firstly, policymakers should strengthen the construction of a digital economy in all provinces, which will accelerate its construction in surrounding areas. In addition, they could focus on digital infrastructure construction in various provinces, rationally use e-commerce platforms, strengthen brand-building, and promote the application of an Internet-based digital economy in the agricultural industry chain.

Secondly, these findings suggest that all regions should focus on creating an environment for innovation and relying on the digital economy to stimulate independent innovation and technological transformation. Therefore, we could solve the problems of traditional agriculture, such as reliance on cheap labor, severe product homogeneity, and failure to pursue product innovation and technological advancement.

Thirdly, the relationship between digitalization and the high-quality development of cooperatives in different regions should be considered. In Western China, attention should be paid to promoting the digital development process. The central and eastern areas can be encouraged to help and provide technical support to the western region.

6.3. Limitations and New Directions

Although this paper conducted systematic theoretical and empirical analyses, some limitations still require improvements. Firstly, one limitation of this paper is its scope, in that we only focused on the impact of digitalization on the development of specialized farmers' cooperatives, using China as a case study. The results of this paper can provide evidence for countries such as China to develop specialized farmers' cooperatives. Future research could expand the scope of the study to include other countries where extended digitalization has occurred in agriculture, which could enrich our research. Secondly, due to the limitations of the research data, we only focused on the short panel data of 30 Chinese provinces and cities from 2017 to 2020, with limitations in the time dimension. Future studies could extend the timeframe, which would be more meaningful for the high-quality development of specialized farmers' cooperatives.

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