



Article Research on the Development Level of Rural E-Commerce in China Based on Analytic Hierarchy and Systematic Clustering Method

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Copyright: © 2022 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). School of Marxism, China University of Petroleum (Beijing), Beijing 102249, China; lixiaoxia@cup.edu.cn

Abstract: The development of rural e-commerce in China has important economic, social, cultural, and ecological values, which is conducive to the sustainable development of rural areas, the efficient use of rural resources, and the comprehensive development of farmers. This paper aims to establish a comprehensive evaluation index system for the development level of rural e-commerce, use the analytic hierarchy method to determine the weights of each level, and conduct cluster analysis of the development level of provinces through the systematic clustering method. The results show that: (1) Infrastructure, digital management, digital governance, technological innovation, and talent cultivation are all important factors affecting the development level of rural e-commerce, of which infrastructure construction, digital business expansion, and e-commerce talent cultivation are more important. (2) Overall, the development level of rural e-commerce in China's provinces presents such a pattern: Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu, Shandong, and Fujian are comprehensively leading; Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjiang, and Tibet are developing rapidly, and the rest of the provinces are developing and growing. (3) The Yangtze River Delta region is the region with the most active development level of rural e-commerce in China. The development of rural e-commerce in China is characterized by the south being better than the north and the east better than the west. The findings of this study can provide a basis for evaluating the level of rural e-commerce in various provinces in China, and provide guidance for the development of rural e-commerce in various provinces to achieve high-quality development in the next step.

Keywords: rural e-commerce; China; AHP; systematic clustering

1. Introduction

China has just completed the historic task of eliminating of absolute poverty [1]. However, how to solve the relative poverty level and realize the sustainable development of rural areas is a long-term problem that the Chinese government and even the whole world must face. In recent years, with the continuous improvement in network, transportation, and other infrastructure construction in rural areas of China, e-commerce has played an increasingly important role in rural development. Developing e-commerce in rural areas will help the agricultural products in rural areas to go to the market better and realize greater economic value; contribute to the overall improvement in farmers' quality and the return of talents, and realize greater social and cultural value; and contribute to the sustainable development of rural environment and realize greater ecological value. It will help narrow the gap between the rich and the poor and achieve greater political value. All in all, the development of rural areas, which has very important practical significance.

The development of rural e-commerce in China is the modern advantage of digital technology in rural areas, an important means to transform agricultural production mode, and an effective way to consolidate the achievements of China's poverty alleviation. In recent years, with China's vigorous popularization of rural basic network coverage and digital facilities construction, China's rural e-commerce has become an important carrier for promoting production and consumption, expanding domestic demand, industrial

upgrading and increasing farmers' income [2]. China's rural e-commerce is developing vigorously and is a new market for China's e-commerce. In order to further make ecommerce a stable market for rural industries, Chinese government departments attach great importance to it. Starting from 2017, Document No.1 of the Central Committee of China vigorously promotes the development of rural e-commerce. China's Ministry of Commerce has also promoted the comprehensive demonstration of e-commerce in rural areas since 2014, supporting demonstration counties in all aspects, such as finance, finance, taxation, infrastructure and technical training [3]. By the end of 2020, China had built 2120 county-level e-commerce public service centers and logistics distribution centers, and 137,000 village-level e-commerce service stations, basically achieving full coverage of express outlets in towns and villages, with the proportion of express delivery directly to villages increasing to over 50%, and over 3000 express parcels collected and delivered in rural areas. In 2021, the number of rural Internet users in China reached 284 million, and the Internet penetration rate in rural areas is 57.6%. In 2021, China's rural online retail sales reached 2.05 trillion yuan, an increase of 11.3% over the previous year, and the growth rate accelerated by 2.4 percentage points. Among them, the online retail sales of agricultural products amounted to 422.1 billion yuan, an increase of 2.8% over the previous year. The rural e-commerce infrastructure has been rapidly improved to support the development of the industry. In 2022, the Chinese government issued the "Digital Rural Development Action Plan (2022-2025)", and the level of rural e-commerce development in China has become an important measure of rural development in China [4]. Therefore, this research is based on the arrangement of key projects in China's "Digital Rural Development Action Plan (2022–2025)" and the government's policy guidance, and establishes this research index system. Judging from the current research situation, although governments at all levels have successively issued policy documents on the development of rural e-commerce, and some scholars have selected a certain area for quantitative evaluation, few studies have taken the current development level of rural e-commerce in China as the research object, integrated relevant national policy arrangements, established a relatively uniform and applicable evaluation index system, and failed to evaluate the overall development level of rural e-commerce in China, lacking the verification of the implementation effect of policies and the effectiveness of policy tools.

However, in the process of promoting the development of rural e-commerce, there are inevitably various problems in China:

First, the degree of rural digital infrastructure construction and popularization is not uniform, which makes the development of the rural e-commerce market in China uncoordinated [5]. The development bases of rural e-commerce in different parts of China are different, and the eastern and western parts, rural areas in the north and south, etc., all reflect different development needs. Farmers' awareness of e-commerce industry in different regions directly leads to different levels of local industrial development.

Secondly, there is a conflict between the traditional Chinese rural differential pattern and the "cross-relationship" development of the rural e-commerce industry under the guidance of digital technology. In China's rural areas, farmers' recognition of e-commerce development mode is gradually increasing, but generally speaking, the development form of e-commerce industry has fundamentally expanded the "man-land relationship" in the rural pattern, resulting in older farmers in rural areas unable to find a "new orientation" suitable for their own development. In the process of continuous promotion, rural ecommerce mobilized some farmers who had been solidified on the land, so that farmers not only "produced" agricultural products, but also participated in the "sales" process [6]. Some farmers stopped planting and breeding themselves and became salesmen, which in itself is a new challenge to the "cross-relationship" development.

Third, China's rural e-commerce still has much room for development in the training of professional talents. At present, China's rural development has also entered the digital age. China has specially promoted the project of "digital e-commerce to promote agriculture", and vigorously promoted rural e-commerce to play a role in China's rural revitalization. This highlights the urgency and necessity of cultivating e-commerce professionals. Digital technology has entered the countryside, adding algorithmic power to the process of rural construction, changing the tradition of rural development based on demographic dividend, and highlighting the important role of talents in rural industrial development and agricultural and rural modernization [7]. Only farmers with e-commerce digital literacy can become the leaders of rural development in the future.

Fourthly, the supply, sales and logistics chain of rural e-commerce in China still needs to be optimized. China's rural e-commerce has not been systematized in the production and supply of large-scale products. On the sales side, rural e-commerce often does not have the ability to compete with professional brand e-commerce, and the marketing model and publicity model need to find a new path for development from the lagging state. In addition, the logistics chain is still unevenly distributed, and the geographical location has become the biggest constraint to the development of e-commerce in some rural areas [8].

These challenges are all problems that the Chinese government has to face. China's government is eager to obtain a high-quality rural e-commerce development level, and it needs to deepen the cognition level of rural e-commerce development in various provinces of China from qualitative to quantitative. The purpose of this paper is to establish a comprehensive evaluation index system, quantitatively measure the development level of rural e-commerce, and provide data support for the government to find a precise policy force point and implement regional strategic control.

2. Literature Review

As an effective measure to promote the digital economy, e-commerce has played an important role in the development of modern society [9–11]. China vigorously promotes the construction of "Digital China", not only taking the combination of digital technology and e-commerce as an important driver of urban development, but also promoting digital rural development as an important aspect of sustainable rural development in the coming period [12–15]. In 2022, China will comprehensively promote rural revitalization, and in terms of focusing on industry to promote rural development, emphasize the implementation of the "digital business to revitalize agriculture" project, promote e-commerce into the countryside, and at the same time promote the healthy development of agricultural and sideline products live-streaming with goods, seize the opportunity of digital development, and create new development in the field of e-commerce. The reason is that, on the one hand, rural e-commerce has played an important role in the early rural development, especially in the process of China's poverty alleviation, rural construction and development, and the improvement in individual farmers [16]. On the other hand, the future development level of rural e-commerce is related to the level of China's agricultural and rural modernization and the overall process of national development [17]. Therefore, this study selects China's rural e-commerce as the research object to examine its development level.

"Accelerating digital development and building a digital China" was identified as the main content of the 14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Long-term Goals for 2035 [18]. If China is to fully embrace the digital age, it must activate the potential of data elements in each region and promote the transformation of digital production, lifestyle and governance as a whole [19]. Rural areas are the basic units that make up Chinese society, and for Chinese culture, they are the birthplace of traditional culture with Chinese characteristics, and for the development of world culture, Chinese rural areas have their own unique economic and cultural characteristics [20]. Therefore, the level of digital development and e-commerce development in rural areas of China is a key issue in building a digital China. From the reports on the development of rural e-commerce in China and regional surveys in the past three years, we found that although there are regional differences in the overall development level of rural China, almost all regions are developing rural e-commerce to varying degrees [21]. In particular, it is more prominent that in some areas, the development of rural industries driven by rural e-commerce has become the main

force of the regional economy, and a number of rural industrial brands and rural network e-commerce managers have been spawned [22]. Therefore, we explore some indicators that can reflect the development level of rural e-commerce in China, and explore the factors that promote the development of rural e-commerce.

Rural e-commerce belongs to the category of digital economy theory, and scholars in different countries and fields have put forward different perspectives. In general, the digital economy is seen as a way to innovate socioeconomic modes of operation through technological convergence [23]. On the basis of excavating the role of the digital economy, the factors that evaluate the development level of the digital economy include: whether the industrial structure adjustment under the influence of the digital economy is positive, whether the market participants are diversified, whether the information technology coverage is comprehensive, and whether the new digital models and new formats are rich [24]. Through the continuous understanding of the digital economy, the discussion and evaluation analysis around rural e-commerce have gradually developed from a single phenomenon analysis to multiangle research [25]. First, some scholars pay attention to the construction of a rural e-commerce theoretical system; they analyze the influencing factors of rural e-commerce, such as policy factors, infrastructure factors, technology popularization factors, talent factors, capital factors, etc. [25]. They also analyze the role of rural e-commerce, such as promoting agricultural and rural modernization, promoting rural regional economic development and transformation, promoting China's urbanization process, and narrowing the gap between urban and rural areas [26]. Second, some scholars enrich the theoretical system of rural e-commerce by analyzing the practical cases of rural e-commerce, for example, the digital agriculture-planning scheme of largescale livestock and poultry farms [27], the research on digital marketing model [28], etc. Third, some scholars have proposed optimization plans by analyzing the constraints on the future development of rural e-commerce. For example, specific measures such as broadband highways, mobile network popularization, public Internet of Things access plans, e-government, and IT employment training have promoted the construction of smart villages [29]. In addition, they also believe that it is necessary to establish a supporting development system on derivative digital services [30], and use the integrated development of the rural public cultural service system and rural tourism, rural brand incubation, and the high-quality development of rural public services [31] to achieve the development of rural e-commerce in the future [32]. It can be seen that the current research on rural e-commerce has been relatively extensive, but the evaluation system for the development level of rural e-commerce has not yet been formed, and the strategic analysis based on quantitative evaluation is not sufficient.

By establishing a comprehensive evaluation index system, this study provides specific quantitative indicators for investigating the current situation of rural digital productivity, finding a breakthrough to stimulate the endogenous power of rural revitalization, promoting the development of the rural digital economy, and improving farmers' quality and skills. Theoretically, this research is conducive to perfecting the theory of digital rural development and enriching the specific mode of rural digital industry development. By introducing the scientific evaluation system and completing the theoretical model construction, it is beneficial to scientifically judge the development level of China's rural e-commerce. In practice, it provides strategies based on data analysis for China to improve the efficiency of rural digital governance, and promote rural revitalization and agricultural and rural modernization. In the history of human development, this study takes the future development of China's rural areas after large-scale poverty reduction as an example, and provides a new way to balance "consolidating poverty reduction achievements" and "sustainable innovation and development" for more regions and countries in the world that are eliminating of absolute poverty. The purposes of this study were: (1) based on literature combing and a fieldwork method, citespace is used to establish a comprehensive and scientific evaluation index system for rural e-commerce development level; (2) based on the analytic hierarchy method, the weight of each indicator of the rural e-commerce development

system is determined, and the development level and growth rate of the rural e-commerce development level in various provinces in China from 2019 to 2021 are calculated; (3) based on the system dustoring method, relying on the 25 characterization indicators established

on the system-clustering method, relying on the 25 characterization indicators established at the first level, SPASS 25.0 is used to cluster the analysis of 31 provinces and put forward targeted measures. Although there may still be imperfections in the evaluation method, the results of this study provide data support for assessing the development level of rural e-commerce in various provinces, and also improve the guidance for the next step of rural e-commerce development in various provinces.

3. Construction of Indicator System

This paper adopts the methods of a literature review and field investigation to determine the evaluation index system. Firstly, based on the connotation and characteristics of rural e-commerce development, the research team determined the rules indicators (firstlevel indicators and second-level indicators) reflecting the development level of rural e-commerce. Secondly, using citespace software, the related literature (based on HowNet) from 2001 to 2022 was classified and analyzed, and the high-frequency vocabulary catalogue, which is the basis of index selection, was obtained. Finally, a questionnaire was set up to interview 20 government officials (including county-level, municipal-level, provinciallevel rural revitalization bureaus) and 20 university scholars of related research in Beijing, and the opinions and data of 40 officials were collected, so as to clarify the final index system, as shown in Table 1.

Rural e-commerce Digital e-commerce Digital e-commerce Digital e-commerce Online retail sales of agricultural digital economic income C10 % Rural e-commerce Agriculture digitalization level B6 Village logistic agricultural digital economic of the structure digital service structure digital economic for the dilage economere ecore the number of employed people C12 <	Target Layer	Rule Layer (First)	Rule (Secondary)	le Index Layer dary)	
Rural e-commerce Digital business A2 Management	Rural e-commerce development level		Internet penetration B ₁	Proportion of fiber-optic households in villages C ₁	%
Rural e-commerce development level Digital business A2 Digital economic benefits B5 Digital economic benefits B5 Online retail sales of agricultural digital economic income C10 number Rural e-commerce development level Management decisions B7 Management decisions B7 Village -commerce and figure and				Proportion of mobile terminals per capita in the village C ₂	number
Village logistics intelligent service terminal coverage C4%Infrastructure A1Infrastructure A1The average amount of digital services purchased by villagers in a year C5numberDigital asset investment B3The proportion of financial investment in the village's digital infrastructure C6%Digital platform B4The average number of villagers' e-commerce APP usage C7numberDigital platform B4Village e-commerce service site coverage C8%Digital business A2Digital economic benefits B5Online retail sales of agricultural products accounting for the proportion of total transactions C9%Rural e-commerce development levelAgriculture digitalization level B6Village level e-commerce annual output value increase C11numberManagement decisions B7The number of digital e-commerce management service agencies in the village C13number			Logistics system B ₂	Number of village logistics distribution chains C ₃	number
Infrastructure A1 The average amount of digital services purchased by villagers in a year C5 number Digital asset investment B3 The proportion of financial investment in the village's digital infrastructure C6 % The average number of villagers' e-commerce APP usage C7 number Digital platform B4 The average number of villagers' e-commerce APP usage C7 number Village e-commerce service site coverage C8 % Digital business A2 Digital economic benefits B5 Online retail sales of agricultural products accounting for the proportion of total transactions C9 % Agriculture digitalization level B6 Village e-commerce annual output value increase C11 number Rural e-commerce development level Management decisions B7 The number of digital e-commerce management service agencies in the village C13 number				Village logistics intelligent service terminal coverage C ₄	%
Rural e-commerce Management Management Village e-commerce annual output value increase C11 number Management Management Management The number of digital e-commerce management service agencies in the village C13 number		Infrastructure A ₁	Digital asset investment B ₃	The average amount of digital services purchased by villagers in a year C_5	number
Rural e-commerce development level				The proportion of financial investment in the village's digital infrastructure C_6	%
Bigital plation b4 Village e-commerce service site coverage C8 % Digital business A2 Digital economic benefits B5 Online retail sales of agricultural products accounting for the proportion of total transactions C9 % Agriculture digitalization level B6 Agriculture digitalization level B6 Village e-commerce overs the number of employed people C12 number Rural e-commerce development level Management decisions B7 The number of digital e-commerce management service agencies in the village C13 number			Digital platform B ₄	The average number of villagers' e-commerce APP usage C_7	number
Rural e-commerce development level Management decisions B ₇ Online retail sales of agricultural products accounting for the proportion of total transactions C ₉ % Rural e-commerce development level Management decisions B ₇ Village -level e-commerce of the village C ₁₃ number Management decisions B ₇ The number of digital e-commerce and financial affairs number				Village e-commerce service site coverage C ₈	%
Digital business A2 Digital business A2 Digital business A2 Digital business A2 Annual per-capita agricultural digital economic income C10 number Rural e-commerce development level Agriculture digitalization level B6 Village-level e-commerce annual output value increase C11 number Rural e-commerce development level Management decisions B7 The number of digital e-commerce management service agencies in the village C13 number		Digital business A ₂	Digital economic benefits B ₅	Online retail sales of agricultural products accounting for the proportion of total transactions C ₉	%
Business A2 Agriculture Village-level e-commerce annual output value increase C11 number Rural e-commerce digitalization level B6 Village e-commerce covers the number of employed people C12 number Rural e-commerce Management The number of digital e-commerce management service agencies in number Management the village C13 number				Annual per-capita agricultural digital economic income C ₁₀	number
Rural e-commerce development level digitalization level B ₆ Village e-commerce covers the number of employed people C ₁₂ number Management decisions B ₇ Management decisions B ₇ The number of digital e-commerce management service agencies in the village C ₁₃ number			Agriculture digitalization level B ₆	Village-level e-commerce annual output value increase C_{11}	number
Kural e-commerce The number of digital e-commerce management service agencies in number development level Management the village C ₁₃ number				Village e-commerce covers the number of employed people C_{12}	number
decisions B ₇ The proportion of party affairs village affairs and financial affairs		Digital governance A ₃	Management decisions B ₇	The number of digital e-commerce management service agencies in the village C_{13}	number
Digital governance A_3				The proportion of party affairs, village affairs, and financial affairs disclosed online C_{14}	%
Agricultural product quality and safety tracking chain coverage C ₁₅ %			Monitoring and early warning B ₈	Agricultural product quality and safety tracking chain coverage C_{15}	%
early warning B ₈ Coverage of rural digital e-commerce quality assurance service chain C ₁₆ %				Coverage of rural digital e-commerce quality assurance service chain C_{16}	%
TechnicalDigital application rate of agricultural production C_{17} %		Technological innovation A_4	Technical applications B ₉	Digital application rate of agricultural production C_{17}	%
applications B_9 The proportion of agricultural intelligent machinery C_{18} %Technological $\%$				The proportion of agricultural intelligent machinery C ₁₈	%
innovation A ₄ Innovative davelopment B ₄ Contribution rate of technological innovation in agricultural %			Innovative development B ₁₀	Contribution rate of technological innovation in agricultural product production C ₁₉	%
The increase in the number of digital agricultural product brands C_{20} %				The increase in the number of digital agricultural product brands $C_{\rm 20}$	%
$\frac{1}{1}$ The proportion of full-time e-commerce in rural areas C ₂₁ %		Talent cultivation A=	Smart farmers B ₁₁ -	The proportion of full-time e-commerce in rural areas C_{21}	%
Talent cultivation A ₅ The proportion of digital returnees to entrepreneurs C ₂₂ %				The proportion of digital returnees to entrepreneurs C_{22}	%
Cultivation system B_{12} Number of local internet celebrity cultivation institutions C_{23} number			Cultivation system B ₁₂ -	Number of local internet celebrity cultivation institutions C_{23}	number
The proportion of digital e-commerce professionals introduced C_{24} %				The proportion of digital e-commerce professionals introduced C_{24}	%

Table 1. Evaluation index system.

The index system of rural e-commerce development level includes four levels: target layer, rule layer (primary and secondary) and index layer. Specifically, the target layer is an index that comprehensively reflects the development level of rural e-commerce. The first-level indicators include five dimensions: infrastructure A₁, digital management A₂, digital governance A₃, technological innovation A₄ and talent cultivation A₅. Secondary indicators are composed of 12 subindicators: Internet penetration B₁, logistics system B₂, digital asset investment B₃, digital platform B₄, digital economic benefits B₅, agriculture digitalization level B₆, management decisions B₇, monitoring and early warning B₈, technical applications B₉, innovative development B₁₀, smart farmers B₁₁ and cultivation system B₁₂, which are the core indicators that can be specifically reflected and measured in the process of rural e-commerce are analyzed. The design of first-level indicators corresponds to its connotation classification. Specifically:

 A_1 reflects the digitalization level of rural e-commerce development level, that is, means and methods. Based on digital technology, infrastructure A_1 makes full use of scientific and technological dividends in the process of industrial development, and promotes the industry to meet the new demand of digital economy development.

A₂ reflects the economic benefits of the development level of rural e-commerce, that is, the upgrading of rural industries with economic development as the judgment index, which is different from the mainstream of traditional rural economic development. The rural industries driven by digitalization not only expand the field in scale development, but also pursue quality improvement and growth rate in quality development, injecting new ideas into the rural economy.

 A_3 and A_4 reflect the governance benefits of rural e-commerce development level. On the basis of rural economic revitalization, the development of rural industry in digital construction is directly linked to the level of rural digital governance and technological innovation, and affects other areas of agricultural and rural modernization.

A₅ reflects the main benefits of rural e-commerce development level agriculture, rural areas and farmers. The prosperity of agriculture lies in the fact that agriculture has leapfrogged traditional "farming" and gradually realized agricultural modernization. The prosperity of rural areas lies in the integration of rural construction and development into the overall construction and development of "Digital China" and the realization of systematic upgrading. The prosperity of farmers lies in their all-round self-development, and their production and living standards have been greatly improved, which has become the main driving force for rural revitalization and development.

4. Empirical Analysis

4.1. Data Sources

Based on China's rural development data from 2019 to 2021, this paper evaluates and analyzes the development level of rural e-commerce in China. The raw data of each indicator were from the China statistical yearbook for the regional economy, the China city statistical yearbook, the China civil affairs' statistical yearbook, statistical yearbook and statistical bulletin of provinces, autonomous regions, statistical yearbook, and statistical bulletin of relevant cities. The missing data are supplemented by SPASS25.0. The original indicator data are normalized to eliminate the effect of unit inconsistencies between changes and to positive the negative indicators.

The positive indicator is calculated as:

$$Z_{ij} = \frac{X_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}$$
(1)

The negative indicator is calculated as:

$$Z_{ij} = \frac{\max(X_j) - X_{ij}}{\max(X_j) - \min(X_j)}$$
(2)

where Z_{ij} represents the metric data after data normalization, X_{ij} represents the raw data of the j_{th} indicator in the i_{th} province, and $\max(X_j)$ and $\min(X_j)$ represent the maximum and minimum values in the raw data for the j_{th} indicator in the i_{th} province [33].

4.2. Weight Calculation

According to the evaluation index system of China's rural e-commerce development level constructed in Table 1, for this paper, we invited 40 experts to score the importance of each level index, and then used Yaahp software to calculate the judgment matrix and check the consistency. Based on this, the weight of each index in the index system was calculated. The process is mainly divided into the following three steps:

(1) Suppose that the judgment matrix determined by the experts is as follows:

$$\boldsymbol{A} = \left(\boldsymbol{q}_{ij}\right)_{n \times n} \tag{3}$$

The construction method of the judgment matrix is mainly calculating which index is more important through the expert evaluation. The scoring standard consisted of a 1–9 scale method to quantify the decision-making judgment (Table 2) [34–36].

Table 2. The 1–9 scale method.

Scale Meaning	
1	Indicates that two indictors are equally important.
3 Indicates that when the two indicators are compared, the for slightly more important than the latter.	
5	Indicates that when the two indicators are compared, the former is more important than the latter.
7	Indicates that when the two indicators are compared, the former is deeply more important than the latter.
9	Indicates that when the two indicators are compared, the former is extremely more important than the latter.
2,4,6,8 The comparison of the importance of the two indicators the above scales.	
Reciprocal	If the comparison between the factors i and j is judged as q_{ij} , then the judgment of the comparison between the indicators j and i is $1/q_{ij}$.

(2) The consistency test was conducted on the above matrix, and the specific formula is as follows: $CI = \lambda$

$$CR = \frac{CI}{RI} = \frac{\lambda_{\max} - n}{(n-1)RI}$$
(4)

where *n* is the number of parameters participating in the evaluation, λ max is the maximum eigenvalue, and *RI* is the mean random consistency index. If the *CR* calculation result is less than the threshold value, it can be considered that the results of the above judgment matrix can be used; otherwise, the judgment matrix is further corrected until the test is satisfied [37–39].

(3) After completing the consistency test, geometric averaging was performed according to the method, and the weight size of the target index is:

$$W_{j} = \frac{\left(\prod_{i=1}^{n} q_{ij}\right)^{\frac{1}{n}}}{\sum_{i=1}^{n} \left(\prod_{i=1}^{n} q_{ij}\right)^{\frac{1}{n}}}, i = 1, 2, 3 \dots n$$
(5)

Through the analytic hierarchy process, the weight values of each index in the evaluation system are finally obtained in Table 3. As can be seen from Figure 1, the weight values of infrastructure, digital business, digital governance, technological innovation and talent cultivation are 0.2234, 0.2113, 0.1718, 0.1844 and 0.2091, respectively, indicating that the importance of the five first-level indicators is relatively close. However, at the present stage of rural e-commerce development, infrastructure construction, digital business expansion and e-commerce talent cultivation are still to be more important. See Table 3 for the weight of each secondary index and index layer.







(b)

Figure 1. Cont.



Figure 1. Radar chart of provincial rural e-commerce development level based on criterion layer: (a) 2019; (b) 2020; (c) 2021.

0

Rule Layer (First)	Weight	Rule Layer (Secondary)	Weight	Index Layer	Weight
		B ₁	0.0(12	C1	0.0312
			0.0015	C ₂	0.0301
		B ₂	0.0582	C ₃	0.0281
A_1	0.2234		0.0382 -	C_4	0.0301
		B ₃	0.0553 -	C ₅	0.0271
	_			C ₆	0.0282
		В.	0.0486	C ₇	0.0251
		54	0.0400	C ₈	0.0235
	0.2113	B ₅	0.1101 -	C ₉	0.0501
A_2				C ₁₀	0.06
		B ₆	0 1012	C ₁₁	0.0611
			0.1012	C ₁₂	0.0401
	0.1718	B ₇	0.0915 -	C ₁₃	0.0503
A_3				C ₁₄	0.0412
·		B ₈	0.0803 -	C ₁₅	0.0471
				C ₁₆	0.0332
	0.1844	B ₉	0.0912 -	C ₁₇	0.0518
A4				C ₁₈	0.0394
		B ₁₀	0.0932 -	C ₁₉	0.0473
				C ₂₀	0.0459
	0.2091	B ₁₁	0.1182 -	C ₂₁	0.0685
A_5				C ₂₂	0.0497
0		B ₁₂	0.0909 -	C ₂₃	0.0534
				C ₂₄	0.0375

4.3. Assessment of the Level of Development

The total score of rural e-commerce in each province was calculated by using the data normalization results combined with the weight of each indicator:

$$S_i = \sum_{j=1}^{24} W_j \times C_{ij} \tag{6}$$

A quantitative assessment of the development level of rural e-commerce in 31 provinces in China between 2019 and 2021 yielded Figure 1 and Table 4. From the radar chart of Figure 1, it can be seen that the five provinces of Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu and Shandong show a high level of development in the five standard layers of infrastructure, digital management, digital governance, technological innovation, and talent cultivation, reaching more than 0.9 points; the six provinces of Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjiang and Tibet have a low level of development in the five standard layers of infrastructure, digital management, digital governance, technological innovation, and talent cultivation, all of which are below 0.6 points. Table 4 shows the comprehensive scoring level of 31 provinces in the past three years. The provinces with a total score of more than 0.9 points are Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu and Shandong; the provinces with a total score of more than 0.8 points are Fujian, Tianjin, Hubei, Sichuan, Anhui, Chongqing, Henan, Guizhou and Shaanxi; the province with a total score of more than 0.7 points is Jiangxi; the provinces with a total score of more than 0.6 points are Guangxi, Hebei, Hunan, Shanxi, Hainan, Liaoning, Yunnan, Jilin and Heilongjiang; and the provinces with a total score of less than 0.6 points are Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjiang and Tibet.

Province	2019	2020	2021
Beijing	0.9725	0.9767	0.9893
Guangdong	0.9380	0.9502	0.9598
Shanghai	0.9959	0.9983	1.0000
Zhejiang	0.9403	0.9504	0.9565
Jiangsu	0.9483	0.9560	0.9663
Shandong	0.9241	0.9409	0.9507
Fujian	0.8498	0.8698	0.8996
Tianjin	0.8400	0.8600	0.8899
Hubei	0.8435	0.8676	0.8974
Sichuan	0.8258	0.8458	0.8757
Anhui	0.8300	0.8542	0.8841
Chongqing	0.8200	0.8400	0.8699
Henan	0.8233	0.8451	0.8750
Guizhou	0.8110	0.8310	0.8609
Jiangxi	0.7953	0.8132	0.8431
Shaanxi	0.8138	0.8338	0.8637
Guangxi	0.6392	0.6692	0.7059
Hebei	0.6730	0.7030	0.7397
Hunan	0.6482	0.6782	0.7149
Shanxi	0.6480	0.6835	0.7202

Table 4. China's rural e-commerce development level (2019–2021).

Province	2019	2020	2021
Hainan	0.6259	0.6577	0.6944
Liaoning	0.6403	0.6703	0.7069
Yunnan	0.6185	0.6485	0.6852
Jilin	0.6254	0.6554	0.6921
Heilongjiang	0.6111	0.6411	0.6778
Inner Mongolia	0.4372	0.4794	0.5197
Ningxia	0.3632	0.4053	0.4457
Gansu	0.3911	0.4332	0.4736
Qinghai	0.3290	0.3688	0.4041
Xinjiang	0.1726	0.1936	0.2151
Tibet	0.1025	0.1227	0.1488

Table 4. Cont.

Figure 2 is a colored map of the average score of each province in the past three years, and the darker the color, the higher the development level of rural e-commerce in the region. From Figure 2, it can be seen that the Yangtze River Delta region is the region with the highest level of rural e-commerce development in China. Analyzing the reasons, on the one hand, the infrastructure construction in the region is better, and the construction level of network communication and logistics links is at the forefront of the country; on the other hand, the region has the courage to innovate technologies and mechanisms, incubate a number of high-quality brands, and the professionalism of farmers and the level of agricultural modernization have been continuously improved. In addition, the overall level of rural e-commerce in the Pearl River Delta region and the Beijing–Tianjin–Hebei region is also relatively high, which is mainly due to the region's high level of economic development and relatively perfect infrastructure. It can also be seen from Figure 2 that the development pattern of rural e-commerce in China is that the east is superior to the west and the south is superior to the north, which is closely related to the overall economic development pattern of the country.



Figure 2. Average development level by province (2019–2021).

Figure 3 reflects the development growth rate of rural e-commerce in each province in 2020 and 2021. As can be seen from the figure, in the past 2 years, the provinces with a growth rate of more than 8% are Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjiang, and Tibet; the provinces with a growth rate of more than 4% are Guangxi, Hebei, Hunan, Shanxi, Hainan, Liaoning, Yunnan, Jilin, Heilongjiang; the provinces with a growth rate of more than 2% are Fujian, Tianjin, Hubei, Sichuan, Anhui, Chongqing, Henan, Guizhou, Jiangxi, Shaanxi; and other provinces have a slower growth rate and remain within 2%. Analyzing the reasons, several provinces with high comprehensive scores, such as Shanghai, Beijing, Zhejiang, Jiangsu, etc., have been fully developed in the early stage, and the volume is large, so the growth rate is slower; in several provinces with lower comprehensive scores, such as Gansu, Qinghai, Xinjiang, Tibet, etc., due to the gradual popularization of networks and logistics in recent years, as well as the promotion of Internet celebrities and high-quality products, rural e-commerce has developed rapidly.



Figure 3. The growth rate of rural e-commerce development in various provinces (2020–2021).

4.4. Clustering Analysis

In order to more intuitively show the homogeneity of the rural e-commerce development level in 31 provinces of China and seek a reasonable classification promotion strategy, we further conducted a cluster analysis on 31 provinces based on the original index data of the evaluation index system. As for the selection of clustering methods, the k-means method, fuzzy clustering method and systematic clustering method are commonly used. Among them, the k-means method and fuzzy classification method are, respectively, suitable for the classification of large sample data sets and qualitative variables [40,41]. In this paper, the samples of 31 provinces are mainly open quantitative statistical data, so systematic clustering method was chosen.

SPSS25.0 was used for the systematic clustering of standardized data, and the steps were simplified as follows. First, the Euclidean distance between 25 indicators of the constructed index system was calculated, and the formula was as follows:

$$d_{ij} = \sqrt{\sum_{k=1}^{p} (X_{ij} - X_{jk})^2}$$
(7)

Secondly, based on the consideration of the characteristics of indicators, the method of deviation sum of squares was selected for cluster analysis. The formula is:

$$D_{kr}^{2} = \left(\frac{n_{i} + n_{p}}{n_{i} + n_{r}}\right) D_{kp}^{2} + \left(\frac{n_{i} + n_{q}}{n_{i} + n_{r}}\right) D_{kp}^{2} + \left(\frac{n_{i}}{n_{i} + n_{r}}\right) D_{pq}^{2}$$
(8)

Finally, we determined the specific classification number. According to the pedigree diagram output by the software, it can be seen that there are various classification methods,

but the determination of classification number in the academic circle is still to be explored. Most scholars believe that the determination of the cluster number needs to be judged based on the combination of practice and theory. In this paper, the clustering validity function was used to screen the cluster number options and, finally, the cluster number was determined into four categories, as shown in Table 5.

 Table 5. China's rural e-commerce development level clustering.

Category	Province
First cluster	Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu, Shandong, and Fujian
Second cluster	Tianjin, Hubei, Sichuan, Anhui, Chongqing, Henan, Guizhou, Jiangxi, and Shaanxi
Third cluster	Guangxi, Hebei, Hunan, Shanxi, Hainan, Liaoning, Yunnan, Jilin, and Heilongjiang
Fourth cluster	Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjiang, and Tibet

Figure 4 shows the scatter chart of the development level of rural e-commerce in each province in the past three years. Figure 5 shows the development growth rate of rural e-commerce in each province in the past two years. By combining these two factors that can reflect the current situation and trend in rural TV development and the clustering results obtained by the systematic clustering method, the development of rural e-commerce in each province was comprehensively analyzed. Combining Table 5 and Figures 4 and 5, the results are relatively consistent. We studied and analyzed the development characteristics and status quo of these four types of provinces:



Figure 4. Cont.



Figure 4. Scatter chart of development level of 31 provinces in the past 3 years: (a) 2019; (b) 2020; (c) 2021.



Figure 5. Scatter chart of growth rate of 31 provinces in the past 2 years: (a) 2020; (b) 2021.

There are seven provinces in the first cluster, namely, Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu, Shandong and Fujian, which are all leading in the development level of rural e-commerce. Such provinces have the advantages of policy orientation, geographical location, economic support, infrastructure coverage and reputation, and the digital e-commerce market is booming in these regions. At the same time, the region pays special attention to the cultivation of rural e-commerce subjects, the formation of the e-commerce market and the cultivation of digital talents. Through policy support, they excavate the characteristic resources of rural areas and actively promote the successful implementation of the new pattern of rural e-commerce. By improving and optimizing rural logistics systems and infrastructure construction, they have encouraged such areas to accumulate both hard power and soft power. In addition, through the implementation of the rural e-commerce one million talents plan, they grasped the endogenous power of rural human resources in the process of comprehensively promoting rural revitalization, and stimulated new momentum into the promotion process of the project of "developing agriculture through digital commerce" in such areas.

There are nine provinces in the second cluster, namely, Tianjin, Hubei, Sichuan, Anhui, Chongqing, Henan, Guizhou, Jiangxi and Shaanxi, where rural e-commerce has grown. These provinces have a rich agricultural production base, and thanks to digital e-commerce, agricultural products that were previously confined to local markets are "going global" and "coming alive". Such a model not only unblocked sales and increased income, but also gradually formed a unique regional characteristics of rural e-commerce/product brands. As a representative of the development and growth of China's rural e-commerce, these provinces constantly summarize the experience gained in the process of development, and achieve the goal of the innovation cycle by adjusting the regional rural e-commerce development strategy.

The third cluster includes nine provinces, namely, Guangxi, Hebei, Hunan, Shanxi, Hainan, Liaoning, Yunnan, Jilin and Heilongjiang. Such provinces are geographically scattered from southern to northern China, but tend to be strongly influenced by regional culture in terms of development characteristics. The entry of digital e-commerce provides a platform for these regions to realize cultural communication and e-commerce. Due to the presence of more and more e-commerce network celebrities, new farmers can go through digital platforms into the national public vision. More people are interested in these provinces through the spread of Internet celebrity culture. E-commerce net celebrities choose the way of "e-commerce to help farmers" to achieve the dual goals of spreading culture and helping farmers to sell. In addition, China's poverty alleviation has also played a supporting role in the development of rural e-commerce on the basis of poverty alleviation.

The fourth cluster consists of six provinces, namely Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjian and Tibet, where rural e-commerce is developing rapidly. Most of these provinces are representatives of small and miscellaneous local agricultural products, and most of them are ancient agricultural areas. Although they have rich agricultural resources, they are limited by problems such as weak foundation, unbalanced development and talent shortage in e-commerce development, forcing these regions to catch up with the opportunity period of rapid development of digital e-commerce in recent years. Many years ago, the Chinese government began to attach importance to the development of these provinces achieve development. At present, these provinces, in view of their own characteristics and advantages, choose to attack on the weak side. They make full use of the capital invested by the Chinese government, including the cultivation of agricultural products' brands, IP building of regional e-commerce, introduction of e-commerce talents, and construction of logistics system into the revitalization list, and gradually form a rural e-commerce ecological system led by "digital commerce to develop agriculture".

5. Conclusions

This study establishes a comprehensive evaluation index system for the development level of rural e-commerce in China. Based on citespace and the expert survey method, 5 rule layer (first) indicators, 12 rule layer (secondary) indicators, and 24 index layer indicators are determined. Based on the statistical data from 2019 to 2021, this study first uses the analytic hierarchy process to determine the index weight, then evaluates the development level of rural e-commerce in 31 provinces in China, and finally uses the systematic clustering method to cluster 31 provinces. Its conclusions are as follows:

- (1) The first three indicators of comprehensive weight are infrastructure, digital operation and talent cultivation, whose weights are 0.2234, 0.2113 and 0.2091, respectively. Therefore, if the government wants to realize the rapid improvement in the development level of rural e-commerce, it can pay more attention to the above three indicators when making policies.
- (2) At present, the overall development level of rural e-commerce in China shows a positive trend. Based on the data of the past three years, China's provinces can be divided into four categories. The first category is the overall leading type, which is the highest level of development and the slowest growth rate, including Beijing, Guangdong, Shanghai, Zhejiang, Jiangsu, Shandong and Fujian. Tianjin, Hubei, Sichuan, Anhui, Chongqing, Henan, Guizhou, Jiangxi and Shaanxi are in the growth category, which is characterized by a high level of development and low speed of development. The third category is to catch up with the strong, big players, that is, the development level is low and the development speed is fast, and it includes Guangxi, Hebei, Hunan, Shanxi, Hainan, Liaoning, Yunnan, Jilin and Heilongjiang. The fourth category is rapid development, that is, the lowest level of development and the fastest development, including Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjian and Tibet.
- (3) From the perspective of geographical pattern, the development of rural e-commerce in China is characterized by the south being superior to the north and the east superior to the west. The Yangtze River Delta is the region with the highest level of development, which mainly benefits from the developed infrastructure construction, mature talent cultivation system and proactive innovation consciousness in this region.
- (4) In order to better promote the high-quality development of rural e-commerce, research shows that the following aspects should be started: First, promote the popularization of new infrastructure in rural areas and accelerate the coverage of digital infrastructure construction. Second, guide the development of rural digital e-commerce to be normalized, and strengthen the construction of farmers' operational thinking, rural digital-market brand cultivation, digital-market risk circulation and other aspects. Third, promote the modernization of the rural digital governance system and mechanism and improve the system and system construction of modern agricultural operation organization. Fourth, realize the whole process of digital technology attached to rural e-commerce and promote technological innovation in the process of technology application. Fifth, stimulate the role of farmers' all-round positioning, and make full use of compulsory education, vocational education, and skills training to revitalize rural human resources.

6. Limitations and Further Study

The evaluation method proposed in this study is a comprehensive evaluation system based on literature review, data analysis and expert research, which is scientific and practical. Although some important findings have been made in this paper, this study may have some limitations. First of all, the calculation of index weight has direct reference significance for the government to take relevant measures in the future to better promote the development of rural e-commerce. However, this is not immutable. Because the situation in each place is very different, scientific policies must be formulated in combination with local conditions in the specific implementation. Secondly, the advantage of city classification in this paper is to provide reference for the Chinese government to better realize regional, coordinated development in the future. If a region wants to achieve better development, it must first objectively understand its own situation, and find allies with similar situations and assistants with better situations. However, it is undeniable that this classification method also has certain limitations, which are mainly affected by the evaluation index system and time, and need to keep up with the time, constantly update and improve. Finally, the empirical test of the evaluation index system still needs to be further enriched and improved.

Next, it can be more fully verified based on richer sample data from different areas. For the expansion of this research, especially from China to foreign countries, the evaluation index system and evaluation clustering model in this paper can basically be directly applied. However, it should be noted that the national conditions of different countries are different. It is best to adjust the evaluation index system according to the actual situation of the country, and integrate it with the latest policy and technical development, and then comprehensively evaluate the development level of rural e-commerce in this area by using the evaluation cluster model, which will play a positive role in promoting the development of local rural e-commerce. At the same time, the research can also be expanded from provincial units to municipal and county-level units, so as to achieve more targeted, high-quality development of rural e-commerce in various administrative regions.

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