

# *Statistical Measurement of the Level of Rural Digitization in Zhejiang Province*

Songyan Zhang, Xiaoling Huang, Yaping Lin

*Zhejiang University of Science and Technology, Hangzhou, China*

**Keywords:** Rural Digitization, Digital Villages, Rural Digital Economy, Indicator System

**Abstract:** This paper constructs the evaluation index system of rural digitization level from 16 specific indicators in 4 dimensions. Based on the panel data of 11 prefecture-level cities in Zhejiang Province from 2017 to 2021, the entropy value method is used to determine the objective weight of each indicator, and the formula is used to measure the rural digitization level of each city in Zhejiang Province. The results show that the level of rural digitization in Zhejiang Province has been significantly improved during the examination period, and the average value has steadily increased year by year. However, there are still differences in the development speed of each city, with Hangzhou leading the rest of the province in terms of rural digitization level, Ningbo, Wenzhou, Jiaxing, Huzhou, Jinhua, and Taizhou in terms of rural digitization at a medium level with a large development potential, while Shaoxing, Quzhou, Zhoushan, and Lishui cities have a relatively low level of rural digitization. Accordingly, countermeasures for the development of rural digitization in Zhejiang Province are proposed.

## 1. Introduction

The rapid development of information technology has attracted more attention to the concept of the digital economy. This digital economy not only influences urban economic development but also plays a vital role in transforming rural areas. This paper aims to comprehensively evaluate the level of digitalization in rural areas in Zhejiang Province and its impact on rural economic development. The study will provide statistical measurements of the rural digitalization level and provide decision support to enhance rural economic development.

## 2. Literature review

### 2.1. Rural digital economy

Tapscott first put forth the idea of the "digital economy" in the 1990s. He pointed out that the digital economy is a new economic form based on human intelligence networking and that the Internet and e-commerce will have a significant impact on it [1], but he did not give a clear definition. In recent years, many scholars have analyzed the meaning of the digital economy from a richer perspective. Barefoot et al. (2018) defined the digital economy from the perspective of the Internet and related information and communication technologies, including the following three aspects: (1)

digital infrastructure; (2) e-commerce; and (3) digital media [2]. Ding (2020) believes that the digital economy is a new economic and social form that utilizes digital knowledge and information as key production factors, supported by networked and intelligent digital infrastructure. It promotes the deep integration of new-generation information and communications technologies, such as big data and cloud computing, with economic and social activities through the transition and proliferation of the "techno-economic paradigm" [3].

In 2019, the General Office of the CPC Central Committee and the General Office of the State Council issued the "Outline of the Digital Rural Development Strategy", which first proposed the concept of rural digital economy, which refers to the economic form that naturally emerges in the process of agricultural and rural modernization and transformation, accompanied by the application of network, information, and digital technology, as well as the improvement of farmers' modern information skills. Cui et al. (2020) believe that the rural digital economy relies on the modern information network in rural areas, and with the help of new generation information technology, it injects digital technology, human resources, information, knowledge, management, and other production factors into the primary, secondary, and tertiary industries in rural areas [4]. In this way, it can optimize resource allocation, accelerate industrial integration, enhance the digitalization level of rural industries, and promote the vigorous development of new industries and new formats in rural areas with digitalization as the main feature, thus promoting high-quality growth of the agricultural and rural economies [4].

## **2.2. Measurement of the level of rural digital development**

Domestic and international research on measuring the level of digital development mainly focuses on the construction of indicators, assessment methods, and analysis of results. The Organization for Economic Cooperation and Development (2014) believes that forward-looking statistical measures of the level of digitization should be built around six areas: first, to reveal the link between ICT investment and macroeconomic performance; second, to define and measure the skill needs of the digital economy; third, to develop indicators to monitor security, privacy, and consumer protection issues; fourth, the goals of ICT on society facilitation should be measured in a way that enhances the impact of the digital economy on society; fifth, investment should be made in the development of comprehensive, high-quality data infrastructure; and sixth, a statistical framework suitable for utilizing the Internet as a data source should be established [5]. Liu et al. (2020), on the other hand, constructed a digital economy evaluation index system for China's sub-provinces from the three dimensions of information development, Internet development, and digital transaction development [6].

As far as the rural digital economy is concerned, Mu et al. (2021) concluded that the formation of agricultural and rural digital economies includes the following three basic elements: the construction of agricultural and rural digital infrastructure, the level of agricultural digitization, and rural digital industrialization, and used this as a first-level indicator to construct an evaluation index system for the development of agricultural and rural digital economies [7]. Wu et al. (2022) constructed the indicator system for the development level of China's rural digital economy from the four dimensions of the digital economic environment, digital infrastructure, digital transformation of agriculture, and digital enhancement of life [8].

## **2.3. Research related to the construction of digital villages in Zhejiang Province**

Zhejiang's digital village construction has been at the forefront of the country, contributing many commendable practice cases. Hu et al. (2023) have conducted a systematic examination of the "digital village map" panoramic governance platform in Wusi Village, Zhejiang Province, to analyze the logic

of the digital village "holistic governance" generation and introduced the "technology-thinking-value" explanatory direction to explain its realization of the rationale [9]. To explain the realization of its reasoning, they offered the "technology-thinking-value" explanatory direction and examined the generation logic of the "overall wise governance" of the digital village. In addition, the digitization of rural governance has always been a hot topic in the construction of digital villages, Tong et al. (2022) found that, based on a comparative study of five counties (cities and districts) in Zhejiang Province, the county government tends to implement a unified digital governance platform in all the villages in the county, and the villages in general show a state of being involved [10].

Based on the literature review, current discussion on digital countryside construction in Zhejiang primarily focuses on rural governance digitization, with less attention on other aspects of rural Zhejiang's digital economy construction. This allows us to condense the following open research positions: Few studies have developed a comprehensive indicator system to systematically measure Zhejiang's level of digital village construction. Based on the measurement results, we can categorize Zhejiang's digital village development characteristics, identify current issues, and propose workable solutions. This paper aims to address this issue.

### **3. Construction of an evaluation index system for rural digital development**

This paper follows the three principles of scientificity, representativeness, and accessibility and combines the meaning of digital countryside to construct an indicator system for measuring the digital development of rural villages in Zhejiang Province from the four dimensions of rural digital development environment, rural digital infrastructure construction, digital transformation of rural agriculture, and improvement of rural residents' living standards (Table 1).

#### **3.1. Rural digital development environment**

The construction of digital villages requires a good digital development environment, including policy support, market mechanisms, talent training, and many other aspects. By optimizing the digital development environment, more capital and talents can be attracted to the countryside to promote the construction and development of digital villages. Drawing on the studies of Wu et al. (2022) [8] and Mu et al. (2021) [7], this paper selects four aspects to represent the development level of the rural digital development environment: farmers' digital literacy (the average education level of rural residents), digital talent ownership (the number of people employed in the information transmission, software, and information technology service industries), rural electricity consumption per capita, and the number of agricultural and rural digital bases (the number of Taobao villages).

#### **3.2. Rural digital infrastructure construction**

Digital infrastructure is the foundation for the construction of digital villages, including technical facilities such as the Internet, the Internet of Things, big data, and artificial intelligence. Through the construction of digital infrastructure, the speed and efficiency of information circulation in the countryside can be enhanced, the intelligent level of agricultural production can be improved, and the transformation and upgrading of the rural economy can be promoted. Drawing on the studies of Wu et al. (2022) [8] and Zhang et al. (2023) [11], this paper selects four aspects, namely, rural Internet broadband penetration, rural cable TV coverage, rural computer penetration, and rural cell phone penetration, to represent the level of rural digital infrastructure construction.

### 3.3. Digital transformation of rural agriculture

The digitization of agriculture is a crucial aspect of building digital villages, encompassing digitalizing agricultural production, management, sales, and other related processes. By leveraging digital technology, it enhances the efficiency and quality of agricultural production, optimizes the production process, and advances agricultural modernization. Drawing on the study of Wu et al. (2022) [8], the use of fertilizer per unit of output value, the use of pesticides per unit of output value, the use of plastic film per unit of output value, and the effective irrigation rate were selected to measure the level of digital transformation in rural agriculture.

### 3.4. Improvement of rural residents' living standards

The primary aim of digital village construction is to enhance the quality of life for rural inhabitants, enabling the majority of them to access and benefit from digital technologies. Digitization can uplift living standards, elevate public services like healthcare and education, and bolster their overall well-being and connectivity. Drawing on the research of Kong et al. (2023) [12], the per capita disposable income of rural residents, per capita consumption expenditure of rural residents, Engel's coefficient of rural residents, and per capita transportation and communication expenditure of rural residents are selected to reflect the improvement of the living standard of rural residents.

## 4. Measurement and Analysis

### 4.1. Sample and Data Sources

This paper takes Zhejiang Province as the research area, takes the rural development of 11 prefecture-level cities as the research object, and chooses the panel data of each prefecture-level city in Zhejiang Province from 2017 to 2021 as the sample. The data for the indicators involved mainly come from the “Statistical Yearbook of Zhejiang Province” in each year and the statistical yearbook of each prefecture-level city.

### 4.2. Method

Comprehensive evaluation methods include subjective empowerment evaluation methods and objective empowerment evaluation methods. Subjective empowerment methods rely on individual subjective judgment, leading to insufficient objectivity. Thus, this paper selects the entropy method within the objective empowerment methods, utilizing the principle of information entropy to establish weights and enable a more objective and accurate evaluation of the research object. This paper draws on the panel entropy method used by Yang and Sun (2015) [13], and adds a time variable on the basis of the cross-sectional entropy method so that comparisons between different years can be realized. Based on the entropy method, the measurement indexes of rural digitization level in Zhejiang Province are objectively assigned, and the comprehensive score of rural digitization level in each prefecture-level city in Zhejiang Province is calculated. The specific steps are as follows:

1) Standardized processing;

Let there be a total of  $r$  years,  $n$  regions (prefecture-level cities), and  $m$  indicators;  $x_{ijk}$  denotes the value of the  $i$  year, the  $j$  region, and the  $k$  indicator. Because of the different scales among the indicators, it is necessary to standardize the indicators.

Standardization of positive indicators:

$$x'_{ijk} = \frac{x_{ijk} - x_{min,k}}{x_{max,k} - x_{min,k}} \quad (1)$$

The inverse indicator is the opposite of the positive indicator.  $x_{\max,k}$ ,  $x_{\min,k}$  denote the maximum and minimum values of the  $k$  indicator in the  $n$  region and the  $r$  year, respectively. After the standardization process  $x''_{ijk}$  takes the value range of  $[0, 1]$ , and its meaning is the relative size of  $x_{ijk}$  in  $n$  region,  $r$  year. Since a value of 0 occurs after standardization, the standardized data are offset by adding 0.001 (the amount of the offset can be adjusted as appropriate):

$$x''_{ijk} = x'_{ijk} + 0.001 \quad (2)$$

2) Determination of the weight of each indicator;

$$p_{ijk} = \frac{x''_{ijk}}{\sum_i \sum_j x''_{ijk}} \quad (3)$$

3) Calculation of the entropy of each indicator;

$$e_k = -\frac{1}{\ln(rn)} \sum_i \sum_j p_{ijk} \ln(p_{ijk}), k > 0, k = \ln(rn) \quad (4)$$

4) Calculation of the coefficient of variation for each indicator;

$$g_k = 1 - e_k \quad (5)$$

5) Normalization of the coefficient of variation and calculation of the weight of each indicator;

$$w_k = \frac{g_k}{\sum_k g_k} \quad (6)$$

The weights of the indicators for measuring the level of rural digitization in Zhejiang Province are finally calculated as shown in Table 1. It can be seen that the highest weighted indicators are the number of digital talents and the agricultural and rural digital bases.

Table 1: Evaluation index system of rural digitization level in Zhejiang Province.

Primary indicator	Secondary indicator	Tertiary indicator	Entropy	Weight
Level of digital development in rural areas	Rural digital development environment 0.4712	Farmers' digital literacy	0.9698	0.0307
		Digital talent ownership	0.7246	0.2802
		The number of agricultural and rural digital bases	0.8870	0.1150
		Rural electricity consumption per capita	0.9555	0.0453
	Rural digital infrastructure construction 0.1886	Rural Internet broadband penetration	0.9614	0.0393
		Rural cable TV coverage	0.9596	0.0411
		Rural computer penetration	0.9467	0.0542
		Rural cell phone penetration	0.9469	0.0540
	Digital transformation of rural agriculture 0.1553	The use of fertilizer per unit of output value	0.9688	0.0318
		The use of pesticides per unit of output value	0.9765	0.0239
		The use of plastic film per unit of output value	0.9764	0.0240
		The effective irrigation rate	0.9257	0.0756
	Improvement of rural residents' living standards 0.1847	Per capita disposable income of rural residents	0.9696	0.0309
		Per capita consumption expenditure of rural residents	0.9761	0.0243
		Engel's coefficient of rural residents	0.9439	0.0571
		Per capita transportation and communication expenditure of rural residents	0.9288	0.0724

6) Calculate the final composite score of rural digitization level in Zhejiang Province

The value obtained by standardizing and translating the indicators in region  $j$  in year  $i$ , multiplying them by the weight of each indicator, and summing them up is the level of rural digitalization in

region j in year i.

$$M_{ij} = \sum_k w_k x''_{ijk} \quad (7)$$

The final calculation of the comprehensive score of rural digitization level in Zhejiang Province is shown in Table 2.

Table 2: Evaluation index system of rural digitization level in Zhejiang Province.

	2017	2018	2019	2020	2021	Average	Growth rate
Hangzhou	0.4291	0.4842	0.5121	0.5339	0.5642	0.5047	7.08%
Ningbo	0.3535	0.3844	0.3294	0.3857	0.3859	0.3678	2.22%
Wenzhou	0.3740	0.3800	0.3661	0.3443	0.4464	0.3822	4.52%
Jiaxing	0.3341	0.3911	0.4163	0.4452	0.4492	0.4072	7.68%
Huzhou	0.2902	0.3426	0.3763	0.3407	0.3698	0.3439	6.25%
Shaoxing	0.2416	0.2880	0.2447	0.2803	0.2729	0.2655	3.09%
Jinhua	0.2829	0.3392	0.3210	0.3694	0.4281	0.3481	10.91%
Quzhou	0.2084	0.1738	0.2129	0.2048	0.2380	0.2076	3.38%
Zhoushan	0.2667	0.3173	0.2588	0.2716	0.3074	0.2844	3.61%
Taizhou	0.2753	0.3276	0.3328	0.3459	0.3681	0.3299	7.53%
Lishui	0.1974	0.2155	0.2022	0.2527	0.2185	0.2173	2.57%
Average	0.2957	0.3312	0.3248	0.3431	0.3680	0.3326	5.62%

### 4.3. Analysis of assessment results

#### 1) Comprehensive analysis

In general, the level of rural digitalization in Zhejiang Province has been significantly improved, with the average value steadily increasing year by year, from 0.2957 in 2017 to 0.3680 in 2021, with an average annual growth rate of 5.62%. Among them, the annual growth rate of Hangzhou, Jiaxing, Huzhou, Jinhua, and Taizhou exceeded the average level of Zhejiang Province. However, there are differences in the development speed of various cities, with Jinhua, the city with the fastest development of rural digitalization, at 10.91%, which is 8.69 percentage points higher than Ningbo, the city with the slowest development of rural digitalization.

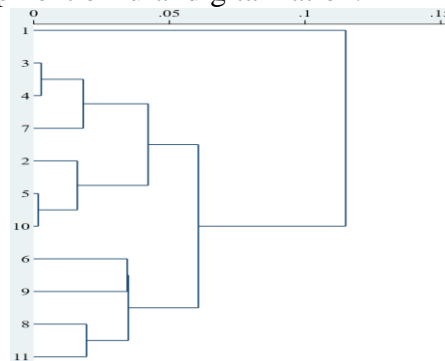


Figure 1: System clustering dendrogram

Table 3: Distribution of rural digital economy development level in Zhejiang Province.

Development level	Area
High-level	Hangzhou(1)
Medium-level	Ningbo(2) , Wenzhou(3),Jiaxing(4),Huzhou(5),Jinhua(7),Taizhou(10)
Low-level	Shaoxing(6),Quzhou(8),Zhoushan(9),Lishui(11)

#### 2) Regional analysis

In order to explore the differences between regions and understand the characteristics of regional development in depth, this article uses cluster analysis to conduct a classified analysis of the digital

development status of rural areas in various cities in Zhejiang Province in 2021. The results are shown in Figure 1 and Table 3.

Category 1: high-level development areas. According to the results of indicator construction and clustering analysis in this article, Hangzhou is the only city in Zhejiang Province that belongs to the high-level development area of rural digitalization. The reasons can be attributed to the following aspects: Firstly, Hangzhou has unique advantages in digital rural construction. Hangzhou itself is the capital city of Zhejiang Province and one of the important economic centers in the country. The level of digital development has always been in a leading position. Secondly, Hangzhou has a rich reserve of talents in digital rural construction. According to statistics, in 2021, the number of employed people in Hangzhou's information transmission, software, and information technology service industries exceeded 330,000, far higher than other cities in the province. These talents play an important role in digital rural construction and agricultural and rural digital reform, providing a strong talent guarantee for the development of rural digitalization in Hangzhou.

Category 2: medium-level regions. This category includes Ningbo, Wenzhou, Jiaxing, Huzhou, Jinhua, and Taizhou. These regions have actively implemented policies to support rural digitalization and focused on infrastructure construction, including fiber broadband networks and 4G/5G mobile networks. While they provide a good network foundation for digital technology in agriculture and rural areas, they may have relatively less investment in government, social capital, and talent resources compared to Hangzhou. The construction of digital villages in these regions started later, resulting in a relatively weak foundation for rural digitalization development. However, they possess a good foundation and potential for further development with continuous technological advancements and government support.

Category 3: low-level development areas. This category includes Shaoxing, Quzhou, Zhoushan, and Lishui. The relatively low level of rural digitalization in these four cities may be attributed to several factors. First, compared to other regions in Zhejiang Province, the economic development of these regions is relatively lacking, leading to limited investment in digital infrastructure construction, talent reserves, scientific and technological innovation, resulting in low digitalization. Second, Quzhou, Lishui, and Zhoushan are located away from the economic core development zone of Zhejiang Province, with limited transportation and closed information flow, affecting the application of digital technology in agricultural and rural development. Third, the agricultural industry in these areas lacks the demand and motivation for the application of digital technology. Notably, the agricultural modernization statistics of each city in 2021 reveal the need for improvement in agricultural modernization.

## **5. Conclusions and policy implications**

### **5.1. Conclusions**

The article's main findings are: between 2017 and 2021, rural digitalization in Zhejiang Province has significantly improved, with a steady increase in the average value each year. However, development speeds vary among different cities. Hangzhou leads in rural digitalization, while Ningbo, Wenzhou, Jiaxing, Huzhou, Jinhua, and Taizhou are at a medium level with potential for growth. Shaoxing, Quzhou, Zhoushan, and Lishui have relatively low levels of rural digitalization.

### **5.2. Policy implications**

1) As the leading force in digital rural construction in Zhejiang Province, Hangzhou has a strong foundation in rural digital development. However, there is still a need to further promote innovative digital rural development, enhance the industrial system of rural digital areas, and deepen coordination with urban digital economy. Additionally, Hangzhou should implement measures to support the digital development of other cities in the province, overall improving the level of rural

digitalization and achieving coordinated progress in Zhejiang Province. This can be done through sharing experiences and technology in rural digitalization, establishing closer cooperation and communication mechanisms, providing support in digital infrastructure construction and training, as well as offering opportunities and resources through various platforms and channels.

2) Cities in Zhejiang Province with medium-level digitalization in rural areas should increase their investment in digital rural construction resources to promote the improvement of digitalization. Firstly, they should strengthen policy support by formulating a digital development plan, clarifying development goals, key areas, and specific measures of digital rural construction, and introducing a series of policies and measures to encourage enterprises and individuals to participate. Secondly, they should introduce social capital to attract more enterprises and social organizations to participate. Finally, they should strengthen the construction of a talent team by increasing the cultivation and introduction of digital talents and improving the quality of digital talents in rural areas. Additionally, guiding universities and scientific research institutions to cooperate with rural areas to provide more talent support for digital rural construction would be beneficial.

3) Cities with relatively low levels of rural digitalization should prioritize strengthening digital infrastructure development and promoting digital agriculture. To ensure the systematic advancement of digital infrastructure construction, the government can coordinate resources through strategic planning, provide financial support and policy guidance to encourage participation from businesses and individuals, and collaborate with academic and research institutions to attract technical and talent support. Simultaneously, efforts should focus on increasing the promotion of digital agricultural technology among farmers through demonstration projects, technical training, and facilitating innovative digital agricultural models to enhance agricultural production efficiency and competitiveness.

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