Research on the Evaluation System for Digital Countryside Construction

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Abstract

[Purpose/Significance] Benchmarking against the *Digital Rural Construction Guide 1.0*, constructing an evaluation system facilitates identifying existing problems in the digital rural construction process, clarifying development directions, and providing guidance for accelerating the comprehensive upgrading of agricultural and rural modernization in China. [Method/Process] The TF-IDF algorithm is employed to extract keywords from the *Guide*, thereby determining evaluation elements and constructing a comprehensive evaluation index system for digital rural construction level; the Data Envelopment Analysis (DEA) method combined with the BCC model is utilized to conduct quantitative measurement of the digital rural construction level across 31 provinces, municipalities, and autonomous regions nationwide. [Results/Conclusion] The evaluation index system constructed by benchmarking against the *Guide* comprises four dimensions: digital infrastructure, digital economy, digital environment, and digital inclusiveness, enabling reasonable assessment of digital rural construction level; 22 regions achieved DEA efficiency, with varying focuses in their digital rural construction; 9 regions failed to achieve DEA efficiency, exhibiting irrationalities in input-output allocation of their digital rural construction; finally, entry points for improving and enhancing digital rural construction levels across various regions are identified through analysis.

Full Text

Preamble

Research on the Evaluation System of Digital Village Construction
The Fourth Paper in the Series on Digital Rural Development Research Based on Policy Informatics

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Abstract:
[Objective] To promote construction through evaluation, identify existing problems in the digital village construction process, and clarify development directions. [Methods] Keywords from the *Guide* were extracted using the TF-IDF algorithm, and the digital village construction level of 31 provinces, municipalities, and autonomous regions across China was quantitatively measured using Data Envelopment Analysis (DEA) combined with the BCC model. [Results] Twenty-two regions achieved DEA efficiency, each with different digital village construction priorities; nine regions did not achieve DEA efficiency, indicating unreasonable input-output relationships in their digital village construction. [Limitations] DEA is a non-parametric analysis method that evaluates relative efficiency; conclusions can only reflect the digital village construction level of each province in a specific year. [Conclusions] The evaluation index system constructed based on the *Guide* can reasonably assess digital village construction levels.

Keywords: digital village; policy text; evaluation system; DEA methods
Classification Number: G203

1 Introduction

Digital villages represent both the strategic direction for rural revitalization and a crucial component of building a digital China. The *Digital Rural Development Strategy Outline* explicitly states that "digital villages are an endogenous agricultural modernization and transformation process accompanying the application of networking, informatization, and digitization in agricultural and rural economic and social development, as well as the improvement of farmers' modern information skills."In July 2021, the Central Committee of the Communist Party of China and the State Council released the *Digital Village Construction Guide 1.0* (hereinafter referred to as the *Guide*), which proposes an overall reference architecture for digital village construction and several applicable scenarios for regional reference. Under policy guidance, various regions have actively planned and laid out their digital village initiatives, with many provinces and municipalities already issuing digital village development plans or construction opinions, thereby launching China' s rural digital transformation journey.

As digital village construction progresses, there is an urgent need to establish a scientific, comprehensive, and standardized evaluation system for digital village construction levels. Such a system would help regions identify imbalances, inefficiencies, and inadequacies in the digital village construction process, thereby promoting further development of digital villages.

2 Related Research

In recent years, domestic research on constructing digital village construction evaluation index systems has emerged continuously, primarily focusing on two aspects. First, studies have examined digital village construction evaluation index systems from different perspectives, including research on the innovation-driven system for digital village development [1], evaluation index systems for regional differences in rural revitalization development [2], evaluation index systems for rural digital economy [3], readiness evaluation index systems for digital village development [4], evaluation index systems for agricultural informatization levels [5], evaluation index systems for smart villages [6], and evaluation index systems for rural ecological revitalization effectiveness [7]. Second, various methods have been applied to study digital village construction and development, such as using the entropy-weighted TOPSIS method to measure the rural industry revitalization development index [8], employing spatiotemporal range entropy method to measure rural revitalization development levels and analyze regional disparities and spatial polarization [9], utilizing factor analysis and TOPSIS methods to measure rural development levels [10], applying comprehensive index measurement models to assess national rural modernization levels [11], and using vertical and horizontal 拉开档次法 (vertical and horizontal disparity method) to measure dynamic development levels of rural revitalization [12].

In addition to the aforementioned methods, Data Envelopment Analysis (DEA) has been frequently used in agricultural and rural research in recent years. Examples include using super-efficiency DEA models for efficiency measurement combined with comprehensive entropy methods to evaluate provincial agricultural modernization development [13]; constructing a three-stage super-efficiency SBM-DEA model to evaluate rural environmental pollution governance efficiency and compare regional differences [14]; employing super-efficiency DEA models and Malmquist index models to measure rural public cultural service fiscal expenditure efficiency from static and dynamic perspectives [15]; and combining DEA models to measure digital inclusive finance efficiency in western China [16].

Overall, recent research on digital village and rural revitalization evaluation index system construction has been relatively abundant, with diverse research methods. However, few studies have evaluated digital village construction levels based on policy benchmarks, and most have constructed evaluation index systems from theoretical perspectives based on various policy documents. No evaluation system based on the *Guide* has yet emerged, and the application of DEA in the agricultural and rural fields remains limited. As digital village construction continues to advance, establishing a comprehensive and standardized digital village construction level evaluation index system guided by the *Guide* offers stronger directionality and planning compared to systems based on other policy texts. Using DEA to quantitatively measure the digital village construction levels of various provinces, municipalities, and autonomous regions can promote construction through evaluation, help identify existing problems, clarify development directions, and provide theoretical support and practical guidance for accelerating the comprehensive upgrading of agricultural and rural modernization in China.

3 Research Design

The policy content from Chapters 2 to 8 of the *Guide* was selected as sample text. After standardization and cleaning, the text was segmented and tokenized, with paragraphs serving as processing units for identifying key policy texts. The TF-IDF algorithm was used to extract keywords from the policy text, followed by manual screening and processing. Since keywords extracted through TF-IDF are typically fragmented, the extracted keywords from each section were semantically integrated with the corresponding content of the *Guide* to refine the evaluation content targeted by each indicator.

Based on the requirements proposed in the *Guide* and following the principles of scientificity, comprehensiveness, guidance, and feasibility, a digital village construction level evaluation index system was constructed. The evaluation system comprises four dimensions: digital infrastructure, digital economy, digital governance, and digital welfare, including 11 first-level indicators and a total of 64 indicators. It should be clarified that the research object of these indicators refers to rural areas, including not only administrative villages but also streets and townships where the population is primarily engaged in agricultural production or where the registered population is primarily rural. The evaluation index system is presented in Table 1 .

Sample data were selected from 31 provinces, municipalities, and autonomous regions across China. Except for a few indicators where only real-time data could be obtained, the research time point was 2020. For missing data in certain regions such as Tibet, the mean substitution method was used for processing. For a small number of indicators where data were difficult to obtain, 2019 data were used as substitutes. Since DEA employs a non-random method, and the evaluation results are relatively sensitive to data value fluctuations and factor selection, formal data should be used as much as possible in DEA analysis. Therefore, all data sources are publicly published statistical materials, including the *China Statistical Yearbook*, *China Rural Statistical Yearbook*, *China Urban-Rural Construction Statistical Yearbook*, *China Rural Poverty Monitoring Report*, *National County-Level Agricultural and Rural Informatization Development Level Evaluation Report*, as well as official government websites and internal government documents.

In DEA models, decision-making units do not require dimensionless processing or weight assignment, as the DEA model will derive the optimal solution based on input data. However, data standardization is necessary. Therefore, all decision-making unit data must be pre-adjusted to numeric format to ensure no missing values, spaces, zeros, negative numbers, or punctuation marks appear, with output data on the left and input data on the right.

In the DEA model, following the principle of efficiency ratio, negative indicators (where smaller values are better) are treated as input indicators (denoted as X), while positive indicators (where larger values are better) are treated as output indicators (denoted as Y). When selecting input indicators, the top-weighted third-level indicator under each first-level indicator was first selected, totaling 11 indicators. Then, one third-level indicator with the highest weight in each dimension was selected from these to serve as input indicators, aiming to reduce dimensionality to meet the application conditions of the DEA model. Ultimately, four input indicators were selected: X1, X2, X3, and X4, representing the digital infrastructure dimension, digital economy dimension, digital environment dimension, and digital welfare dimension, respectively.

The fundamental purpose of vigorously promoting digital village construction is to enable people in rural areas to live happy and convenient lives. Therefore, digital village construction not only assists in rural prosperity and industrial development, achieving local employment and stable income growth, but also pays greater attention to the spiritual wealth of rural residents and rural cultural development. Consequently, when selecting output indicators, the following were chosen: gross output value index of agriculture, forestry, animal husbandry, and fishery (with the previous year as 100, calculated at comparable prices), number of rural employees, per capita disposable income of rural residents, number of township comprehensive cultural stations, and agricultural and rural informatization levels. Ultimately, five output indicators were selected.

DEA application has a limitation: the number of indicators in the input-output system and the number of decision-making units must satisfy the empirical condition $n \geq 2(m + s)$ (where n is the number of decision-making units, m is the number of input variables, and s is the number of output variables). When $m \times s$ is much larger than $m + s$, the condition $n \geq 2m \times s$ must also be satisfied [18].

The final selected input and output indicators satisfy these application conditions. The specific indicators are shown in Table 3 , and the input-output indicator values for each province, municipality, and autonomous region are presented in Table 4 .

This study establishes a comprehensive evaluation index system for digital village construction levels guided by the *Guide*. The index system is divided into four dimensions: digital infrastructure, digital economy, digital environment, and digital welfare, comprising 11 first-level indicators and 64 indicators in total. Using Data Envelopment Analysis combined with the BCC model, this study evaluates the efficiency of digital village construction levels across 31 provinces, municipalities, and autonomous regions in China, providing a quantitative assessment of digital village construction levels and drawing the following conclusions:

(1) The 22 provinces and municipalities that achieved DEA effectiveness each

have different digital village construction priorities. First, Beijing, Tianjin, and Shanghai are municipalities directly under the central government where government authority reaches directly, playing leading and exemplary roles in all aspects of construction and development. Therefore, their overall planning and implementation of digital village inputs are more robust, achieving relatively high input-output efficiency across all dimensions, particularly in the digital economy dimension. However, the construction of the digital welfare dimension needs strengthening. Second, Hebei, Liaoning, Heilongjiang, Jiangsu, Zhejiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, and Chongqing are non-remote regions with stable development levels across various aspects and rapid policy response and implementation. Therefore, these 13 provinces and municipalities can achieve complementary development across dimensions during digital village construction, where even if certain aspects are deficient, others can compensate. Third, Guizhou, Tibet, Qinghai, and Xinjiang are remote regions with relatively backward development levels across various aspects. However, the state has vigorously promoted construction and development in remote regions with timely policy responses. Therefore, although their inputs in digital infrastructure, digital economy, and digital welfare dimensions are below average, their digital village construction efficiency is relatively high, with inputs being well utilized across all dimensions.

(2) The digital village construction levels of the nine provinces and municipalities that did not achieve DEA effectiveness need improvement. First, Inner Mongolia, Jilin, Yunnan, Shaanxi, Gansu, and Ningxia exhibit increasing returns to scale, where increased inputs will yield proportionally higher outputs. This indicates that these six provinces and municipalities have significant growth potential in digital village construction levels. Although their input-output has not achieved maximum efficiency, minor improvements should enable them to achieve technical effectiveness in the short term. Second, Shanxi, Anhui, and Henan exhibit decreasing returns to scale, where increased inputs cannot yield proportionally higher outputs, and incremental input scale can only produce relatively smaller output scale benefits.

Based on these conclusions, the following targeted recommendations are proposed:

(1) Digital village construction planning. First, the three municipalities of Beijing, Tianjin, and Shanghai have relatively high construction levels and should continue to play leading and exemplary roles. While maintaining current input levels in digital infrastructure and digital economy dimensions, they should moderately increase construction inputs in digital governance and digital welfare dimensions. Second, the 13 non-remote regions (Hebei, Liaoning, Heilongjiang, Jiangsu, Zhejiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, and Chongqing) have stable

construction levels and should strive for higher levels in the future by moderately increasing inputs across all digital village construction dimensions to achieve better outputs. Third, the four remote regions (Guizhou, Tibet, Qinghai, and Xinjiang) have relatively low construction levels and should moderately increase inputs in digital infrastructure and digital economy dimensions to achieve higher outputs, providing a solid foundation for digital governance and digital welfare construction. Fourth, for the six regions of Inner Mongolia, Jilin, Yunnan, Shaanxi, Gansu, and Ningxia, while maintaining current input levels, Inner Mongolia and Jilin should increase inputs in digital infrastructure and digital economy dimensions; Yunnan, Shaanxi, and Gansu should increase inputs in digital infrastructure, digital economy, and digital welfare dimensions; and Ningxia should increase inputs in digital infrastructure, digital economy, and digital governance dimensions. Fifth, the three regions of Shanxi, Anhui, and Henan should avoid input redundancy in the future by appropriately reducing inputs to ensure good utilization across all dimensions.

(2) Implementation of construction planning. First, for regions that achieved DEA effectiveness, the focus should be on improving input-output conversion efficiency, identifying gaps, and further exploring how to achieve higher outputs with lower inputs. Second, for regions that did not achieve DEA effectiveness, the focus should be on balancing input-output across dimensions, solving existing problems, and achieving DEA effectiveness in digital village construction levels as soon as possible. Third, the construction of digital governance and digital welfare dimensions needs strengthening across all regions. Each region should adapt measures to local conditions, proceed step by step, and timely feedback on relevant suggestions and demands from rural residents. The ultimate goal of digital village construction is to enhance the happiness and satisfaction of rural residents in their daily lives.

Establishing a comprehensive evaluation index system for digital village construction levels guided by the *Guide* and using quantitative measurement to promote construction through evaluation aims to help regions identify existing problems and propose targeted solutions, further advancing digital village construction development and contributing to the comprehensive upgrading of agricultural and rural modernization in China.

6 Limitations and Future Research

In terms of research hierarchy, China' s vast rural areas have significant differences in natural conditions, development levels, and advantageous characteristics, and corresponding evaluation index systems should not be uniform. Regarding research methods, DEA evaluates relative efficiency and cannot distinguish between regions at the same level or regions with uniformly low levels. Moreover, DEA is a non-parametric analysis method, and there may be nonlinear relationships among the various input and output variables used, which can affect analysis results. In terms of research content, this empirical study was conducted only at the provincial scale and represents a horizontal comparison of cross-sectional data; therefore, conclusions can only reflect the digital village construction level of each province in a specific year.

Future research should combine the development needs, stages, and objectives of evaluation objects to appropriately adjust and select subsequent indicators based on local conditions around the first- and second-level indicator framework, forming a more realistic digital village evaluation index system. The DEA model should be optimized and combined with other evaluation methods, research scales should be expanded, and multi-year data should be used for longitudinal analysis to obtain more comprehensive and in-depth evaluation results.

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Author Contributions:
Duan Yaoqing: Proposed research ideas and designed the research framework;
Yi Yujie: Collected and analyzed data, drafted the paper, and revised the final version.

Note: Figure translations are in progress. See original paper for figures.