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A MULTI-DIMENSIONAL FRAMEWORK FOR DEVELOPING ASSESSMENT TOOLS TO MEASURE SUSTAINABILITY FOR COUNTY-LEVEL RURAL E-COMMERCE ECOSYSTEMS

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ABSTRACT

The sustainability of County-level Rural E-commerce Ecosystems (CREES) is vital for advancing rural industrial revitalization goals in China. Although rural e-commerce plays a significant role in promoting rural development, it often faces sustainability challenges linked to poverty alleviation initiatives, which can undermine its effectiveness. This study introduces a novel framework, the Sustainability of Rural E-commerce Ecosystems Model (SREEM), designed to assess the sustainability of CREES. Utilizing a Modified Delphi-AHP technique, the framework integrates theories from rural e-commerce ecosystems, sustainable development, and rural revitalization practices. It identifies three key dimensions of sustainability; Robustness, Niche Creation, and Endogenous Development Capacity that are critical to the health of rural e-commerce ecosystems. The Modified Delphi method, involving three rounds of expert consultations, was used to refine the SREEM Index system. The validity of the framework was further confirmed through the Analytical Hierarchy Process (AHP) and MATLAB, resulting in a comprehensive four-level SREEM hierarchy.

Keywords: China, County-level ecosystems, Rural e-commerce, SREEM (Sustainability Rural E-commerce Model), Sustainability

1.0 INTRODUCTION

Rural e-commerce in China has rapidly transformed the economic landscape, providing new opportunities for poverty alleviation and economic development in previously underserved regions. Since traditional methods are inadequate for success (Wan Nur et al., 2023), the Chinese government has significantly invested in promoting e-commerce to enhance rural economic development. Despite these investments and initial successes, the sustainability of County-level Rural E-commerce Ecosystems (CCREE) remains a critical concern. Current development models are government-driven and top-down, raising questions about their long-term viability and capacity for self-sustaining growth.

Previous studies have highlighted the immediate economic benefits of rural e-commerce initiatives, such as increased household incomes and employment opportunities (Cui et al., 2017; Jha et al., 2016). However, there is an urgent need for a comprehensive assessment

tool that effectively evaluates the sustainability of China's County-level Rural E-commerce Ecosystems Sustainability (CCRESS). Existing tools and frameworks often fall short of capturing the multifaceted nature of sustainability, which encompasses dimensions such as robustness, niche creation, and endogenous development capacity.

Current assessment tools frequently focus on isolated aspects of sustainability or rely on fragmented theoretical foundations, lacking the holistic approach necessary for a comprehensive evaluation of CCRESS. For example, while some tools may address economic stability or environmental impacts individually (Mei & Jiang, 2020; Li-yuan et al., 2020), they fail to integrate these aspects into a unified framework that reflects the interactions between different dimensions (Li-yuan et al., 2020; Sheng & Zhongbing, 2015; Chenghao, 2019; Yuehuan et. al., 2020).

This research aims to develop a comprehensive framework for assessing the sustainability of China's County-Level Rural E-commerce Ecosystem (CCREE). Rather than directly evaluating the sustainability of the ecosystems, the study focuses on designing an assessment tool that can help identify new pathways for development. By leveraging opportunities from initiatives like "County Commercial System Construction" and "Digital Commerce for Agricultural Development," the framework aims to promote high-quality, sustainable growth in rural e-commerce. This multi-dimensional assessment framework will provide insights to guide future efforts in enhancing the sustainability and resilience of rural e-commerce ecosystems in China.

2.0 LITERATURE REVIEW

2.1 Development of County-level Rural E-commerce Ecosystem

The development of the CCREE is rooted in the County-level Rural E-commerce Public Service System (CREPSS) (Jie et al., 2020). This system is structured around the concept of *one centre, five systems,* and operates based on enterprise-led, government-driven, market-oriented, and win-win cooperation (Yang et al., 2022). The key components of CREPSS include the following:

- Rural E-commerce Public Service Center (REPSC) is the central hub connecting various resources within the CCREE.
- Rural E-commerce Training System (RETS) - Focuses on enhancing the skills and capabilities of rural entrepreneurs and stakeholders.
- Agricultural Products E-commerce Supply Chain Management System (APESCMS) - Ensures efficient management and distribution of agricultural products.
- Rural E-commerce Marketing System (REMS) - Promotes effective marketing strategies to boost product awareness and engage consumers in rural areas.
- Rural E-commerce Logistics Service Sites System (RELSS) - Optimizes logistics to enhance service delivery.
- Rural E-commerce Service Sites System (RESSS) - Ensures the provision of necessary services to facilitate rural e-commerce operations.

Under the guidance of national government initiatives, local governments are actively involved in constructing and expanding the support infrastructure for rural e-commerce. This includes the gradual implementation of supervision and security systems to enhance operational efficiency. Consequently, a three-tier public service network has emerged for e-commerce, functioning at the county, township (town), and village levels (Zhaoying & Yihuan, 2022).

2.2 Understanding the Concept of CCREE and CCREES

This study defines the County-level Rural E-commerce Ecosystem (CCREE) as a top-down initiative spearheaded by the Chinese government. Its primary objectives include enhancing county-level e-commerce infrastructure, establishing a county-level service network for rural e-commerce, and cultivating local e-commerce development capabilities (Liu & Ai, 2019).

The goal of CCREE is to provide a wide array of e-commerce services accessible to residents in both urban and rural areas, encompassing the sale of industrial and agricultural products, agricultural materials e-commerce, and various convenience services. This initiative aims to create an integrated county-level e-commerce ecosystem that includes consumption, marketing, logistics, packaging, finance, and training. The ecosystem leverages e-commerce platforms and internet technologies to connect a diverse range of stakeholders, including operators, online merchants, new retail systems, suppliers of agricultural products, producers of agriculture-related goods, e-commerce platforms, providers of agriculture-related services, governments, farmers, consumers, and other participants, all linked through specific interest relationships.

Ecosystem health is intrinsically linked to sustainability (Costanza, 1992). Sustainability, in a nutshell, refers to the concept of development that fulfils the present needs without compromising the needs of the future generation (Raja Adzrin, 2023; Armstrong, 2020). A healthy ecosystem features an optimized internal structure, effective external functions, relative stability, and sustainability (Jian, 2011). Iansiti and Levien (2002) proposed "health" as a comprehensive metric for assessing the effectiveness of business ecosystems.

The CCREE is a top-down initiative launched by both central and local governments. It exists outside the realm of natural ecosystems and is distinct from endogenous commercial ecosystems. Its formation is supported by the establishment of a comprehensive CREPSS. The primary objectives of CCREE are to facilitate e-commerce development and achieve poverty reduction.

This research defines CCREES as an ideal state of CCREE, characterized by a stable public service system that effectively fulfils its functions. The ecosystem exhibits strong diversity among its participants, fostering an agglomeration effect in the rural e-commerce industry. CCREES possesses the capacity for endogenous development, self-adjustment, and adaptability, enabling it to withstand external changes and threats. Moreover, it meets the current and future social needs of various stakeholders within the CCREE, ensuring sustained value growth and the sustainable, healthy, and high-quality development of the ecosystem.

2.3 Conceptual Framework

A sustainable rural e-commerce ecosystem in China requires endogenous development capacity, enabling it to thrive through internal resources and capabilities rather than relying solely on external support. Assessing sustainable development typically involves creating an index system that utilizes mathematical methods to establish measurable indicators based on the ecosystem's characteristics and functions.

For CCREE, a comprehensive and multi-dimensional index system is crucial for evaluating sustainability. This system aims to assess the ecosystem's sustainable state, identify weaknesses, and guide improvements toward high-quality development and rural revitalization.

Drawing on theories of Rural Revitalization Strategy (Liu, 2019), Rural E-commerce Ecosystems (Zhang et al., 2023; More, 1993), and Rural E-commerce Ecosystem Sustainability (Zang et al., 2023), this study introduces the Sustainability of Rural E-commerce Ecosystem Model (SREEM). SREEM evaluates CCREE sustainability through three key dimensions:

- Robustness - The ability of the system to withstand and recover from disturbances.
- Niche Creation - The capacity to develop and occupy unique market spaces.
- Endogenous Development Capacity - The ability to leverage local resources and talent for internal growth.

This framework provides a clear and actionable assessment of CCREE sustainability, supporting the optimization of rural e-commerce and contributing to overall rural development as shown in **Fig. 1.**

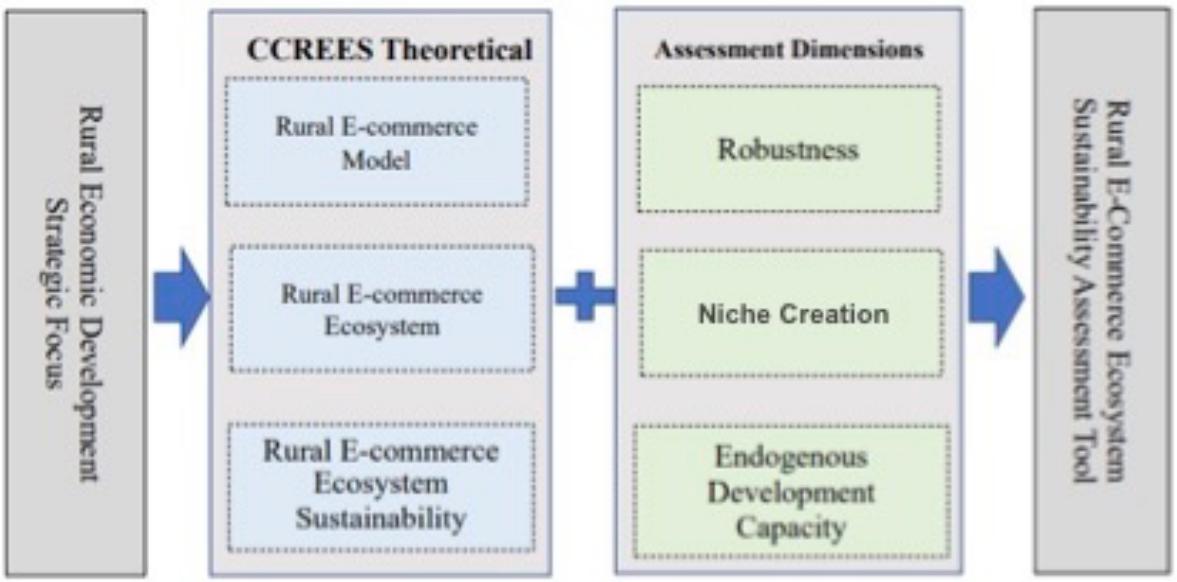

Fig. 1 *SREEM Framework*

3.0 METHODOLOGY

3.1 Research Design

The sustainability assessment tool for CCREE poses a multi-criteria decision-making challenge, requiring the development of a robust assessment framework with carefully selected indicators. The Analytic Hierarchy Process (AHP) serves as an effective multi-criteria decision-making tool, providing a methodology for calibrating a numeric scale to measure both quantitative and qualitative performances (Vaidya & Kumar, 2006). However, AHP is rarely used in isolation; it is often integrated with or complements other methodologies (Forman & Gass, 2001).

The Modified Delphi and AHP techniques are widely recognized in academic discourse as effective multi-criteria decision-making tools (Khan et al., 2022). This study employs a combined approach utilizing the Delphi technique alongside AHP (Delphi–AHP) to develop an assessment tool for CCREES (Hsu & Lin, 2013). The study unfolds in three stages as follows (**Fig. 2.**):

- Modified Delphi Method – This stage involves screening relevant indicators for the SREEM.
- AHP Method – The relative weights of the evaluation indicators across each layer of the SREEM are determined, culminating in a comprehensive assessment framework.
- Application of SREEM – Finally, the SREEM is applied to evaluate CCREES, focusing on a sample of 72 National Rural E-commerce Comprehensive Demonstration Project counties in Hunan Province, China.

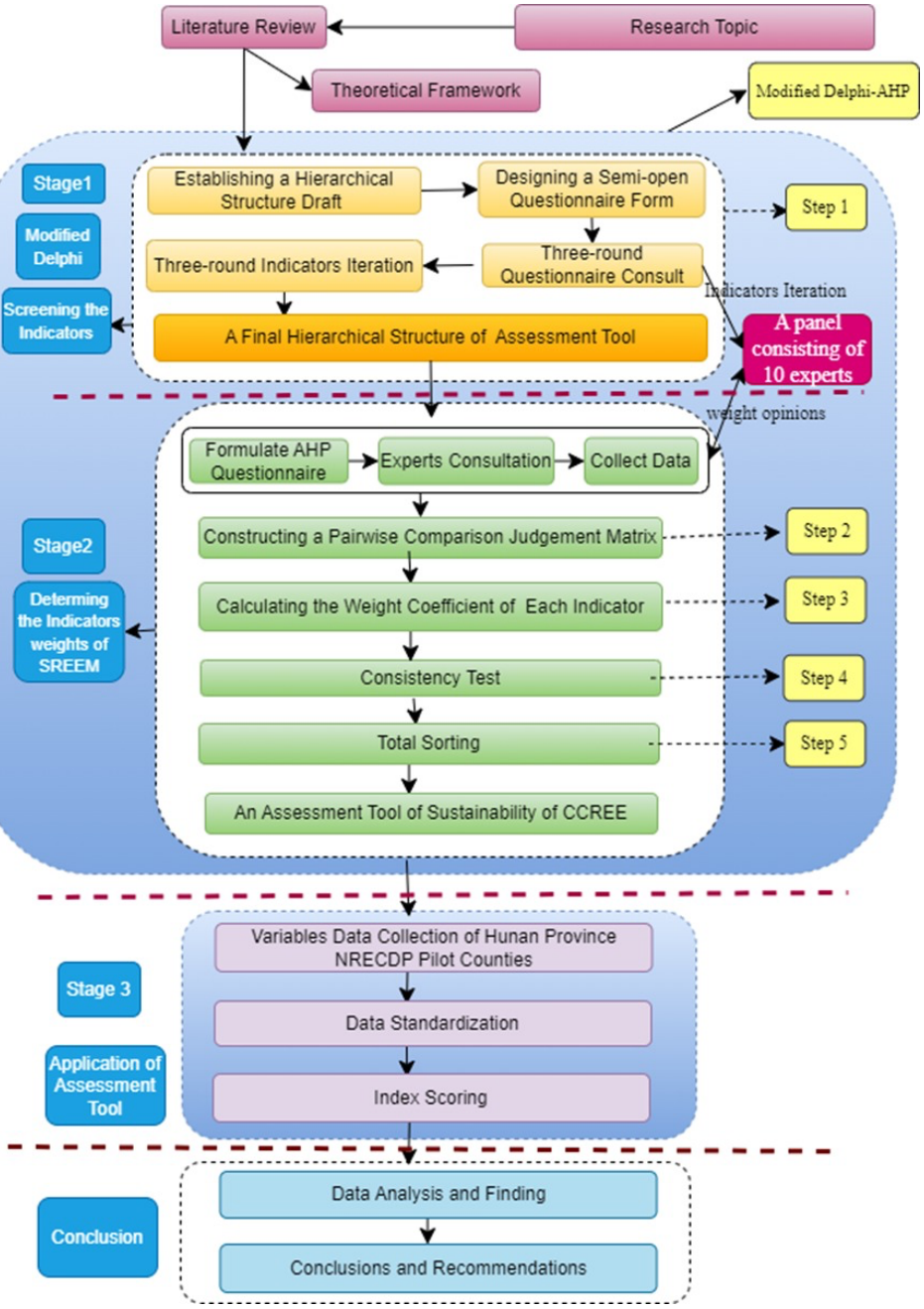

Fig. 2. *Research Design*

3.2 Development of Assessment Tool

3.2.1 Stage I: Constructing a Hierarchical Model of the SREEM Draft

The SREEM must reflect the structural robustness of the CCREE. The CCREE is organized through the Rural E-commerce Public Service System (REPSS), which includes the Rural E-commerce Public Service Centre (REPSC), Agricultural Products E-commerce Supply Chain Management System (APESCMS), Rural E-commerce Service Sites System (RESSS), and Rural E-commerce Training System (RETS). Thus, the SREEM should demonstrate the CCREE's ability to sustain its organizational structure, functional vitality, and resilience under pressure, ensuring the delivery of high-quality services for current and future generations. This requires consideration of the sustainability and predictability of the CCREE structure, as well as the survival rate of the core population, which significantly impacts robustness.

3.2.2 Indicators Source of the SREEM

The index system for the SREEM was developed through a comprehensive approach, drawing from three key sources:

- **Ecosystem Health Evaluation Index System**
  Building on the foundational work of Iansiti and Levien (2002), who identified three critical factors influencing business ecosystem health—Robustness, Productivity, and Niche Creation—this study incorporates these dimensions into the SREEM. By integrating these elements with the functions and structure of the County-level Rural E-commerce Ecosystem (CCREE), the index system reflects the essential characteristics that contribute to ecosystem vitality.

- **Performance Evaluation Index System of NRECDP**
  To improve the operational effectiveness of the NRECDP, the Chinese government established a performance evaluation index system. This system, assessed by a third party across all NRECDP counties, comprises three dimensions: fostering rural e-commerce's endogenous development capability, organizational implementation, and work performance. Selected indicators from these dimensions have been integrated into the SREEM to ensure alignment with the objectives and framework of the CCREE.

- **Publicly Available Research Reports**
  The index system also derives insights from research reports on the County Digital Rural Index, which encompasses four dimensions: Rural Digital Infrastructure Index, Rural Economic Digital Index, Rural Governance Digital Index, and Rural Life Digital Index (Lai et al., 2024). The "Digital Rural Index," measured across 1,880 counties in China (Digital Village Project Team, 2020), includes relevant indices such as Digital Infrastructure, Digital Production, Digital Supply Chain Management, Digital Marketing, Digital Finance, and Digital Consumption, all closely related to the Endogenous Development Capacity of the CCREE.

This research adheres to six principles of index system construction and draws upon three key sources of indicator content, all while thoroughly considering the conceptual framework of CCREES. The focus is on the dimensions of robustness, niche creation, and endogenous development capacity. By synthesizing these three sources, the index system for the SREEM is robust and multifaceted, providing a comprehensive framework for assessing the sustainability of the CCREE.

3.2.3 Stage II: Screening Indicators of the SREEM via the Modified Delphi Method

- **Formation of a Panel of Experts for Evaluating Rural E-Commerce Indicators**
  Following recommendations from the Delphi literature, a panel of ten experts was formed, selected for their expertise in CREE. These experts were invited to evaluate the practicality of the proposed indicators in the SREEM draft developed in Stage 1. Selection criteria included familiarity with rural e-commerce, practical experience, industry influence, and diverse backgrounds (academia, e-commerce, government, rural e-commerce services). Unrelated experts were excluded. The panel comprised three senior academics/researchers, three e-commerce experts, three government representatives, and one rural e-commerce service expert, covering all dimensions of the CCREE.

- **Implementation of the Modified Delphi Questionnaire Process**
  This study used a three-round expert survey, conducted via email and WeChat over two months, to refine the SREEM indicators. A semi-structured questionnaire was developed based on the SREEM draft, allowing experts to select indicators and suggest additional ones. The questionnaire was sent to ten industry experts, who provided feedback. In the first round, all ten experts responded, offering valuable input on the framework, leading to significant revisions. These changes resulted in the second SREEM draft, with three main indicators, ten sub-indicators, twenty-six sub-sub-indicators, and thirty-seven detailed indicators. A second questionnaire, reflecting the updated draft, was sent to the same experts. Their feedback showed strong approval of the changes, resolving issues like overlap and redundancy. A third round of surveys was then conducted, with only minor adjustments suggested. As the third round revealed minimal changes, a fourth round was unnecessary. The final SREEM, presented in Table 1, includes three dimensions, eight criteria, twenty-three indicators, and thirty-five variables.

3.2.4 Stage III: Application of the Assessment Tools

- **Implementation of AHP**
  To determine the weight of each indicator in SREEM, the AHP method will be used for weight surveys at various levels, and MATLAB software will be utilized to calculate the weight coefficients, resulting in the final assessment tool for CCREES. This process will be conducted in the upcoming phase of the study. The study utilizes 72 NRECDP pilot counties in Hunan Province as samples to apply the SREEM model for assessing CCREEs. Continuous data covering from 2017 to 2021 will be collected across thirty-five variables (organized into four-level indicators) for each of the seventy-two counties, resulting in a total of 12,600 data points. All data will be quantitative, sourced from official government departments, websites, and publicly available research. After data collection, Excel will be used for cleaning, standardization, index calculation, and statistical analysis, resulting in CREES assessment results for the seventy-two counties. The sustainability assessment results will be analysed comprehensively, covering three perspectives: longitudinal (2017-2021), cross-sectional (72 counties), and same-level indicators (total, first-level, second-level, and third-level indicators), providing a full view of CREES development in Hunan Province. This entire process will be implemented during the next phase of the study.

4.0 RESULT AND ANALYSIS

4.1 SREEM Structure

As shown in Table 1, The hierarchical structure is the result of the findings from the Delphi process used in the study. Through several rounds of questionnaires with the expert panel, the indicators for SREEM were identified, organized, and classified. As a result of this process, the final SREEM structure comprises three dimensions, eight criteria, twenty-three indicators, and thirty-five variables.

4.1.1 Robustness (A)

Robustness is evaluated through the organizational structure of CCREE, focusing on the Survival Rate, Ecosystem Structure Persistence, and Predictability.

- **Survival Rate (A1)** is measured by the Survival Rate of the Core Population (A11) evaluated using REPSC.
- **Ecosystem Structure Persistence (A2)** is assessed through three components: RETS (A21), RESSS (A22), and RELS (A23), all part of CREPSS.
- **Predictability (A3)** is evaluated based on the Predictability of the REPSC (A31) and the E-commerce Industry (A32), assessing the adaptability of CCREE's core populations to environmental changes and threats.

4.1.2 Niche Creation (B)

Niche Creation evaluates CCREE's activity level, focusing on Population Variety (B1) and Value Creation Capability (B2) for the ecosystem.

- **Population Variety (B1)** is measured through factors like Emerging Online Merchants (B111), Provincial-Level Leading Enterprises (B112), Farmers' Cooperatives (B113), Family Farms (B114), and other agricultural operators.
- **Value Creation (B2)** includes the value of Agricultural Products Sold to Cities (B21) (Duan et al., 2024) and the value of Industrial Products Sold to Rural Areas (B22).

4.1.3 Endogenous Development Capacity (C)

This dimension focuses on CCREE's alignment with digital rural development and high-quality rural revitalization goals. It draws on indicators from the NRECDP performance evaluation tool and the County Digital Rural Index (Guo & Chen, 2022). The capacity is evaluated through three key areas:

- **Rural E-commerce Infrastructure (C1)** includes indicators such as County Rural Digital Infrastructure (C11), Public Warehousing and Distribution Facilities (C12), and Cold Chain Logistics for Agricultural Products (C13) (ZJU, 2021).
- **Prosperous Industry (C2)** is driven by consumer demand for quality agricultural products, assessed through Characteristic Agricultural Products (C21), Agricultural Product Brands (C22), Geographical Indication Products (C23), Industrial Base (C24), E-commerce Industry Clustering (C25), and Digital Production (C26).
- **Rural E-commerce Service Ability (C3)** is measured through indicators from the County Digital Rural Index, including Digital Consumption Service (C31), Digital Life Service (C32), Digital Marketing Service (C33), Supply Chain Service (C34), and Digital Financial Services (C35).

Table 1. The SREEM Index System

First level indicators	Second level indicators	Third level indicators	Fourth level indicator
A Robustness	A1 Survival Rate	A11 Survival Rate of Core Populations	A111 Put into Use REPSC
			A112 Annual Incubating Enterprise Network for Business Management
	A2 Persistence of Ecosystem Structure	A21 Persistence of Rural E-commerce Training System (RETS)	A211 Annual Investment in Rural E-commerce Training (10,000 ¥)
		A22 Persistence of Rural E-commerce Service Sites System (RESSS)	A221 Village-level E-commerce Service Site Coverage （%）
			A222 The Proportion of Sustainable Operation Sites in the Total Village Sites in the County （%）
		A23 Persistence of Rural E-commerce Logistics System) (RELS)	A231 The Coverage Rate of the Village-level Logistics Sites（%）
			A232 Unified Warehouse Co-allocation Logistics Enterprises from County to Village
	A3 Predictability	A31 Predictability of (Rural E-commerce Public Service Centre) REPSC	A311 Annual Investment Amount (10,000 ¥)
			A312 Continuously Operated by Professional Third-party Enterprise
		A32 Predictability of the E-commerce Industry	A321 Annual Government Support for the E-commerce Industry (10,000 ¥)
			A322 Number of Annual Training for E-commerce Practitioners (person-time)
B Niche Creation	B1 Variety	B11 Key Population Variety	B111 Total Number of New Online Merchants (per 10,000 people)
			B112 Number of Leading Enterprises above the Provincial Level (per 10,000 people)
			B113 Farmers' Cooperatives (per 10,000 people)
			B114 Family Farm (per 10,000 people)
	B2 Value Creation	B21 Value Creation of Agricultural Products Sold to the City	B211 Cumulative Number of Individual Agricultural Products Added
		B22 Value Creation of Industrial Products Sold to the Rural	B221 Number of Packages Received
C Endogenous Development Capacity	C1 Rural E-commerce Infrastructure	C11 County Rural Digital Infrastructure	C111 Digital Infrastructure Index
		C12 Rural E-commerce Public Warehousing and Distribution Facilities	C121 Local Green Warehouses Used to Store Agricultural Produce

First level indicators	Second level indicators	Third level indicators	Fourth level indicator
		C13 Cold Chain Logistics Facilities for Agricultural Products Preservation	C131 Agricultural Product Supply Chain Cold Chain Logistics Construction Project Award (10,000 ¥)
	C2 Prosperous Industry	C21 Characteristic Agricultural Products	C211 Hometown of Chinese Specialties
			C212 SC License
		C22 Characteristic Agricultural Product Brand	C221 Number of “Two Products”
		C23 Geographical Indication Product	C231 Geographical Indications
		C24 Characteristic Industrial Base	C241 National OVOP Demonstration Villages and Towns
			C242 National Rural Characteristic Industry 100-million-yuan (¥) town (township)
			C243 National Rural Characteristic Industry 100-million-yuan (¥)
		C25 E-commerce Industry Agglomeration	C251 Live Streaming Base
			C252 E-commerce Industrial Park
		C26 Digital Production	C261 Digital Production Index
	C3 Rural E-commerce Serviceability	C31 Digital Consumption Service	C311 Digital Consumption Index
		C32 Digital Life Service	C321 Digital Life Services Index
		C33 Digital Marketing Service	C331 Digital Marketing Index
		C34 Supply Chain Service	C341 Digital Supply Chain Index
		C35 Digital Financial Services	C351 Digital Financial Index

4.2 Determining Weights of All-level Indicators in the SREEM

4.2.1 Constructing the Pairwise Comparison Judgment Matrix

Saaty's scale and expert surveys were utilized to construct pairwise comparison judgment matrices. During matrix construction, indicator weights, and qualitative assignments were derived from expert input. The judgment matrices were developed based on the hierarchical structure of the SREEM. The same ten experts involved in the Modified Delphi method were invited to participate in the survey, rating the importance of each indicator within the SREEM. The expert survey was administered through the questionnaire Star platform (https://www.wjx.cn/vm/OtT3WYe.aspx). Using the relative scores provided by the experts for each indicator, a synthetic judgment matrix was generated for each level by applying the geometric mean aggregation method. This approach effectively synthesized expert opinions. The eigenvectors and eigenvalues for each judgment matrix were calculated using MATLAB's geometric mean method.

The goal layer matrix is denoted as $A^{(k)}=(a_{ij})^k$ for k= 1, 2…,10. To obtain the pairwise comparison matrix $A=(a_{ij})$, first compute the geometric mean of $(a_{ij})^k$ using the following formula (Eq. (1)).

$$a_{ij} = \prod_{k=1}^{s} (a_{ij}^{(k)})^{\lambda_k}$$

(1)

where λ_k represents the weighting factor assigned to the *k*-th expert.

4.2.2 Calculating the Weight of Each Index

In this study, the judgment matrix is solved using MATLAB software to compute its eigenvectors and eigenvalues. Each column of the judgment matrix A is normalized as shown in Eq. (2).

$$a_{ij}^{*} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad \text{for } i, j = 1, 2, \ldots, n.$$

(2)

Subsequently, the row-wise summation is performed, denoted in Eq. (3).

$$W_i = \sum_{j=1}^{n} a_{ij}^{*}.$$

(3)

To obtain the weight vector *W*, normalize W_i as follows (Eq. (4))

$$W_i = \frac{W_i}{\sum_{j=1}^{n} W_j} \quad \text{for } i, j = 1, 2, \ldots, n.$$

(4)

Next, calculate the maximum eigenvalue λmax using the formula (Eq. 5)

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i},$$

(5)

Where $(AW)_i$ represents the *i*-th component of the matrix-vector product *AW*. The relationship $AW = \lambda_{max} W$ is then satisfied (Khan et al., 2022).

4.2.3 Calculation of Combined Weights and Consistency Check for Each Layer

To determine the aggregated weights of elements within a given tier relative to the overall objective and their interdependencies with elements in the preceding layer, the ranking outcomes of all elements within the same tier are utilized. This involves calculating the weight values for the significance of each element in the current tier to the elements in the higher tier. Simultaneously, a consistency check is performed using the consistency verification method described earlier. MATLAB software is employed to compute the hierarchical single rankings and consistency test results, providing the weight coefficients for indicators at each level.

The formula for calculating the weight of the *j*-th indicator in the second tier relative to the *i*-th indicator in the first tier (Ye & Liu, 2023) is as follows:

$$W_{ij} = W_i \times b_{ij}$$
$$RI = \sum W \times RI_i, \text{ CR=CI/ RI=CI<0.1}$$

(6)

Here, W^{ij} represents the weight of the *j*-th indicator at the second level to the iii-th indicator at the first level (Ye & Liu, 2023). *CI* denotes the Consistency Index, *RI* is the calculated Random Index (as shown in Table 2), and *CR* refers to the Consistency Ratio.

Table 2. Random Consistency Index (RI) (Fuyang et al., 2014)

Order of matrix	**1**	**2**	**3**	**4**	**5**	**6**	**7**
RI	0	0	0.515	0.893	1.119	1.249	1.345
Order of matrix	8	9	10	11	12	13	14
RI	1.420	1.462	1.487	1.516	1.541	1.558	1.580

Due to space limitations, the specific computational procedures are not presented in this paper. However, Table 3 provides a comprehensive summary of the weight coefficients for the indicators at each level. This summary marks the culmination of the development process for the CCREES assessment tool.

Table 3. Weights of the Indicators in the SREEM

First-level Indicators	Second-level Indicators	Third-level Indicators	Fourth-level Indicator
A 0.4133	A1 0.2062	A11 0.2062	A111 0.1250
			A112 0.0812
	A2 0.1185	A21 0.0359	A2110.0359
		A22 0.0188	A221 0.0040
			A222 0.0148
		A23 0.0639	A231 0.0389
			A232 0.0250
	A3 0.0887	A31 0.0562	A311 0.0265
			A312 0.0298
		A32 0.0324	A321 0.0221
			A322 0.0103
B 0.1829	B1 0.0984	B11 0.0984	B111 0.0275
			B112 0.0397
			B113 0.0203
			B114 0.0110
	B2 0.0845	B21 0.0689	B211 0.0689
		B22 0.0155	B221 0.0155
C 0.4038	C1 0.0977	C11 0.0237	C111 0.0237
		C12 0.0414	C121 0.0414
		C13 0.0326	C131 0.0326
	C2 0.1949	C21 0.0401	C211 0.0201
			C212 0.0201
		C22 0.0466	C221 0.0466
		C23 0.0246	C231 0.0246
		C24 0.0334	C241 0.0100
			C242 0.0126
			C243 0.0108
		C25 0.0379	C251 0.0174
			C252 0.0206
		C26 0.0122	C261 0.0122
	C3 0.1112	C31 0.0245	C311 0.0245
		C32 0.0199	C321 0.0199

5.0 SUGGESTION FOR FUTURE RESEARCH

Future research may extend the application of the SREEM Index System to regions beyond Hunan, facilitating comparative analyses of rural e-commerce ecosystems across various parts of China. Furthermore, investigating the long-term sustainability and resilience of CREES under differing socio-economic and environmental conditions could yield critical insights. Incorporating qualitative methodologies, such as community feedback and case studies of local enterprises, would further enrich the evaluation process, offering a more holistic understanding of the effectiveness and adaptability of rural e-commerce ecosystems in diverse contexts.

6.0 CONCLUSION

This study introduces the conceptual framework of County-level Rural E-commerce Ecosystem Sustainability (CCREES) and develops an associated assessment tool, the Sustainability of Rural E-commerce Ecosystem Model (SREEM). The CCREE is defined as the rural e-commerce ecosystem established through government-led initiatives in China, specifically, the National Rural E-commerce Comprehensive Demonstration Project (NRECDP), organized under the County-level Rural E-commerce Public Service System (CREPSS) framework. CREPSS comprises six modules: the Rural E-commerce Public Service Centre (REPSC), Rural E-commerce Training System (RETS), Rural E-commerce Service Sites System (RESSS), Rural E-commerce Logistics Service Sites (RELS), Rural E-commerce Marketing System (REMS), and Agricultural Products E-commerce Supply Chain Management System (APESCMS).

The NRECDP focuses on nurturing the county-level rural e-commerce ecosystem by facilitating the circulation of downstream industrial products and providing services for agricultural products. Its objectives include cultivating endogenous development capabilities, fostering population aggregation, enhancing niche creation, promoting high-quality development, and achieving rural revitalization goals. CCREES embodies the ideal state of the CCREE, characterized by a stable organizational structure, an active ecological population, strong value creation capabilities, comprehensive e-commerce infrastructure, a thriving industry, robust service capabilities, efficient product circulation, and resilience to environmental changes.

SREEM is developed based on six fundamental principles and refined through Modified Delphi research involving ten authoritative experts. The resulting framework consists of three primary indicators, eight secondary indicators, twenty-three tertiary indicators, and thirty-five quaternary indicators. Using the AHP method, the same experts conducted a weight survey to determine the final weight coefficients for each indicator in SREEM.

This study contributes to the academic field by establishing a theoretical framework and an assessment tool for CCREES, thereby enhancing our understanding of the developmental dynamics of exogenous rural e-commerce ecosystems. Additionally, it facilitates practical applications by evaluating CCREES, providing insights for the advancement of rural e-commerce, and fostering rural revitalization through enhanced robustness, niche creation, and the augmentation of endogenous development capabilities.

CO-AUTHOR CONTRIBUTION

The authors declare that there are no conflicts of interest regarding this article. Author 1 conducted the fieldwork, compiled the literature review, provided the data, and performed the statistical analysis. Author 2 was responsible for writing the entire manuscript. Author 3 interpreted the results.

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