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The supporting role of rural cultural construction in the implementation of the rural revitalization strategy and its specific manifestations

Yishan Li[1,*]

[1] College of Marxism, Xinjiang Normal University, Urumqi, Xinjiang, 830017, China

SUMMARY: *The process of rural cultural development can be considered as one of the factors that play a crucial role in rural revitalization and also offer a valuable ideological and cultural contribution towards implementing that policy in a unified manner. In the current research, an assessment system of rural cultural development is created, and the DEA-Malmquist measure is used to evaluate how rural cultural development actions have been implemented in a particular region in the timeframe between 2012 and 2023. When rural cultural development is used as the explanatory variable, its impact on rural revitalization is examined in terms of benchmark regression, dynamic panel estimation based on the system GMM estimator, and threshold-effect models. It is found that the sample area had relatively good results on rural cultural development in 2013-2019 with overall scores of over 1. Nevertheless, additional improvement is still needed since the average overall score in 2012-23 was 0.984, which is less than 1. The empirical evidence confirms that rural cultural development has a significant positive effect on rural revitalization at the 1 percent level. Moreover, the promotion effect is enhanced when it is supported by more effective government policy.*

KEYWORDS: *DEA-Malmquist; System GMM estimation; Threshold model; Rural cultural development; Rural revitalization*

1 Introduction

Since China is the only country in the world that does not have a break in its civilization, it needs to ensure continuity in its historical context during the process of modernization. It involves creating a unique modern culture alongside the preservation of its time-honored tradition. The fact that China is one of the few agricultural superpowers highlights the central position of the rural culture in its civilization history [1]. Being an essential part of national progress, rural construction should be based on specific regional customs. The Chinese version of modernity should not be confined to the cities, but should also be present in rural life, which can be characterized by unique features of the nation. Hence, unique rural culture can become the foundation of the agricultural development. It is important to note that cultural revival is essential in creating attractive rural places and can be used as an indicator of the quality of rural modernization [2-4. Nevertheless, rural development has tended to be a slow process as technology, information, and skills gaps are preventing the dissemination of rural culture. Consequently, taking advantage of the availability and flexibility of cultural dissemination, we must utilize the rural culture as a lever to reinvent the development strategy.

We can eliminate promotion issues by setting themes, content and methods of dissemination of information about rural culture, which will become the basis of rural development and

*17726757686@163.com
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revitalization [5]. The process of modernizing rural culture does not just add to the richness of the spiritual life of its people but it has also added value to national cultural soft power, bringing a new form of vitality in the villages. It needs a constant search of cultural richness and originality of dissemination in order to enable a wider understanding, appreciation and involvement in the development of rural culture [6-8]. At the same time, incorporating contemporary technological tools improves the effectiveness of the spread of rural culture, offering examples of rural revival with Chinese features, which offer strong evidence of the nationwide rural revival [9]. Accordingly, considering this context, the mechanism behind rural cultural development and rural revitalization is investigated as a way to make a small contribution towards addressing the problem in rural cultural development.

The study of rural cultural development has developed throughout a lengthy period. After the implementation of the New Rural Construction policy and particularly since the Rural Revitalization Strategy was implemented, the scholarly interest in the relationship of rural cultural development and rural revitalization grew significantly, bringing considerable research results. Comparing cultural development in cities and rural areas, Literature [10] determined significant differences between the urban and rural regions of China in terms of cultural development. The slow pace of cultural development of rural China has been increasingly seen as one of the critical factors constraining the overall rural development and the realization of the Rural Revitalization Strategy. According to Literature [11], the lack of talent in rural areas may be addressed by the fact that college students can become the primary source of innovation to develop rural cultural development and rural revitalization. Their knowledge and contemporary outlook allows them to compensate the weaknesses in the grassroots cultural governance and enable the exchange of cultures between the city and the countryside. Literature [12] also notes that having a clear appreciation of the worth of the rural culture, i.e., circular economy value, ecological livability value, green leisure value, urban-rural integration value, and agricultural talent value, will assist in reducing the cultural development gap between urban and rural areas. Literature [13] also states that rural cultural development is a multifaceted and structured process as well as a critical support to rural revitalization and suggests that the development of rural cultural curricula and enhancement of rural cultural service systems would promote both rural cultural development and national rural revitalization objectives.

The revitalization of rural areas is a great tradition, and the rural culture has opened up new perspectives of development. Literature [14] claims that the cultural development of the village is an inseparable part of rural revitalization in China. The steps to develop rural culture include enhancing infrastructure, maintaining local traditional cultural features, and facilitating the modernization of rural culture which will help to enhance labor productivity and competitiveness and establish new sources of economic growth. Literature [15] has conducted field studies in four suburbs and five counties in Tianjin, demonstrating that the rural revitalization needs not only material development but also cultural development. The revitalization will be driven by integrating local resources to support unique rural cultural industries as one of the main engines of revitalization. Literature [16] states that creation of rural cultural halls enhances the welfare of the people and meets the spiritual and cultural requirements of the farmers and serves as an important step in rural cultural development. There are still some challenges, such as lack of services, construction problems, and financial limitations.

The recent changes in the social sphere have influenced the development of rural areas and peasant life greatly. The modern Chinese rural culture must deal with complex historical, theoretical, and value-related thinking. Literature [17] suggests that the reformation of the culturally remembered villages into marketable IP is significant to the development of rural culture. Using state-of-the-art information, science, and smart technologies could make the

designing process of rural cultural creativity more diversified and speed up this development. According to literature [18], cultural revival forms one of the critical elements of rural revival, which acts as the key to the realization of holistic rural revivification. It suggests forming the long-term system and generating unique rural cultural symbols within the framework of constructing rural public cultural spaces to enable moving towards a bidirectional interactive mode. Literature [19] deals with issues of rural cultural development, such as a lack of funding, a single supply model, an imbalance in distribution, and poor community involvement, with specific recommendations: widening the source of financing, improving the corresponding systems, implementing professional groups, and refining/rewriting models of development.It asserts that the paramount goal of cultural development should be prioritizing farmers' spiritual and cultural needs as the highest guiding principle.

The present work has its focus on the way in which rural cultural development can be used to revitalize the countryside. The paper will take 20 cities in one specific region as research subjects to choose the input and output indicators to construct an assessment model of rural cultural development. Then, DEA-Malmquist model is used to estimate the rural cultural development of the region on average and its 20 cities in 2012-2023. Further, an index system is developed on that basis to assess the revitalization level of the same sample region during the specified time frame. The obtained rural cultural development index and rural revitalization index are then considered as explanatory and explained variables, respectively, as well as threshold and control variables. Last but not least, through the combination of static regression, dynamic regression, and threshold-effect analysis, the paper studies the facilitative function of rural cultural development in promoting rural revitalization, as well as the threshold effect that goes along with the level of government policy support.

2 The Supporting Role of Rural Cultural Development in Rural Revitalization

The culture of rural has many forms of values. It fits in the overall goal of the national rural revitalization programme and acts as a key driver in the overall revival of agriculture and rural areas. On the above basis, the current analysis addresses the position of rural cultural development in facilitating rural revitalization.

2.1 Injecting Economic Momentum

Rural tourism development is a key element in promoting rural economic growth. The creation of unique cultural tourism sectors does not only bring fresh vigor to rural economic growth but also facilitates the integration of the three major rural industries, thus contributing to industrial success and economic progress in the rural communities.

To begin with, it creates a new growth area in the rural economy. Culture may be used in industrial production as both a factor of production and an inspiration to innovation and change. The development of cultural tourism can be used to transform these distinctive assets into a new industry by exploring and using the multiplicity of values associated with unique resources like festival culture, intangible cultural heritage and folk crafts.

Second, it encourages the development of rural cultural tourism economies. As the trend of the so-called rural cultural tourism is becoming more and more popular, villages use their traditional folklore and unique natural settings to create major business opportunities to the tourists on an ongoing basis. At the same time, they provide better experiences to those who are nostalgic and want to go back to nature, which brings rural tourism to a further stage of development.

Thirdly, it diversifies rural industries. The cultural tourism industry has a high integration potential. Developing it can promote the integrated development of agriculture and services, advance the marketization process and industrial structure upgrading in rural areas, and facilitate the transition from agriculture-dominated single-track development to multi-industry convergence.

2.2 Providing Motivation

The unique spirit and cultural essence embodied in rural culture play a vital role in shaping farmers' moral values, ideals, beliefs, and local customs.

First, it drives conceptual innovation and transforms rural customs. Rural cultural development inherits and advances China's outstanding traditional culture while embodying core socialist values. By maximizing the educational power of traditional culture, it eliminates outdated practices, curbs the spread of harmful mindsets, and fosters civilized, harmonious, healthy, and mutually supportive social norms in rural areas, thereby advancing rural spiritual civilization.

Second, it enriches rural cultural life and strengthens farmers' cultural identity. Developing rural culture significantly invigorates villages and enriches farmers' spiritual lives.

Third, it meets farmers' spiritual and cultural needs. As living standards rise, farmers' demands for spiritual and cultural enrichment continue to grow.

2.3 Optimizing Grassroots Management

Strengthening the development of rural spiritual civilization can enhance villagers' collective consciousness and improve the effectiveness of rural governance.

First, it reinforces farmers' sense of collective identity and awareness of the rule of law. As urbanization progresses, the “hollowing out” of rural areas has become increasingly severe, weakening farmers' sense of collective collaboration. Strengthening villagers' collective cooperation mindset can advance the process of making villagers' decision-making more scientific and institutionalized.

Second, it optimizes rural management and self-governance models. Developing rural culture helps promote grassroots social governance and strengthen the functions of grassroots self-governance.

3 Evaluation of Rural Cultural Development Based on DEA-Malmquist

As analyzed above, rural cultural development plays a significant role in promoting rural advancement through economic, spiritual, and governance dimensions. This chapter evaluates the rural cultural development in a specific region, laying the groundwork for subsequent research into its concrete manifestations in the implementation of rural revitalization.

3.1 Evaluation Indicator System

The evaluation indicator system for rural cultural development is shown in Table 1. The following output indicators were selected for assessing rural cultural development: rural radio coverage rate, township cultural station coverage rate, rural library holdings, number of organized rural cultural activities, and number of rural cultural practitioners. Rural cultural fiscal expenditure serves as the input indicator.

Table 1: Evaluation index system of rural culture construction

Target	Index layer (output)	Index layer (input)
Rural culture construction	Country broadcast coverage(%)	The financial expenditure of rural culture(%)
	Coverage of rural cultural stations(%)	
	Country book quantity (1 hundred books)	
	Number of country cultural activities (times)	
	Country cultural practitioners (a)	

3.2 Evaluation Method Model Selection

The research takes the position of using Data Envelopment Analysis (DEA) and considers all the cities within the chosen region as a single decision-making unit. The study can perform an empirical analysis of rural cultural development throughout the region by implementing the previously identified indicator system of rural cultural development into the DEA framework, which will allow it to give a quantitative foundation of analyzing the rural cultural development index system.

3.2.1 Data Envelopment Analysis (DEA) Method

DEA is a quantitative assessment method based on several input and output variables. Its main application is to find out the efficiency rates of units of the same kind and the comparative performance of their efficiency. DEA has the underlying notion that every object under consideration should be regarded as a decision-making unit and all the units should be considered as one evaluation set. DEA creates an efficient frontier by identifying the finest possible input-output combination. These objects are regarded as the most efficient decision-making units (DMUs). The efficiency of the other DMUs is assessed based on their proximity to this frontier. Simultaneously, DEA may be applied to conduct the projection analysis of relatively inefficient DMUs. It provides particular optimization guidance by analyzing input overlaps and output deficiencies. General flow of the DEA approach can be easily depicted in Figure 1.

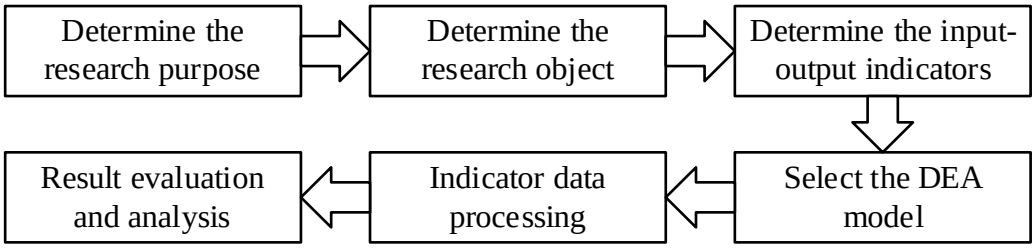

Figure 1: DEA method flow chart

3.2.2 Types of DEA Models

DEA is a nonparametric measure of efficiency that has the ability to determine the relative efficiency of decision-making units with multiple inputs and outputs. Of all the DEA models, the CCR and the BCC models are the two representative classic forms. Contrary to these stable assessment models, the Malmquist index model can be applied to analyze the whole-system dynamism using the concept of distance functions.

(1) CCR Model:

$$\begin{aligned}
&\min\left\lfloor \theta-\varepsilon(e^T+e^T s^+)\right\rfloor \\
&s.t.\sum_{j=1}^{n}\lambda_j x_j+s^-=\theta_{x0} \\
&\sum_{j=1}^{n}\lambda_j y_j-s^+=y_0 \\
&\lambda_j\geq 0, s^-\geq 0, s^+\geq 0,\ j=1,2,\ldots,n
\end{aligned} \tag{1}$$

In formula (1), θ represents the comprehensive efficiency index of factor inputs and outputs, λ denotes the weighting coefficient, x_j is the input variable, y_j is the output variable, and s^+, s^- are the slack variables for inputs and outputs, respectively.

(2) BCC Model:

$$\begin{aligned}
&\min h_{j0}=\sigma \\
&s.t.\sum_{j=1}^{n}X_{ij}\lambda_j\leq\sigma X_{ij0}\quad i=1,\ldots,m \\
&\sum_{j=1}^{n}Y_{rj}\lambda_j\geq Y_{rj0}\quad r=1,\ldots,s \\
&\sum_{j=1}^{n}\lambda_j=1 \\
&\lambda_j\geq 0,\ j=1,\ldots,n
\end{aligned} \tag{2}$$

In Equation (2), h_{j0} represents the value of pure technical efficiency, σ represents the value of the j th decision-making unit relative to the $\sum_{j=1}^{n}\lambda_j=1$ efficient value, X_{ij} represents the value of the j th decision-making unit on the i th value on the input indicator, Y_{ij} is the value on the r output indicator, after pairwise transformation of formula (2) the formula is:

$$\begin{aligned}
&Max\quad h_{j0}=\sum_{r=1}^{n}u_r y_{rj0}-u_{j0} \\
&s.t.\sum_{i=1}^{m}v_i x_{ij}=1 \\
&\sum_{r=1}^{s}u_i y_{rj}-\sum_{i=1}^{m}v_i x_{ij}-u_{j0}\leq 0 \\
&u_r, v_i\geq 0,\quad i=1,\ldots,m\quad j=1,\ldots,n\quad r=1,\ldots,s
\end{aligned} \tag{3}$$

u_{j0} represents the scale reward indicator, which is an indicator to assess whether the evaluated decision unit operates at the optimal scale or not, and it indicates the gap between the production scale where the evaluated DMU is located and the optimal scale.

(3) Malmquist index model

$$D_0(x,y) = \inf\left\{\delta : (x, y/\delta) \in p(x)\right\} \tag{4}$$

In equation (4), δ is the representative variable for the output efficiency indicator, x, y are the input and output vectors respectively, and $p(x)$ denotes the set of production possibilities under certain conditions. In the Malmquist index model, this formula is used to calculate the productivity change of the DMU. Therefore, for the period from t to t+1, the functional expression is as follows:

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \tag{5}$$

Under constant returns to scale, the Malmquist index = the index of change in technical efficiency (EFFCH) × the index of technological progress (TECH), which can be decomposed as follows:

$$\begin{aligned} M_0(x^{t+1}, y^{t+1}, x^t, y^t) &= \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{\frac{1}{2}} \\ &= EFFCH \times TECH \end{aligned} \tag{6}$$

The EFFCH is a measure of the technical efficiency change of a decision-making unit over a given period that indicates the distance towards the production frontier. TECH measures the change in technological advancement of a particular decision-making unit by quantifying the change in the position of the production frontier between two different time periods. Total Factor Productivity (TFP) can be used as an important indicator of assessing technological efficiency of production and also the sustainability of economic growth. It can also be used to determine the changes that occur in the efficiency of production and hence use this information as a foundation of policy formulation and strategic decisions aimed at enhancing production technology and economic development.

In the case where variable returns to scale are considered, the Malmquist Index may be divided into the Pure Technical Efficiency Change Index (PECH), the Scale Efficiency Change Index (SECH), and the Technological Progress Index (TECH). All these constituent parts impact the total factor productivity. If an index value is higher than 1 it means that this index is contributing to the increase of total factor productivity, if it is less than one this means that total factor productivity has decreased.

3.2.3 DEA Model Selection

The DEA method uses the CCR model in cases where the returns to scale are constant and each decision unit is working on the production frontier; that is, all the units are operating at their ideal scale of production. Nonetheless, in the majority of realistic situations, the units are not running at the optimal scale, thus making the model irrelevant. In order to consider the influence of the size of the production on efficiency, the BCC model adds another conceptual element to the equation: overall efficiency is equal to the product of pure technical efficiency and scale efficiency. With the inclusion of scale effects, the BCC model is able to measure relative efficiency values at various scales and hence reflects the efficiency levels of decision units better. DEA-Malmquist index is a further development of the DEA methodology. It facilitates easy and efficient analysis of yearly tendencies and actual results of the evaluated entities and

makes it clear what affects their performance. Consequently, this paper uses the DEA-Malmquist index method to study the evolution of rural cultural construction.

3.3 Data Sources

The time series data (t to t+1) analyzed in this study spans from 2012 to 2023, covering 20 cities (prefectures) within a specific region. The combination of time and region forms the panel data used in this research. Data sources include the Statistical Yearbook, Rural Statistical Yearbook, and the National Economic and Social Development Statistical Bulletins of each city (prefecture) in the region from 2012 to 2023. For more precise calculations, the indicator for fiscal investment in rural culture primarily represents its proportion of total fiscal expenditure. Based on the output orientation defined above and utilizing data from each city (prefecture) in the region from 2012 to 2023, the results were calculated using the model.

3.4 Evaluation Results of Rural Cultural Development

3.4.1 Overall Evaluation Results

After aggregating the data results from 20 prefectures (cities) in the sample region, the geometric mean was taken as the indicator for changes in rural cultural development practices within the sample area. This yielded the comprehensive performance trend of rural cultural development. The effectiveness of rural cultural development practices in the sample region is illustrated in Figure 2, where TE, TP, PTE, SE, and MPI represent technical efficiency, technological progress, pure technical efficiency, scale efficiency, and comprehensive performance, respectively. The same applies below.

During the observation period, the comprehensive performance index for rural cultural development practices in the sample region exceeded 1 from 2013 to 2019, indicating that rural cultural development achieved positive outcomes and further progressed during this period. The comprehensive performance index for rural cultural practices reached 1.021 in 2017 and increased to 1.114 in 2018, reflecting a significant improvement in the overall performance of rural cultural development in the sample region. Nevertheless, in 2020, the development of rural culture indicated a trend of retrogression as the overall performance index declined to 0.809-which is lower than one. This implies that the rural cultural practices should be intensified during that year. By 2021, the performance had improved marginally but was still suboptimal (at 0.998) and this underscores the importance of ensuring more effective rural cultural revitalization initiatives are made. On average, the comprehensive performance index of rural cultural development in this region between 2012 and 2023 is 0.984 which is less than 1. It means that the development of rural culture in the region can still be improved.

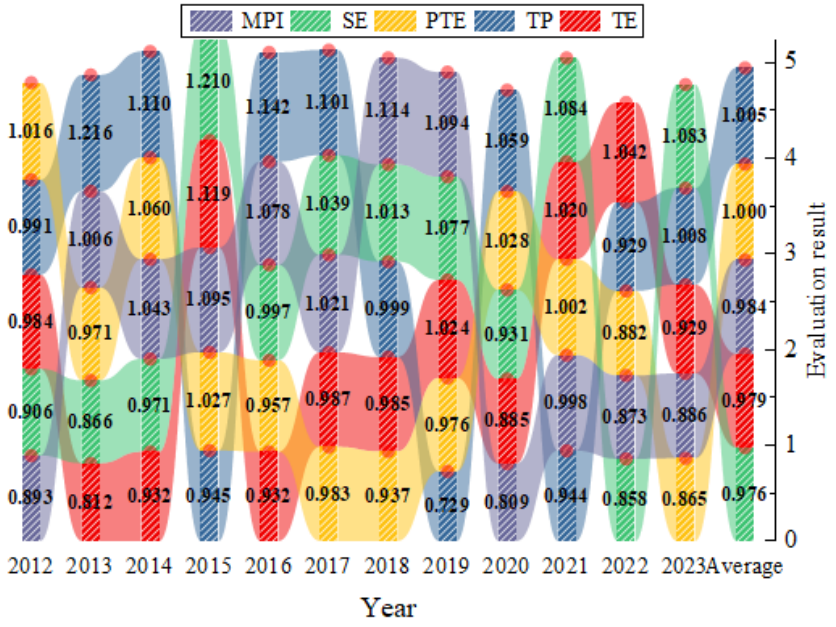

Figure 2: Comprehensive practice effect of rural cultural construction

3.4.2 Comprehensive Performance Index

With respect to the comprehensive performance index, the specific findings on rural cultural development outcomes within the 20 prefecture-level cities (C1-C20) in the sample area are presented in Figure 3. There are considerable differences in the comprehensive performance index of rural cultural development between these 20 prefecture-level cities which imply that there are significant differences in the effectiveness of rural cultural development projects. As an example, the comprehensive performance index of rural cultural development in C16 in 2018 was 2.054, which is higher than 1, whereas the index in C12 was only 0.830. The figures were 1.006 and 1.010 in C1 and C6 respectively in 2020 and C11 had the lowest figure of 0.869 signifying unfavourable results. Nevertheless, most of the prefectures (Cities) had indices over 1 in 2012-2018 which indicates better effectiveness in rural cultural development.

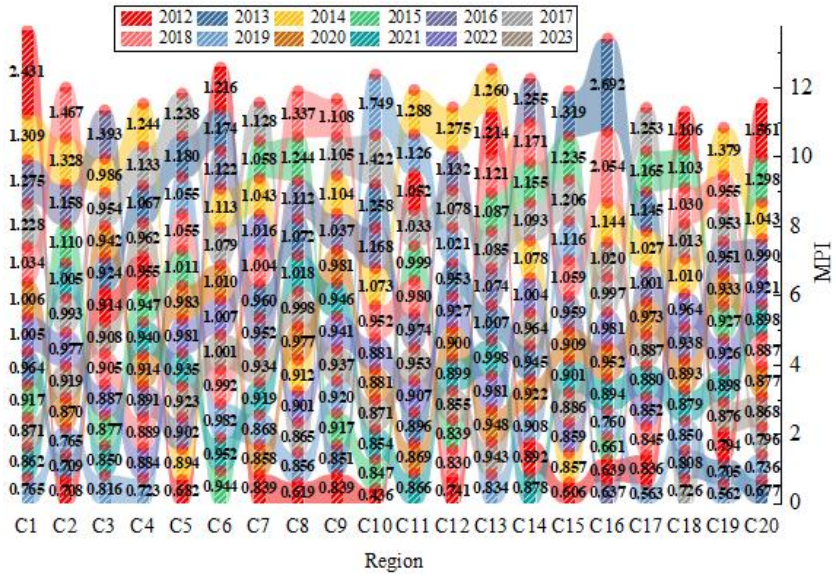

Figure 3: Malmquist index of rural culture revitalization construction

3.4.3 Breakdown of Practical Outcomes

With respect to the decomposition of the practical results, Figure 4 represents the average values of practical results of the rural cultural development across cities (prefectures) in the sample areas in 201223. Figure 5 shows the ranking of practical outcomes in the rural cultural development of these cities (prefectures). In 2012-2023, five out of the seven regions in the sample zone reached the comprehensive performance index of rural cultural development practices of 1 or more: C1, C4, C13, C11, and C6. This indicates that these cities have achieved relatively good development in rural cultural construction following a series of implementation measures. Ranked first, C1 achieved a comprehensive performance index of 1.139, with strong values across other dimensions—technical efficiency, scale efficiency, and pure technical efficiency indices all exceeding 1. C4 ranked second with a comprehensive performance index of 1.078, showing minimal difference from C1, and also maintained values above 1 in all other indices. The comprehensive performance indices for rural cultural development in other cities (prefectures) ranged between 0.9 and 1.0, with C8 recording the lowest index at 0.874.

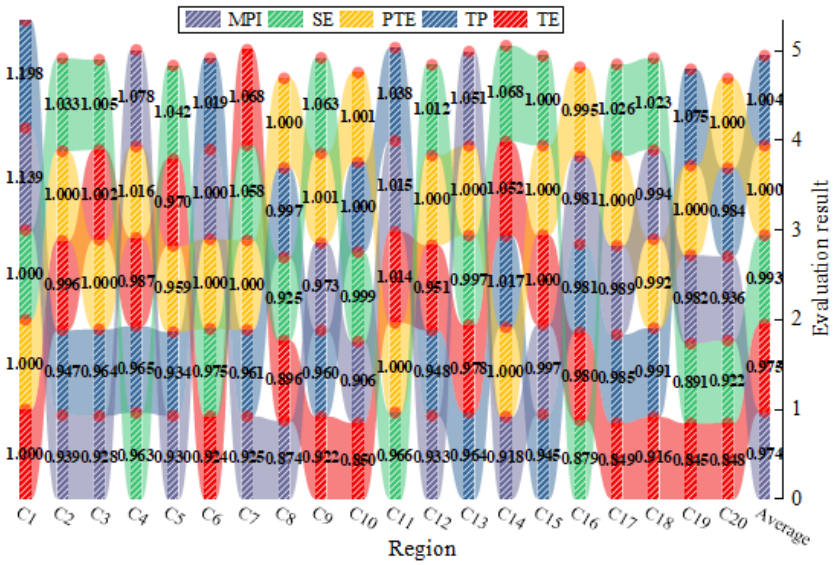

Figure 4: Mean value of practice effect of rural culture construction

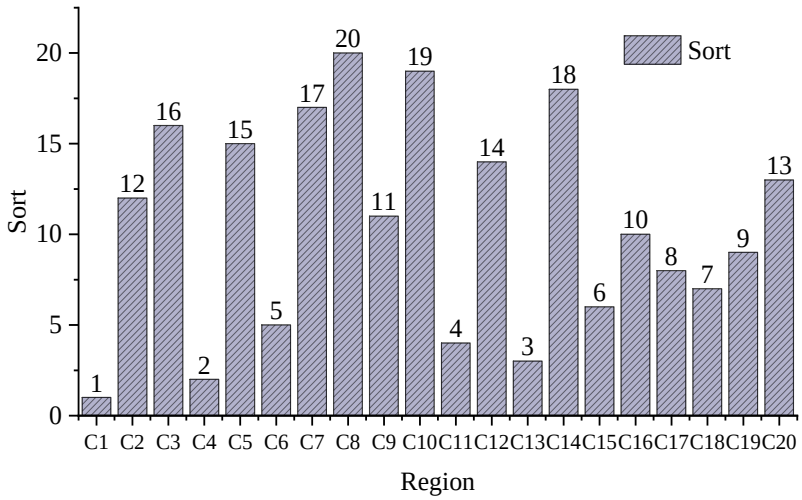

Figure 5: Sort of practice effect of rural culture construction

4 Empirical Analysis of Rural Cultural Development Supporting Rural Revitalization

4.1 System GMM Estimation Method

4.1.1 Basic Settings

Consider a standard dynamic panel model. Compared to the static panel model, the lag term for the dependent variable is added on the right side of the model, and heterogeneity is specified as individual effects. The model can be expressed as:

$$Y_{it} = \gamma Y_{i,t-1} + X^{'}_{it}\beta + \alpha_i + \varepsilon_{it} \tag{7}$$

Here, β is a k-dimensional parameter vector, with $i = 1,\cdots,N, t = 2,\cdots,T$.

In microeconometric studies, dynamic panels typically feature a small number of periods and a large number of individuals, meaning T is less than some constant while $N \to \infty$, and simultaneously $|\gamma| < 1$. For individual heterogeneity α_i and random disturbance terms ε_{it}, we assume the following statistical properties: (1) $E(\alpha_i \mid X_{it}) = 0$, (2) $E(\alpha_i^2 \mid X_{it}) = \sigma_\alpha^2$, (3) $E(\alpha_i \varepsilon_{it} \mid X_{it}) = 0$, (4) $E(\alpha_i \mid X_{it}) = 0$, (5) $E(\alpha_i^2 \mid X_{it}) = \sigma_\alpha^2$, (6) $E(\varepsilon_{it}\varepsilon_{is} \mid X_{it}, X_{is}) = 0$, $i = 1,\cdots,N, t \neq s$. Under these assumptions, parameter estimation methods that were effective in static panel models cannot provide consistent estimators for parameters in dynamic panel models. The fundamental reason lies in the correlation between the explanatory variable $Y_{i,t-1}$ and α_i in model (7), regardless of whether α_i is a fixed effect or a random effect. The approach of instrumental variables is employed to obtain consistent estimators for the model parameters. They apply a first-order difference transformation to model (7), yielding:

$$\Delta Y_{it} = \gamma \Delta Y_{i,t-1} + \Delta X^{'}_{it}\beta + \Delta\varepsilon_{it} \tag{8}$$

where $i = 1,\cdots,N$ and $t = 3,\cdots,T$, $\Delta Y_{it} = Y_{it} - Y_{i,t-1}$, $\Delta Y_{i,t-1}, \Delta X_{it}$ and $\Delta\varepsilon_{it}$ are defined similarly. In the difference model, $Y_{i,t-2}$ serves as a suitable instrumental variable for $\Delta Y_{i,t-1}$. Similarly, $Y_{i,t-3}, Y_{i,t-4},\cdots$ can all serve as instrumental variables for $\Delta Y_{i,t-1}$, i.e., the available-moment conditions in model (8):

$$E(M^{'}_{it}\Delta\varepsilon_{it}) = 0, t = 3,\cdots,T \tag{9}$$

Among these, $M^{'}_{it} = (Y_{i,t-2}, Y_{i,t-3},\cdots, Y_{il}, DeltaX^{'}_{it})$. $\Delta X^{'}_{it}$ serves as its own instrumental variable, while $\Delta Y_{i,t-1}$ has $t-2$ instrumental variables.

4.1.2 System GMM Estimation

The specific estimation principle is as follows: First, establish a system of simultaneous equations comprising the difference equation and the horizontal equation:

$$\begin{cases} \Delta Y_{it} = \gamma \Delta Y_{i,t-1} + \Delta X_{it}^{'} \beta + \Delta \varepsilon_{it}, t = 3, \cdots, T \\ Y_{it} = \gamma Y_{i,t-1} + X_{it}^{'} \beta + \alpha_i + \varepsilon_{it}, \quad t = 3, \cdots, T \end{cases} \tag{10}$$

For period compression, rewrite it in individual vector form:

$$\begin{cases} \Delta Y_i = \Delta Z_i \delta + \Delta u_i \\ Y_i = Z_i \delta + u_i \end{cases} \tag{11}$$

Among these, $\delta = (\gamma \beta^{'})^{'}, Y_i = (Y_{i3}, \cdots, Y_{iT})^{'}, \Delta Y_i = (\Delta Y_{i3}, \cdots, \Delta Y_{iT})^{'}$, Definition $Z_i = (Y_{i,-1} X_i)$, then $\Delta Z_i = (\Delta Y_{i,-1} \Delta X_i)^{'}, Y_{i,-1} = (Y_{i2}, \cdots, Y_{i,T-1})^{'}, \Delta Y_{i,-1} = (\Delta Y_{i2}, \cdots, \Delta Y_{i,T-1})^{'}, X_i = (X_{i3}, \cdots, X_{iT})^{'}$, $\Delta X_i = (\Delta X_{i3}, \cdots, \Delta X_{iT})^{'}, u_{it} = \alpha_{\cdot i} + \varepsilon_{it}, u_i = (u_{i3}, \cdots, u_{iT})^{'}, \Delta u_i = \Delta \varepsilon_i$. Let:

$$\tilde{Y}_i = \begin{pmatrix} \Delta Y_i \\ Y_i \end{pmatrix}, \tilde{Z}_i = \begin{pmatrix} \Delta Z_i \\ Z_i \end{pmatrix}, \tilde{u}_i = \begin{pmatrix} \Delta u_i \\ u_i \end{pmatrix} \tag{12}$$

The system of equations can then be rewritten as:

$$\tilde{Y}_i = \tilde{Z}_i \delta + \tilde{u}_i \tag{13}$$

Since X_{it} is assumed strictly exogenous, ΔX_{it} is also strictly exogenous. Therefore, the discussion of instrumental variables primarily focuses on the endogenous variables $Y_{i,t-1}$ and $\Delta Y_{i,t-1}$. By synthesizing the statistical properties of the random disturbance terms in the difference equation and the horizontal equation, a new instrumental variable matrix can be established:

$$\tilde{W}_i = \begin{pmatrix} W_i & 0 & \cdots & 0 & 0 \\ 0 & \Delta Y_{i2} & \cdots & 0 & X_{i3}^{'} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \cdots & \Delta Y_{i,T-1} & X_{it}^{'} \end{pmatrix} \tag{14}$$

The new instrumental variable matrix satisfies $E(\tilde{W}_i^{'} \tilde{u}_i) = 0$. In system equation (14), for the random vector $\tilde{u}_i$, its variance matrix can be solved:

$$D(\tilde{u}_i) = \begin{pmatrix} \sigma_\varepsilon^2 d \cdot d^{'} & \sigma_\varepsilon^2 d \cdot d_1^{'} \\ \sigma_\varepsilon^2 d_1 \cdot d^{'} & \sigma_\alpha^2 1_{T-2} 1_{T-2}^{'} + \sigma_\varepsilon^2 I_{T-2} \end{pmatrix} \tag{15}$$

Among these, 1_{T-2} denotes the column vector with all elements equal to 1 in the $T-2$ th dimension. Both d, d_1 are matrices with $T-2$ rows and T columns, defined as follows:

$$d=\begin{pmatrix}0&-1&1&0&\cdots&0&0\\0&0&-1&1&\cdots&0&0\\\vdots&\vdots&\vdots&\vdots&\vdots&\vdots&\vdots\\0&0&0&0&\cdots&-1&1\end{pmatrix},d_1=\begin{pmatrix}0&0&1&0&&&\\0&0&0&1&&&\\&&&&\ddots&&\\&&&&&&1\end{pmatrix} \tag{16}$$

Due to the presence of σ_α^2, $D(\tilde{u}_i)$ cannot be simplified. For this scenario, assume $\sigma_\alpha^2=0$. Based on this, define the weight matrix H:

$$H=\begin{pmatrix}d\cdot d' & d\cdot d_1'\\ d_1'\cdot d & I_{T-2}\end{pmatrix} \tag{17}$$

Here, the dimension of H is $(2T-4)\times(2T-4)$. Similar to the approach in differential GMM estimation, we provide the one-step estimate for the system GMM. Let $A=I_N\otimes H$, then:

$$\hat{\delta}_{BB-one}=[\tilde{Z}'\tilde{W}(\tilde{W}'A\tilde{W})^{-1}\tilde{W}'\tilde{Z}]^{-1}\tilde{Z}'\tilde{W}(\tilde{W}'A\tilde{W})^{-1}\tilde{W}'\tilde{Y} \tag{18}$$

Among these, $\tilde{Z}=(\tilde{Z}_1',\tilde{Z}_2',\cdots,\tilde{Z}_N')',\tilde{W}=(\tilde{W}_1',\tilde{W}_2',\cdots,\tilde{W}_N')',\tilde{Y}=(\tilde{Y}_1',\tilde{Y}_2',\cdots,\tilde{Y}_N')'$. Based on the results of the one-step estimation, the residuals of model (14) can be calculated and denoted as $\tilde{e}_i=\tilde{Y}_i-\tilde{Z}_i\hat{\delta}_{BB-one}$. A new weighting matrix is defined: $A^{(2)}=diag(\tilde{e}_1\tilde{e}_1',\cdots,\tilde{e}_N\tilde{e}_N')$. On this basis, the two-step estimation for the system GMM can be obtained:

$$\hat{\delta}_{BB-two}=[\tilde{Z}'\tilde{W}(\tilde{W}'A^{(2)}\tilde{W})^{-1}\tilde{W}'\tilde{Z}]^{-1}\tilde{Z}'\tilde{W}(\tilde{W}'A^{(2)}\tilde{W})^{-1}\tilde{W}'\tilde{Y} \tag{19}$$

4.2 Model Design and Variable Selection

4.2.1 Model Design

Rural revitalization development is used as a dependent variable and rural cultural development is used as an explanatory variable. Because use of a single explanatory variable can be highly biased in empirical estimation, additional control variables are included: the extent of openness to the outside world and the extent of urbanization. Using this assumption, a reference regression model is developed:

$$\begin{aligned}RRI_{it}=&\alpha_i+\beta_1RCCI_{it}+\beta_2OPE_{it}\\&+\beta_3UE_{it}+\varepsilon_{it}\end{aligned} \tag{20}$$

In the equation, RRI_{it} denotes the level of rural revitalization development, and $RCCI_{it}$ refers to rural cultural development. OPE and UR stand for the levels of external openness and urbanization, respectively. α_i is the constant term, ε is the disturbance term, i represents the city, and t indicates the year.

To examine whether the level of rural revitalization is influenced by its lagged value, a first-order lag of the rural revitalization level is introduced. To address potential biases and endogeneity issues in the panel model, the following GMM regression model is constructed:

$$RRI_a = \alpha_0 + \beta_1 RRI_{i,t-1} + \beta_2 RCCI_{it} + \beta_3 OPE_{it} + \beta_4 UR_{it} + \varepsilon_{it} \quad (21)$$

$RRI_{i,t-1}$ represents the rural revitalization development level of the previous year (endogenous variable).

Considering that the impact of rural cultural development on rural revitalization varies with the intensity of government policy support, this paper employs government policy support intensity as a threshold variable. The following model is established to test and determine the threshold value, ultimately confirming the threshold model:

$$RRI_{it} = \alpha + \beta_1 RCCI_{it}(q_i \le \gamma) + \beta_2 RCCI_{it}(q_i > \gamma) + \beta_3 OPEV_{it} + \beta_4 UR_{it} + \varepsilon_{it} \quad (22)$$

In the equation: q is the threshold variable, and r is the unknown threshold value.

4.2.2 Variable Selection

(1) Dependent Variable—Rural Revitalization Index (RRI)

Empirical analysis uses the Rural Revitalization Index as the independent variable. To measure it, a rural revitalization evaluation system consisting of five dimensions is generated to evaluate rural revitalization which are thriving industries, ecological livability, civilized rural culture, effective governance, and ecological prosperity. The five main indicators, 15 sub-indicators, and a set of tertiary indicators in the framework are shown in Table 2.

Table 2: Rural revitalization evaluation index system

Primary indicator	Secondary indicator	Tertiary index meaning
Industrial boom	Rural production benefit	Agricultural forestry husbandry product value/region GDP
	Agricultural mechanization level	Total power/cultivated area of agricultural machinery
	Agricultural stability	Effective irrigation area/cultivated area
Ecological accommodation	Environment level	Expenditure on water expenditure/public budget expenditure
	Chemical intensity	The amount of chemical inputs/the area of the cultivated land
	Rural residents' living quality	Per capita consumption/per capita consumption expenditure
Land civilization	Recreational consumption level	Per capita spending / per capita consumption expenditure
	Health care consumption level	Per capita health care consumption/per capita consumer spending
	Electronic product usage	Resident power
Effective governance	Labor level	Rural employment personnel/employment personnel
	Urban and rural income gap	The income ratio of urban residents and rural residents
	Social public service level	Community service expenditure/public budget expenditure
Live well	Rural income level	Rural per capita disposable income
	Rural consumption level	Rural per capita consumer spending
	The quality of life in rural residents	The engle coefficient of the rural family family

Each of the indicators was scored with the help of the entropy approach. Figure 6 shows the measured values of the annual rural revitalization levels in the sample areas between 2012-2023. The trend of rural revitalization levels growth has leveled off. On average, the average rural revitalization index of all cities has grown by about 74.39 percent since 2012 to 2023; thus, it can be stated that there is a significant improvement in the overall rural development in the sample regions in recent years. Precisely, the growth rate in 2012-2018 was around 41.28, which is a stage of high growth in rural development in the sample regions. Conversely, the growth rate in 2018-2023 was about 24.19, which means that the rural development trend in the sample regions has shifted to slow but steady improvement.

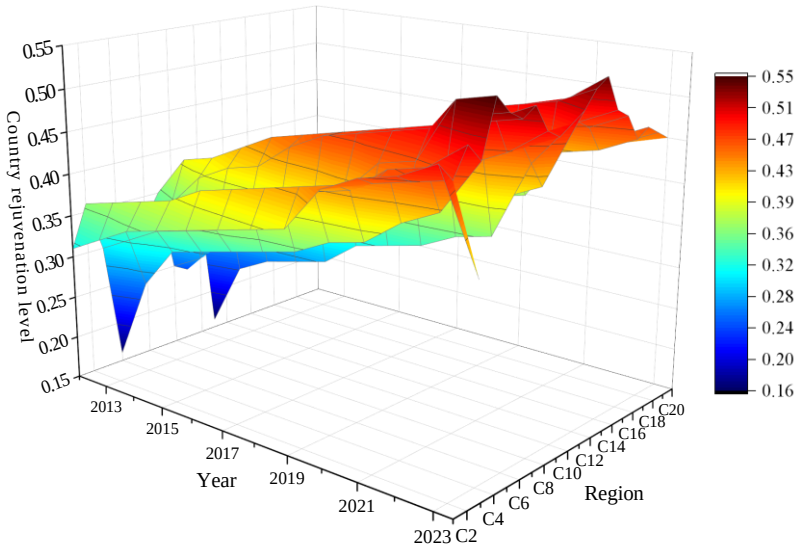

Figure 6: Rural rejuvenation level measure results

(2) Key Explanatory Variable-The Rural Cultural Construction Index (RCCI)

The Rural Cultural Construction Index has three elements: technological progress, pure technical efficiency, and scale efficiency. The index is computed based on the rural cultural construction outcome values that were acquired in the previous section.

(3) Threshold Variable - Government Policy Support Intensity (GOV)

Government policy support is the main institution and the highest level of planning that is used to advance rural cultural development and implement the rural revitalization strategy. On one side, the effectiveness of policy support influences the effectiveness of resources allocation, the extent of cultural facility development, and the capacity of governance mechanisms to be innovative. On the other hand, when implementing rural revitalization, it should react to uncertainty due to changes in the urban-rural relationship and technological advancement. The pilot mechanisms are the means by which policy support supports rural revitalization by establishing pilot counties to empower rural revitalization through cultural industries, and dynamic adjustment tools include assessing the level of cultural facility utilization. Hence, government policy support is represented by the value of local government policy support in the process of rural cultural development (the scale is 0-5). The greater the score, the more robust the policy backing is.

(4) Control Variables

Following the previous research on rural revitalization, the present paper picks two control variables: ① Level of Opening-up (OPE) which is calculated as a quotient of total imports and exports over regional GDP. ② Level of Urbanization (UR) which is quantified as a ratio of urban population to total population.

The data on the constituent indicators, threshold variable, and control variable in the Rural Revitalization Index are obtained through provincial and municipal statistical offices of the sample areas.

4.3 Empirical Results Analysis

4.3.1 Static Regression Analysis

The research performs static regression analysis to determine the impact of rural cultural development on rural revitalization. To achieve the results and capture the difference in methodology, fixed effects and random effects models are used consecutively. The estimated results of the two models are presented in Table 3, with ** and *** representing significance at the 5% and 1% levels, respectively, and the same notation is used throughout. As can be seen from the regression results, one unit change in the rural cultural development index increases the rural revitalization index of the sample areas by an average of 0.045 units. Every estimation passes the significance test of 1% and this shows that rural cultural construction in the sample area has a pronounced positive effect on rural revitalization. Also, all the R-squared values of the models are greater than 0.72 implying that the static regression models have a significant goodness of fit. Nevertheless, openness to the outside world and urbanization do not satisfy the significance test, indicating that they do not play a statistically significant role in the rural development process in this model.

Table 3: The estimation results of the fixed effect model and the stochastic effect model

	Explained variable:Rural revitalization index			
Variables	Fixed model		Random model	
	(1)	(2)	(3)	(4)
RCCI	0.048***	0.042***	0.048***	0.043***
	15.123	10.056	11.077	11.092
OPE		0.029		0.032
		2.135		1.414
UR		0.022		0.020
		1.037		1.052
-cons	0.303***	0.212***	0.271***	0.217***
	41.112	7.103	15.027	6.058
Sample size	240	240	240	240
R^2	0.723	0.736	0.738	0.753

4.3.2 Dynamic Regression Analysis

The paper will also use a dynamic panel model to examine how rural cultural development correlates with rural revitalization in the sample regions. To minimize possible bias and overcome endogeneity issues, the System GMM model is chosen as an empirical estimation. The findings of the System GMM dynamic regression are presented in Table 4. The rural revitalization level with one-period lag is highly significant at the 1 percent level, which means that rural cultural development in the sample region has the path dependence properties and depends on the past state of rural development. The regression coefficients of the rural cultural development index and its three sub-indices, namely technological progress, pure technical efficiency, and scale efficiency, are all positive (0.025, 0.022, 0.018, and 0.015) and statistically significant. This implies that enhancing rural cultural development could help in advancing the rural revitalization strategy in the sample region. Of the three sub-indicators, scale efficiency

has the lowest regression coefficient indicating that rural cultural development in the sample region is mostly associated with technological progress and pure technical efficiency

Table 4: The analysis results of the system GMM dynamic regression

Variables	Explained variable:Rural revitalization index			
	(1)	(2)	(3)	(4)
RRI	0.117***	0.137***	0.184***	0.075***
	1.124	1.111	4.038	3.083
RCCI	0.025***			
	3.121			
TP		0.022**		
		2.082		
PTE			0.018**	
			1.123	
SE				0.015***
				5.167
OPE	-0.033**	-0.031***	1.192***	1.027***
	-2.031	-3.053	-1.149	-0.115
UR	0.037**	0.045**	0.036**	0.029**
	2.091	2.169	2.025	2.137
-cons	0.155***	0.147***	0.115***	0.146***
	4.037	2.156	3.102	5.126
Sample size	240	240	240	240
AR(1)	0.032	0.036	0.019	0.086
AR(2)	0.138	0.167	0.094	0.242
Sargan (p value)	0.827	0.865	0.829	0.849

4.3.3 Threshold Effect Analysis

This research used Bootstrap resampling of 200 to test single-threshold, dual-threshold, and triple-threshold models one after another. The results of threshold effects of the sampling tests are presented in Table 5. The threshold intensities when the policy support of the government is used as the threshold variable, the P -values are 0.039, 0.151 and 0.522, respectively, which means that only the single threshold passes the 1 percent significance test whereas the other two thresholds do not pass the significance test. It has been confirmed that government policy support can be represented by the single threshold effect. In accordance with the results of the threshold effect sampling inspection, this article performs the regression analysis by using a single-threshold model. The result of the threshold estimation is presented in Table 6 with the threshold of government policy support intensity equal to 0.215.

Regression results of the panel threshold model are presented in Table 7. Estimated value of rural cultural development is 0.062 and 0.046 respectively as government policy support intensity is less than 0.215 or greater than 0.215. These values were statistically significant. The regression outcomes prove that the coefficient of rural cultural development is positive irrespective of the degree of government policy support. It suggests that rural cultural development in the sample areas has a positive effect on rural revitalization. Moreover, the changes in the coefficient indicate that the effect of rural cultural development on rural revitalization can be moderated by the intensity of government policy support.

Table 5: Threshold effect self-sampling test

Model	*F* value	*P* value	BS number	10%	5%	1%
Single threshold	36.15	0.039	200	26.043	31.167	44.175
Double threshold	15.641	0.151	200	18.111	20.144	41.159
Triple threshold	15.142	0.522	200	30.623	33.257	39.542

Table 6: Threshold estimate result

Threshold	Statistical value	95% confidence interval
Single threshold	0.215	[0.186,0.213]

Table 7: The regression results of the panel threshold model

Variable	Rural culture construction	t value
ind*I(inter≤0.215)	0.062***	11.055
ind*I(inter≥0.215)	0.046***	12.056
OPE	0.635***	1.131
UR	0.028	0.498
Sample size	240	
R^2	0.782	

5 Conclusion

The research paper applies the DEA-Malmquist model as an evaluation instrument that will help gauge the level of rural cultural construction of a particular region. Through benchmark regression and System GMM estimation, it also examines what role rural cultural construction plays in facilitating the rural revitalization strategy implementation. Key findings are the following.

The average comprehensive performance value of rural cultural construction in the sample region during the observation time was 0.984, which is below 1. It means that rural cultural construction has not been optimized yet. Nevertheless, since 2013-2019, the comprehensive performance value of rural cultural development in this area had been above 1, indicating that significant progress had been made at this point. Between 2012 and 2023, 5 cities, including C1, C4, C13, C11 and C6, continued to have an average score of rural cultural development greater than 1, indicating relatively good rural cultural development levels.

(2) The rural cultural development has a high positive effect on the rural revitalization index at 1%. The dynamic regression analysis shows that the regression coefficients of technological progress, pure technical efficiency, and scale efficiency are 0.025, 0.022, 0.018, and 0.015, respectively. These findings indicate that technological progress and pure technical efficiency have a greater impact on rural development. Furthermore, the threshold-effect analysis also proves that the strength of government policy support is a vital factor in encouraging the rural revitalization via cultural development.

Revitalization of culture is a crucial component of holistic rural revitalization. The supporting systems should be improved, rural cultural development should be promoted, the rural public cultural service system should be enhanced, and development of the rural cultural tourism industry should be stimulated. Such measures might bring the ideological impulse and cultural background to the rural revitalization, which would facilitate the overall rural revitalization.

About the Author

Yishan Li was born in Tangshan, Hebei, P.R. China, in 1997. He obtained a master's degree from Lanzhou University of Finance and Economics in China. He is currently pursuing a doctor's degree at the College of Marxism of Xinjiang Normal University. His main research direction is the research of sinicization of Marxism in China. He is currently studying at the School of Economics and Management, Wuhan University. His main research direction is Western economics and macroeconomic management.

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