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# A Study on the Spatio-Temporal Characteristics and Spatial Differentiation of the Development Efficiency of China's Digital Cultural Industry

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**Abstract:** Under the national digital cultural strategy, it is crucial to systematically evaluate and continuously track the development efficiency of China's digital cultural industry. This paper constructs a global super-efficiency EBM model that considers non-expected outputs, empirically measures the development efficiency of China's digital cultural sector from 2011 to 2023, and uses the Moran index and Dagum Gini coefficient methods to comprehensively and deeply reveal the temporal and spatial characteristics and spatial differentiation of China's digital cultural industry development efficiency. The study finds that: (1) The overall efficiency of China's digital cultural industry is relatively low, with an average efficiency of 0.35, exhibiting a typical "V"-shaped distribution across different periods, and the eastern region significantly outperforms other areas. (2) The global Moran index shows a fluctuating downward trend overall, with a "Λ"-shaped distribution across different periods, and the local Moran index reveals that its spatial distribution is primarily concentrated in "H-H" and "L-L" clusters. (3) The overall disparities exhibit a fluctuating upward trend, with inter-regional disparities being the dominant factor, accounting for an average contribution rate of 38.50%. This study aims to promote the high-quality development of China's digital cultural industry by providing valuable references for future policy-making and decision-making.

**Keywords:** Digital Cultural Industry; Development Efficiency; Spatiotemporal Characteristics; Spatial Differentiation

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## Introduction

Digital cultural industries are a new type of industrial form that is driven by the national cultural digitization strategy, based on information technology, and centered on cultural creative content, achieving a high degree of integration between digital technology and the cultural creative content industry. To promote the prosperity and development of the digital cultural industry, China has issued and implemented a series of guiding policies and guidelines since 2011, and the logic and innovation path of digital cultural industry policies have become increasingly clear [1]. Under the guidance of national macro policies, the scale of China's digital cultural industry market has continued to expand. According to data from iiMedia Research, in the first three quarters of 2024, China's digital cultural revenue reached 4.16 trillion yuan, accounting for 41.8% of the total revenue of the cultural industry. Compared with the same period in 2019, the two figures increased by 2.1 times and 18.9 percentage points respectively [2], highlighting its important contribution to the high-quality development of the

cultural industry. However, while the digital cultural industry is developing rapidly and upgrading its capabilities, it also faces challenges such as insufficient depth and richness of digital cultural product content, inadequate digital technology innovation, difficulties in determining the value of digital copyrights [3], and uneven development of regional symbiosis [4]. Efficiency is one of the key indicators comprehensively reflecting the development level of the digital cultural industry, and it plays an important role in promoting the high-level development of the digital cultural industry and laying a solid foundation for building a "cultural powerhouse".

A review of research findings on the evaluation of the digital cultural industry reveals that they are primarily divided into two categories: parametric methods and non-parametric methods. The former includes random frontier analysis (SFA) and semi-parametric estimation methods, which primarily focus on the evaluation of the cultural industry [5] and its input-output efficiency [6]. Among non-parametric methods, the DEA-Malmquist index method is widely applied. Scholars have used the BCC model to conduct an empirical analysis of the industrial investment efficiency of listed cultural enterprises [7] and have conducted an in-depth analysis of the input-output efficiency of the digital cultural industry from both dynamic and static perspectives [8]. Additionally, current research perspectives are increasingly focusing on the spatial dimension and paying attention to the evaluation of the development efficiency of the digital cultural industry in key regions. Research on the efficiency of digital cultural industry development in provinces and municipalities such as Beijing, Shanghai, Zhejiang, Jiangxi, Hunan, and Chongqing is increasingly abundant. Some scholars have proposed development suggestions from four aspects: digital cultural industry planning, talent teams, market entities, and security risks [9]. Others have conducted in-depth studies on the performance of digital cultural industry development and the mechanisms of influencing factors [10]. Additionally, some scholars have employed a three-stage DEA model to reveal that the efficiency of China's digital cultural industry development exhibits regional differences and non-equilibrium characteristics [11,12].

Existing research provides an extremely important reference value for this study, this paper employs the EBM model to calculate the efficiency of digital cultural industry development in 30 provinces of China from 2011 to 2023. Using the Dagum Gini coefficient and Moran index methods, it comprehensively and deeply reveals the spatiotemporal characteristics and spatial differentiation of China's digital cultural industry development efficiency, providing valuable references for the high-quality development of China's digital cultural industry and the construction of a modern industrial system in the next period. Therefore, the technical route studied in this paper is shown in Figure 1.

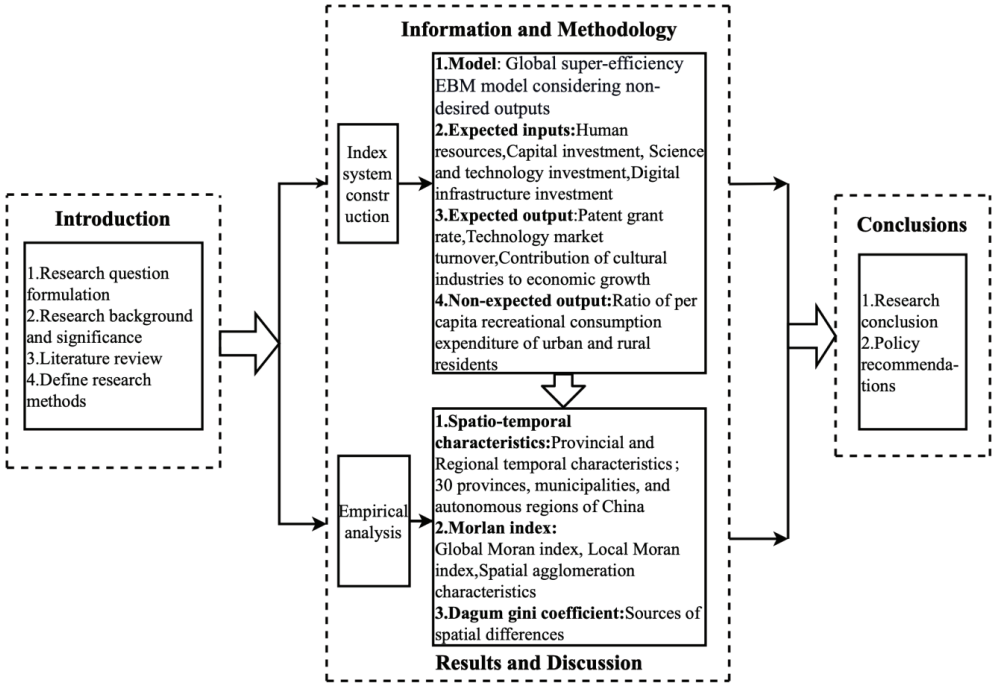



*Fig. 1. The technical roadmap studied in this article*

# 1.Model, Method, and Indicator Selection

## 1.1 Global Super-Efficiency EBM Model Considering Non-Desired Outputs

Constructing a production possibility set (PPS) is a prerequisite for measuring the efficiency of China's digital cultural industry development. This study adopts the global benchmarking method proposed by Pastor and Lovell [13] to expand the framework for global comparability in measuring the efficiency of China's digital cultural industry. Therefor, it draws on the super-efficiency evaluation method proposed by Tone [14]to compare the efficiency of DMUs in the digital cultural industry. Additionally, the measurement results of the efficiency of China's digital cultural industry development under constant returns to scale (CRS) and variable returns to scale (VRS) conditions differ significantly. Based on the views of Zheng et al. [15], this study adopts the measurement results under the VRS condition. In view of this, under the condition of considering non-desired outputs, this paper aggregates all DMUj ( j = 1, 2,…,n ) in all periods t ( t= 1, 2,…, T) to construct the global reference production possibility set:

$$PPS = \{(x^t, y^t) \mid x_i^t \geq \sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j^t x_{ij}^t; i = 1,2, \ldots, p; t = 1,2, \ldots, T;$$

$$y_r^t \leq \sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j^t y_{rj}^t; r = 1,2, \ldots, q; j = 1,2, \ldots, n; \lambda_j^t \geq 0 \} \quad (1)$$

In the above equation (1), x represents factor inputs, y represents desired outputs, and represents the weight of the observed values of DMUs in period t. Therefore, based on the consideration of non-desirable outputs, the global super-efficiency value of the jth DMU can be calculated using Equation (2):

$$\gamma^* = \min_{\theta,\eta,\lambda,S^-,S^+} \frac{\theta + \varepsilon_x^- \sum_{i=1}^{p} \frac{\omega_{ij}^- s_{ij}^-}{x_{ij}}}{\eta - \varepsilon_y^+ \sum_{r=1}^{q} \frac{\omega_{rj}^+ s_{rj}^+}{y_{rj}} - \varepsilon_b^+ \sum_{e=1}^{q^*} \frac{\omega_{ej}^{b-} s_{ej}^{b-}}{b_{q^* j}}}$$

$$s.t. \quad \sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j^t x_{ij}^t - s_{ij}^- \leq \theta x_{ij}, i = 1,2, \cdots, p$$

$$\sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j^t y_{rj}^t + s_{rj}^+ \geq \eta y_{rj}, r = 1,2, \cdots, q$$

$$\sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j^t b_{ej}^t - s_{ej}^{b-} \leq \eta b_{ej}, e = 1, \cdots, q^*$$

$$\sum_{t=1}^{T} \sum_{j=1}^{n} \lambda_j^t = 1$$

$$\lambda_j^t \geq 0; s_{ij}^-, s_{rj}^+, s_{ej}^{b-} \geq 0; j = 1,2 \cdots, n;$$

$$\varepsilon_x^- \geq 0, \varepsilon_y^+ \leq 1; 0 < \theta \leq 1; \eta \geq 1; t = 1,2, \ldots, T \quad (2)$$

Equation (2), $\gamma^*$represents the efficiency value of the evaluated DMUj as the optimal solution of the objective function,$\theta$、$\eta$ represents the radial model efficiency value and its reciprocal, respectively. $x_{ij}$、$y_{rj}$ and $b_{ej}^t$ represent the original values of the inputs, expected outputs, and non-expected outputs of the evaluated DMUj, respectively. While, $s_{ij}^-$、$s_{rj}^+$、$s_{ej}^{b-}$ correspond to the input, expected output, and non-expected output slack values, respectively.The values of $\omega_{ij}^-$、$\omega_{rj}^+$、$\omega_{ej}^{b-}$ are all greater than or equal to 0, representing the weights of the input, expected output, and non-expected output factors, respectively. is a key parameter in the EBM model, with a value range between [0, 1]. If $\varepsilon_x^-$、$\varepsilon_y^+$、$\varepsilon_b^+$= 0, it is equivalent to the radial CCR model; if $\varepsilon_x^-$、$\varepsilon_y^+$、$\varepsilon_b^+$ = 1, it is equivalent to the SBM model.

## 1.2 Research methods

### 1.2.1 Moran Index

The Moran Index is an important indicator in spatial autocorrelation analysis, divided into global Moran Index and local

Moran Index, and widely applied in fields such as socio-economics, cultural ecology, and public services. This study employs the global Moran Index to empirically measure whether China's digital cultural industry development efficiency exhibits spatial clustering, dispersion, or complete independence, and further uses the local Moran Index to reveal any hidden local clustering areas. The specific calculation formula is referenced from Ma Yanyan et al. [16].

### 1.2.2 Dagum Gini Coefficient

This paper adopts the Dagum Gini coefficient and its sub-group decomposition method [17], to empirically analyze the spatial differentiation of the efficiency of China's digital cultural industry development. Compared with the traditional Gini coefficient and Theil index, the Dagum Gini coefficient not only reports the overall efficiency gap of China's digital cultural industry development but also further decomposes it into intra-regional gaps, inter-regional gaps, and inter-regional hyper-diversity, thereby better identifying the spatial sources of efficiency differences in China's digital cultural industry development. The specific calculation formula is referenced from Zhang Hongfeng et al. [18].

## 1.3 Indicator Selection and Data Description

Based on the Cobb-Douglas production function, this paper constructs a digital cultural industry development efficiency evaluation indicator system (Table 1) from the perspectives of inputs and outputs. Among the input indicators, the number of employees in the cultural industry at the end of the year is selected as labor input, the total assets of the cultural industry as capital input, internal R&D expenditure as technological input, and the number of internet broadband access ports as digital infrastructure input. In terms of expected output indicators, this paper starts from the value form of the digital cultural industry and selects patent authorization rate, technology market transaction volume, and the contribution of the cultural industry to economic growth as output elements of the digital cultural industry. Regarding non-expected output indicators, existing literature has rarely mentioned or analyzed them. Given that the industry expects the urban-rural gap in digital cultural industry development to be as small as possible, this paper selects the ratio of per capita cultural and entertainment expenditure between urban and rural residents as the non-expected output indicator. The above indicator data are sourced from the "China Cultural and Related Industries Statistical Yearbook" (2012~2024), "China Statistical Yearbook," and "China Science and Technology Statistical Yearbook." Considering the availability and completeness of sample data, this study takes 30 provinces in China (excluding Taiwan Province of China, Hong Kong Special Administrative Region of China, and Macau Special Administrative Region of China, as well as the Tibet Autonomous Region of China) from 2011 to 2023 as the research object.

*Table 1: Descriptive Statistics of Variables*

| Indicator type | Indicator description | Mean | Standard deviation | Minimum value | Maximum value |
|---|---|---|---|---|---|
| Expected inputs | Human resources (people) | 217313 | 316940 | 1681 | 1.837e+06 |
| | Capital investment (ten thousand yuan) | 3.810e+07 | 5.923e+07 | 520645 | 3.278e+08 |
| | Science and technology investment (ten thousand yuan) | 6.399e+06 | 7.866e+06 | 103,717 | 4.803e+07 |
| | Digital infrastructure investment(ten thousand units) | 2389 | 1948 | 62 | 10395 |
| Expected outputs | Patent grant rate (%) | 0.602 | 0.137 | 0.251 | 1.082 |
| | Technology market turnover (ten thousand yuan) | 6.797e+06 | 1.161e+07 | 5666 | 7.948e+07 |
| | Contribution of cultural industries to economic growth (%) | 0.078 | 0.082 | 0.004 | 0.442 |
| Non-expected output | Ratio of per capita recreational consumption expenditure of urban and rural residents (%) | 3.929 | 1.534 | 1.137 | 9.934 |

# 2.Spatio-temporal Characteristics of China's Digital Cultural Industry Development Efficiency

## 2.1 Temporal Characteristics of China's Digital Cultural Industry Development Efficien-cy

### 2.1.1 Temporal Characteristics of the Development Efficiency of the Digital Cultural Industry at the Provincial Level

From the overall evaluation of the entire period, the average level of digital cultural industry development efficiency in China's provincial regions was relatively low at 0.35, with significant disparities (Table 2). In terms of rankings, 11 provinces had digital cultural industry development efficiency above the average for the entire period, including 5 provinces from the eastern region, 3 from the central region, and 3 from the western region. In terms of provincial disparities, Beijing had the highest digital cultural industry development efficiency, with an average of 1.00, followed by Qinghai and Tianjin, with averages of 0.92 and 0.72, respectively. Yunnan, Henan, and Inner Mongolia ranked relatively lower. In terms of growth rates, provinces with higher digital cultural industry development efficiency during the entire period did not necessarily have faster annual growth rates. Beijing and Shanghai did not grow during the statistical period, while Gansu experienced negative growth. Among the 30 provinces, the annual growth rates of digital cultural industry development efficiency were relatively fast in most provinces. However, seven provinces—Hebei, Xinjiang, Ningxia, Guizhou, Guangxi, Shanxi, and Jiangsu—did not reach the average level for the entire period. Nevertheless, their annual growth rates of digital cultural industry development efficiency all achieved an average annual growth rate of over 29.13%, and through rapid growth, the digital cultural industry development efficiency of these provinces is expected to improve significantly. Additionally, the efficiency of digital cultural industry development in Gansu has declined, with an annual decrease of 0.92%. This is attributed to the lag in human and capital inputs compared to most other regions nationwide from 2011 to 2023, and the widening urban-rural gap at a rate of 4.87%, which exacerbated Gansu's investment in human resources, capital, and other factors lagged behind most other regions in China, with the urban-rural gap growing at a rate of 4.87%. The combination of low-growth investment and unexpected outputs exacerbated the decline in the efficiency of digital cultural industry development. Therefore, the efficiency of Gansu's digital cultural industry should be improved by prioritizing urban-rural integrated development and focusing on enhancing the efficiency of digital cultural industry development.

*Table 2: Time-series characteristics of the efficiency of China's provincial digital culture industry*

| Area/ provincial area sequence | | Overall evaluation | | | Changes in characteristic periods | | | Changes in Characteristic Points | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Entire period | Rank | Annual average growth rate | Growth period (2011-2015) | Adjustment period (2016-2020) | Quality improvement period (2021-2023) | 2011 | 2016 | 2021 | 2023 |
| Eastern region | Beijing | 1.00 | 1 | 0.00 | 1.01 | 0.98 | 1.01 | 1.01 | 0.90 | 1.01 | 1.01 |
| | Tianjin | 0.72 | 3 | 0.14 | 0.87 | 0.52 | 0.78 | 0.37 | 0.48 | 1.03 | 0.47 |
| | Hebei | 0.18 | 22 | 1.22 | 0.08 | 0.04 | 0.57 | 0.12 | 0.05 | 1.02 | 0.14 |
| | Shanghai | 0.70 | 4 | 0.00 | 0.98 | 0.43 | 0.66 | 1.03 | 0.51 | 0.51 | 0.64 |
| | Jiangsu | 0.34 | 12 | 0.33 | 0.38 | 0.11 | 0.65 | 1.01 | 0.12 | 1.00 | 0.25 |
| | Zhejiang | 0.44 | 8 | 0.18 | 0.48 | 0.17 | 0.85 | 1.00 | 0.11 | 1.01 | 0.52 |
| | Fujian | 0.25 | 17 | 0.17 | 0.30 | 0.16 | 0.90 | 0.18 | 0.08 | 1.00 | 0.17 |
| | Shandong | 0.21 | 19 | 0.14 | 0.19 | 0.10 | 0.43 | 0.25 | 0.12 | 0.35 | 0.28 |
| | Guangdong | 0.27 | 15 | 0.22 | 0.20 | 0.15 | 0.60 | 0.20 | 0.10 | 1.00 | 0.34 |
| | Hainan | 0.66 | 5 | 0.64 | 0.79 | 0.31 | 1.01 | 1.00 | 0.09 | 1.01 | 1.01 |
| | Average value | 0.48 | - | 0.30 | 0.53 | 0.30 | 0.75 | 0.62 | 0.26 | 0.89 | 0.48 |

| Area/ provincial area sequence | | Overall evaluation | | | Changes in characteristic periods | | | Changes in Characteristic Points | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Entire period | Rank | Annual average growth rate | Growth period (2011-2015) | Adjustment period (2016-2020) | Quality improvement period (2021-2023) | 2011 | 2016 | 2021 | 2023 |
| Central region | Shanxi | 0.13 | 26 | 0.33 | 0.20 | 0.05 | 0.17 | 0.37 | 0.05 | 0.32 | 0.08 |
| | Anhui | 0.38 | 10 | 0.21 | 0.30 | 0.16 | 0.90 | 0.38 | 0.18 | 0.67 | 1.00 |
| | Jiangxi | 0.36 | 11 | 0.09 | 0.31 | 0.20 | 0.71 | 0.55 | 0.18 | 1.02 | 0.28 |
| | Henan | 0.10 | 29 | 0.19 | 0.09 | 0.05 | 0.22 | 0.12 | 0.06 | 0.31 | 0.11 |
| | Hubei | 0.39 | 9 | 0.14 | 0.26 | 0.25 | 0.84 | 0.26 | 0.19 | 0.91 | 0.61 |
| | Hunan | 0.26 | 16 | 0.22 | 0.21 | 0.15 | 0.53 | 0.16 | 0.15 | 0.31 | 0.33 |
| | Average value | 0.27 | - | 0.20 | 0.23 | 0.14 | 0.56 | 0.31 | 0.13 | 0.59 | 0.40 |
| Western region | Neimenggu | 0.11 | 28 | 0.04 | 0.18 | 0.04 | 0.12 | 0.36 | 0.03 | 0.13 | 0.13 |
| | Guangxi | 0.15 | 25 | 0.63 | 0.02 | 0.05 | 0.52 | 0.03 | 0.04 | 0.47 | 0.24 |
| | Chongqing | 0.19 | 20 | 0.23 | 0.27 | 0.11 | 0.20 | 0.35 | 0.20 | 0.24 | 0.15 |
| | Sichuan | 0.18 | 21 | 0.14 | 0.14 | 0.12 | 0.37 | 0.20 | 0.09 | 0.49 | 0.18 |
| | Guizhou | 0.15 | 24 | 0.76 | 0.10 | 0.06 | 0.41 | 0.12 | 0.04 | 1.00 | 0.11 |
| | Yunnan | 0.07 | 30 | 0.18 | 0.11 | 0.03 | 0.07 | 0.11 | 0.04 | 0.12 | 0.04 |
| | Shanxi | 0.28 | 14 | 0.10 | 0.20 | 0.21 | 0.55 | 0.21 | 0.17 | 0.50 | 0.46 |
| | Gansu | 0.61 | 6 | -0.01 | 0.73 | 0.39 | 0.75 | 1.02 | 0.29 | 1.02 | 0.17 |
| | Qinghai | 0.92 | 2 | 0.08 | 1.00 | 0.78 | 1.02 | 1.04 | 1.03 | 1.03 | 1.00 |
| | Ningxia | 0.47 | 7 | 0.88 | 0.79 | 0.16 | 0.44 | 1.00 | 0.19 | 1.00 | 0.19 |
| | Xinjiang | 0.13 | 27 | 1.15 | 0.06 | 0.04 | 0.38 | 0.21 | 0.02 | 1.01 | 0.04 |
| | Average value | 0.30 | - | 0.38 | 0.33 | 0.18 | 0.44 | 0.42 | 0.20 | 0.64 | 0.25 |
| Northeast region | Liaoning | 0.17 | 23 | 0.20 | 0.21 | 0.07 | 0.26 | 0.51 | 0.05 | 0.45 | 0.13 |
| | Jilin | 0.25 | 18 | 0.01 | 0.41 | 0.11 | 0.20 | 0.75 | 0.08 | 0.26 | 0.17 |
| | Heilongjiang | 0.32 | 13 | 0.11 | 0.46 | 0.12 | 0.53 | 1.01 | 0.15 | 0.59 | 0.46 |
| | Average value | 0.24 | - | 0.11 | 0.36 | 0.10 | 0.33 | 0.75 | 0.09 | 0.44 | 0.25 |
| Full period average | | 0.35 | - | 0.29 | 0.37 | 0.20 | 0.54 | 0.50 | 0.19 | 0.69 | 0.36 |

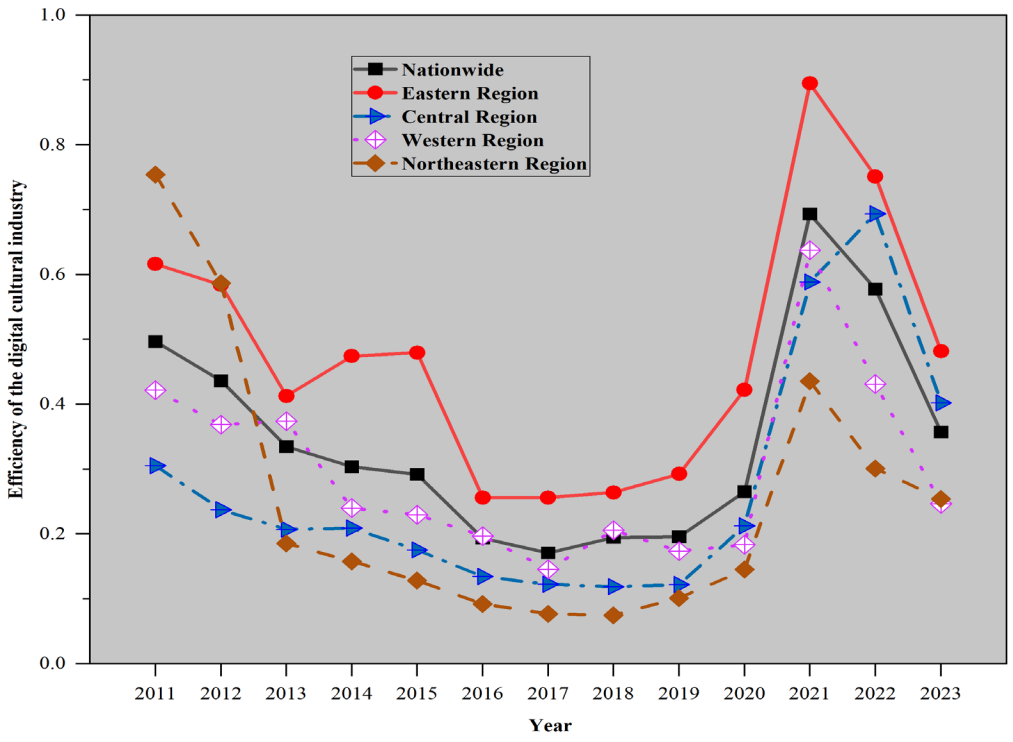
From the perspective of changes in characteristic periods and time points, the development efficiency of China's provincial digital cultural industries is significantly influenced by industrial policies and business layouts, exhibiting distinct stage-specific characteristics. From the perspective of three characteristic periods, China's provincial-level digital cultural industries exhibit a typical "V"-shaped pattern. Specifically, during the "growth period," the average efficiency of digital cultural industry development in 11 provinces exceeded the average level of that period; during the "adjustment period," this number decreased to 9 provinces; and during the "quality improvement period," it increased to 14 provinces. Among these, Beijing, Qinghai, Shanghai, Tianjin, Hainan, and Gansu performed well throughout the statistical period, consistently exceeding the average for each characteristic period. Looking at individual periods, during the "growth period," the average efficiency of digital cultural industry development in 26 provinces was lower than that of the initial year, with an overall downward trend during this period. Affected by the contradiction between high input and low output returns in industrial development and the decline in the growth rate of added value in major industries such as cultural manufacturing, the average efficiency of China's digital cultural industry development decreased by 41.18% in 2015 compared to 2011. During the "growth period," the efficiency of digital cultural industry development in the majority of provinces improved rapidly. Compared with 2016, the efficiency of digital cultural industry development in 24 provinces improved significantly in 2020, with an average

increase of 36.93%. In 2021, China's provincial-level digital cultural industry entered a period of quality improvement and efficiency enhancement, with 14 provinces exhibiting super-efficient development, exceeding the number of provinces with such performance at other time points. In 2022, the state issued the "Opinions on Promoting the Implementation of the National Cultural Digitization Strategy," which brought opportunities for the high-quality development of the digital cultural industry. Provinces across the country seized the window of opportunity for the development of the digital cultural industry, showcasing distinctive highlights in policy guidance, institutional safeguards, technological application, business model innovation, and scenario empowerment.

### 2.1.2 Temporal Characteristics of the Development Efficiency of the Digital Cultural Industry in Regions

The development efficiency of the digital cultural industry in China's four major regions exhibits a fluctuating pattern of decline and rise, with an overall trend of continuous weakening (Figure 2). The eastern region has consistently remained above the national average, while the central, western, and northeastern regions have generally lagged behind the national average. During the "growth period," the annual growth rates of the digital cultural industry development efficiency in the eastern, central, western, and northeastern regions were 30.45%, 19.73%, 38.06%, and 10.83%, respectively. This indicates that during the adjustment phase of the digital cultural industry, the development efficiency of the digital cultural industry in all four regions declined to varying degrees, with the northeastern region experiencing the most significant decline, dropping by 82.99% compared to 2011. During the "adjustment period," except for the western region, which remained basically stable, the development efficiency of the digital cultural industry in the other regions increased, with the eastern region seeing the fastest growth, rising by 64.88% in 2020 compared to 2016. During the "quality improvement period," the development efficiency of the digital cultural industry in the four major regions reached its peak in 2021, thanks to the support of the "Opinions on Promoting the High-Quality Development of the Digital Cultural Industry," which boosted confidence in the development of the digital cultural industry. However, subsequently, due to structural imbalances in the allocation of resources and elements in the digital cultural industry, as well as difficulties in deepening and extending the industrial chain, value chain, innovation chain, and talent chain, the development of the digital cultural industry in the four major regions slowed down and even showed a noticeable downward trend. Nevertheless, it should be noted that during this phase, the average development efficiency of the digital cultural industry in the eastern and central regions remained higher than the national average.

*Figure 2 Trends in the efficiency of digital cultural industry development in China's four major regions*



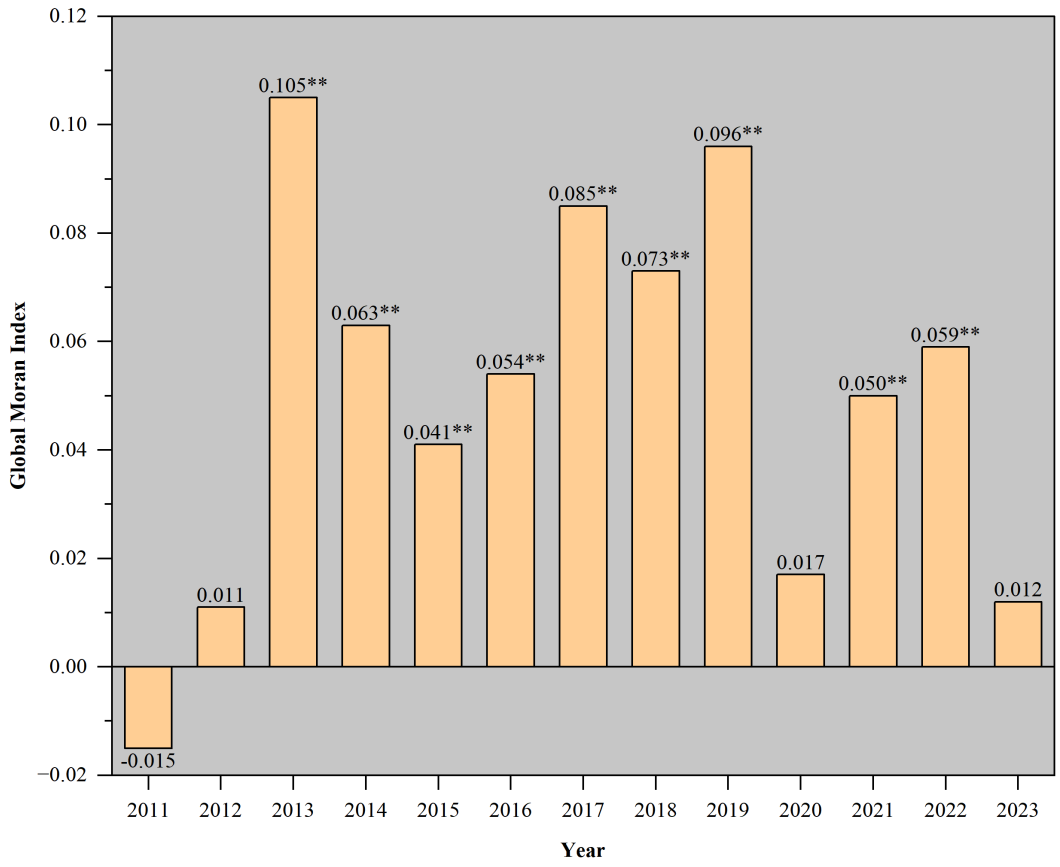
## 2.2 Spatial characteristics of the development efficiency of China's digital culture industry

### 2.2.1 Global spatial agglomeration characteristics of the development efficiency of the digital culture industry

From 2011 to 2023, the overall Moran's index exhibited a fluctuating downward trend, indicating that the spatial clustering efficiency of China's digital cultural industry is gradually weakening (Figure 3). Specifically, the global Moran Index was -0.015 in 2011, with a P-value of 0.290, which is much larger than 0.05. In 2012, although the global Moran Index turned from negative to positive to 0.011, the P-value was 0.101, which is still larger than 0.05, indicating that the development efficiency of China's digital culture industry lacked significant spatial agglomeration characteristics on the global scale from 2011 to 2012. The reason for this is that over the past two years, China's digital culture industry has been in a budding and growing phase, with low allocation efficiency of policies, technologies, and resources. The spatial layout of the industry was not yet clear, and the industry had not yet formed stable spatial correlations. In the following years, the global Moran index is positive, in which the P-value is less than 0.05 from 2013 to 2019 and in 2021 and 2022, indicating that there is a significant spatial agglomeration characteristic in the development efficiency of China's digital culture industry in these nine years, but the P-value in 2020 and 2023 is greater than 0.05, indicating that China's digital culture industry in these two years does not present a significant overall Clustering characteristics. In terms of period, the global Moran index in the "growth period", "adjustment period" and "quality improvement period" shows a "Λ" distribution. The global Moran Index in the "growth period", "adjustment period" and "quality improvement period" is distributed in a "Λ" shape, which shows the trend of "increasing and then decreasing", indicating that there are obvious differences in the spatial agglomeration characteristics of the development efficiency of the digital culture industry in each period.

Note: ** indicates significance at a 5% significance level.

*Fig. 3 Global spatial agglomeration of the development efficiency of China's digital culture industry*




### 2.2.2 Local spatial agglomeration characteristics of the development efficiency of the digital culture industry

The spatial distribution of the development efficiency of China's digital culture industry is mainly characterized by "H-H" and "L-L" agglomeration (Table 3). Among them, "high - high" agglomeration is mainly distributed in Beijing, Tianjin,

Shanxi, Shandong, Qinghai, Ningxia, Gansu and other provinces, while "low - low" agglomeration is mainly distributed in Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan and other provinces. It is worth noting that the development efficiency of the digital culture industry in some provinces is characterized by "high-low" agglomeration, such as Guangdong, Fujian, and Jiangsu. In terms of period, the local spatial agglomeration characteristics of the development efficiency of China's digital culture industry in the "growth period", "adjustment period" and "quality improvement period" are quite different. In the "growth period", the "high-high" agglomeration and "low-low" agglomeration have a "Λ" distribution, and the "adjustment period" has a "Λ" distribution, and the "adjustment period" has a "Λ" distribution. The "adjustment period" is stable, and the "quality improvement period" has a downward trend, reflecting that the local spatial distribution of the development efficiency of China's digital culture industry is unbalanced.

*Table 3: Local spatial clustering of efficiency in China's digital culture industry*

| Year | High-High agglomeration | Low-High agglomeration | Low-Low agglomeration | High-Low agglomeration |
|---|---|---|---|---|
| 2011 | Neimenggu, Gansu, Qinghai, Ningxia (4) | Tianjin, Hebei, Jilin, Shanghai, Anhui, Jiangxi, Shandong, Henan, Hainan, Shanxi, Xinjiang, Heilongjiang (12) | Zhejiang, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan (6) | Beijing, Shanxi, Liaoning, Jiangsu, Fujian, Hubei, Hunan, Guangdong (8) |
| 2015 | Beijing, Tianjin, Gansu, Ningxia (4) | Hebei, Neimenggu, Liaoning, Shanghai, Zhejiang, Anhui, Shandong, Henan, Shanxi, Xinjiang (10) | Jilin, Heilongjiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan (13) | Shanxi, Jiangsu, Qinghai (3) |
| 2019 | Beijing, Tianjin, Shanxi, Shandong, Shanxi, Gansu, Qinghai (7) | Hebei, Neimenggu, Liaoning, Jilin, Heilongjiang, Henan, Ningxia, Xinjiang (8) | Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan (15) | - |
| 2023 | Beijing, Tianjin, Shanxi, Liaoning, Jiangsu, Anhui, Shandong (7) | Hebei, Neimenggu, Jilin, Shanghai, Zhejiang, Jiangxi, Henan, Hubei, Gansu, Ningxia, Xinjiang (11) | Heilongjiang, Fujian, Hunan, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan (9) | Guangdong, Shanxi, Qinghai (3) |

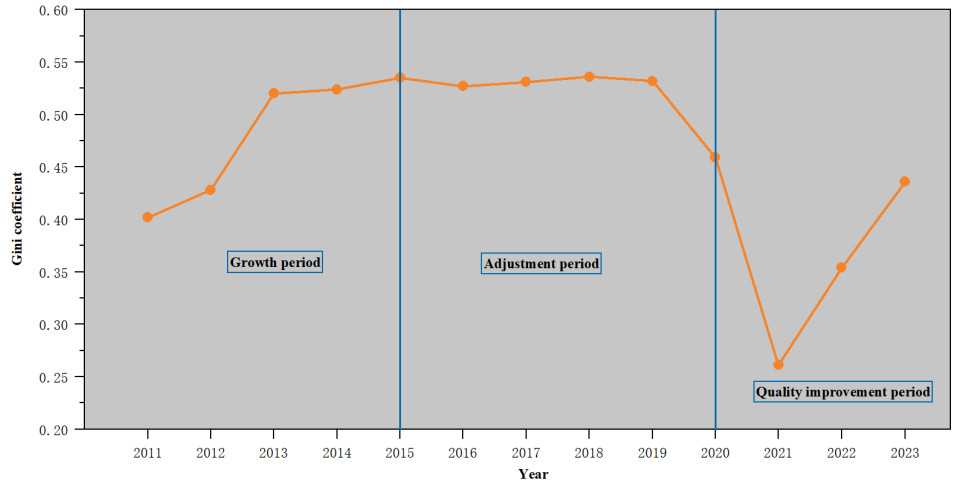
# 3.Spatial Differences in the Development Efficiency of China's Digital Culture Industry

## 3.1 Regional differences in the development efficiency of the digital culture industry

According to Figure 4, the overall Gini coefficient of the development efficiency of China's digital culture industry fluctuates between 0.26 and 0.54, with the overall state decreasing and then increasing, indicating that the regional gap in the development efficiency of the digital culture industry narrows more slowly. During the statistical period, the Gini coefficient of the development efficiency of China's digital culture industry increased by an average of 2.69% per year, and compared with 2011, it increased by 8.46% in 2023.

Sub-period, "growth period", China's digital culture industry development efficiency of the regional gap is expanding trend, the average growth rate of 7.71%, the economic strength of the regions and industrial resource endowment there is a significant gap, the eastern region shows a strong first-mover advantage. In the "adjustment period", the regional gap did not continue the expansion trend of the previous period, with an average growth rate of 2.85%, down 4.86 percentage points, the gap between the regions is shrinking, thanks to the period of the various regions continue to strengthen the digital culture industry resource factor flow and optimize the allocation efficiency, the formation of cross-regional growth poles. During the "quality improvement period", the average growth rate was 5.22%, 2.37 percentage points higher than that of the "adjustment period" and 2.49 percentage points lower than that of the "growth period". During this period, all regions accelerated the promotion of high-quality development of the digital culture industry, and innovation resources, high-end talents, and data elements accelerated their concentration in megacities, leading to a widening of the gap between regions.

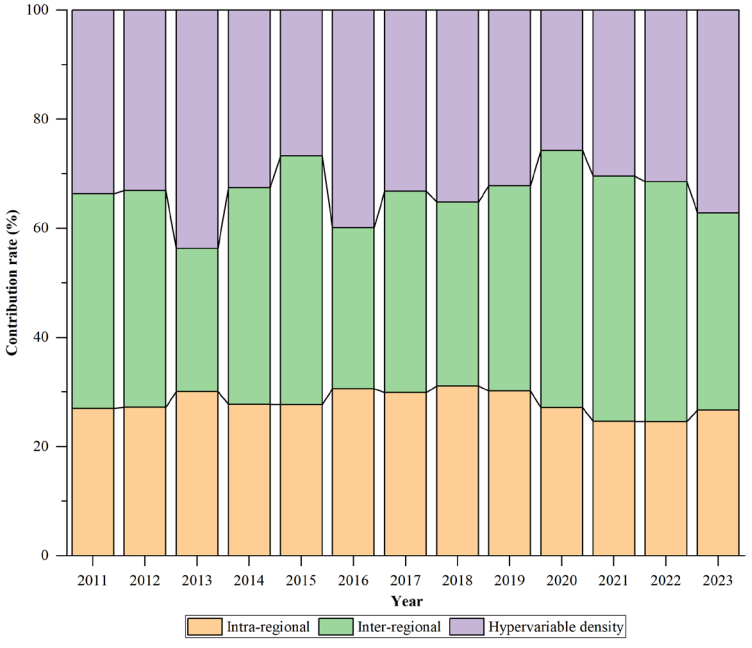
*Fig. 4 Overall regional gaps in the development efficiency of the digital culture industry in the four major regions of China*




## 3.2 Sources of the spatial gap in the development efficiency of the digital culture industry

From the perspective of the spatial sources of regional disparity, it mainly includes inter-regional disparity, intra-regional disparity, and hypervariable density. As can be seen from Figure 5, the contribution rate of intra-regional disparity is from 24.57% to 31.10%, the contribution rate of inter-regional disparity is from 26.25% to 47.10%, and the contribution rate of hyper-variable density is from 25.76% to 43.69%, indicating that the inter-regional disparity is the dominant factor of the spatial disparity of China's development efficiency of the digital culture industry and that reducing the disparity between different regions is the response to the problem of uneven development of the digital culture industry. Key. In addition, the contribution rate of hypervariable density follows closely, indicating that the phenomenon of cross-overlap in different regions also has a greater impact on the regional gap in the development efficiency of China's digital culture industry, and provinces under the same level of efficiency are very likely to belong to different tiers in different regions, which increases the degree of regional differences in the development efficiency of the digital culture industry. From the perspective of the three major periods, the contribution rate of intra-regional differences shows an inverted "V" type change, and the contribution rate of inter-regional and hyper-variable density shows a "V" type change, from the "growth period" to the "quality improvement period", from the "growth period" to the "quality improvement period". From the "growth period" to the "quality improvement period", the average contribution rate of inter-regional differences is 38.14%, 36.97%, and 41.66% respectively, indicating that it is still the most important source of regional disparities in the period, which is consistent with the results of the whole period.

*Fig. 5 Spatial sources of regional disparities in the development efficiency of China's digital culture industry*



### 3.3 Decomposition of the Gini coefficient of development efficiency of the digital culture industry

On the one hand, the Gini coefficient of the development efficiency of the digital culture industry among China's four major regions during the statistical period generally shows a fluctuating downward trend. The decline is especially obvious in the period from 2019 to 2021. Specifically, the inter-regional Gini coefficients of the eastern region - western region and the eastern region - northeastern region are larger, and the average value is greater than 0.50, and the inter-regional Gini coefficient of the northeastern region - central region is smaller, and the average value is 0.36. It can be seen that there is a clear gap between the regions with higher efficiency in the development of the digital culture industry and those with lower efficiency, and in contrast to this, the regions with lower efficiency in the development of the digital culture industry The difference between them is not big, but overall the regional gap in the development efficiency of the digital culture industry in different regions still has different degrees of change.

On the other hand, the results of the Gini coefficient decomposition of the development efficiency of the digital culture industry within the four major regions of China are shown in Table 4, and there is a significant difference between the Gini coefficients within each region, among which the Gini coefficient within the western region is the largest, followed by the eastern and central regions, and the northeastern region is the smallest. From the previous analysis, it can be seen that the development efficiency of the digital culture industry in the Western region is lower, the intra-regional differences are larger, and the uneven development is particularly significant. In contrast, the eastern region's digital culture industry development efficiency is relatively high, and its internal development is generally more balanced. From the perspective of the time change, the Gini coefficient of the four regions generally shows a fluctuating upward trend, indicating that the differences in the development efficiency of its internal digital culture industry are gradually increasing.

*Table 4: Dagum gini coefficient difference decomposition results*

| Year | Intra-regional Gini coefficient | | | | Inter-regional Gini coefficient | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Eastern region | Central region | Western region | Northeastern region | East & Central | East& West | East &Northeast | Central & Northeast | Central& Western | West &North-east |
| 2011 | 0.34 | 0.27 | 0.46 | 0.15 | 0.46 | 0.43 | 0.29 | 0.43 | 0.44 | 0.41 |
| 2012 | 0.35 | 0.20 | 0.49 | 0.25 | 0.50 | 0.46 | 0.34 | 0.42 | 0.45 | 0.43 |
| 2013 | 0.47 | 0.22 | 0.57 | 0.37 | 0.50 | 0.53 | 0.55 | 0.35 | 0.57 | 0.60 |
| 2014 | 0.45 | 0.24 | 0.55 | 0.39 | 0.54 | 0.58 | 0.62 | 0.36 | 0.49 | 0.54 |
| 2015 | 0.45 | 0.22 | 0.56 | 0.37 | 0.58 | 0.59 | 0.66 | 0.35 | 0.47 | 0.54 |
| 2016 | 0.50 | 0.23 | 0.59 | 0.25 | 0.50 | 0.58 | 0.55 | 0.31 | 0.49 | 0.55 |
| 2017 | 0.51 | 0.23 | 0.58 | 0.14 | 0.51 | 0.60 | 0.57 | 0.31 | 0.49 | 0.53 |
| 2018 | 0.51 | 0.26 | 0.59 | 0.10 | 0.51 | 0.57 | 0.59 | 0.32 | 0.52 | 0.59 |
| 2019 | 0.49 | 0.31 | 0.59 | 0.10 | 0.53 | 0.58 | 0.53 | 0.28 | 0.53 | 0.52 |
| 2020 | 0.40 | 0.37 | 0.45 | 0.13 | 0.47 | 0.53 | 0.54 | 0.36 | 0.43 | 0.37 |
| 2021 | 0.11 | 0.27 | 0.31 | 0.17 | 0.27 | 0.25 | 0.37 | 0.29 | 0.32 | 0.35 |
| 2022 | 0.17 | 0.28 | 0.48 | 0.28 | 0.24 | 0.40 | 0.44 | 0.49 | 0.43 | 0.47 |
| 2023 | 0.34 | 0.43 | 0.47 | 0.28 | 0.40 | 0.49 | 0.42 | 0.44 | 0.50 | 0.41 |

## 4.Research Conclusions and Policy Recommendations

This paper constructs a global super-efficiency EBM model that takes into account non-expected outputs, scientifically and systematically measures the development efficiency of the digital cultural industry in 30 provinces of China from 2011 to 2023, and further reveals its temporal and spatial characteristics and the degree of spatial differentiation, drawing the

following conclusions:

(1) During the statistical period, the overall efficiency of China's digital cultural industry development was relatively low, with an average efficiency of 0.35. The efficiency of digital cultural industry development exhibited distinct temporal and regional characteristics. From the perspective of three characteristic periods, China's provincial-level digital cultural industries exhibited a typical "V"-shaped pattern, with average efficiency levels during the "quality improvement period" and "growth period" generally higher than those during the "adjustment period." Additionally, the efficiency of digital cultural industry development in eastern regions was significantly higher than that in other regions.

(2) In terms of spatial agglomeration characteristics, the global Moran index of China's digital cultural industry development efficiency showed an overall fluctuating downward trend, with the global Moran index of the three characteristic periods exhibiting a "Λ" distribution pattern, all indicating a fluctuating decline. The local Moran index revealed that the spatial distribution of China's digital cultural industry development efficiency primarily featured "high-high" and "low-low" agglomeration patterns, with significant differences in local spatial agglomeration characteristics across the three characteristic periods.

(3) In terms of the sources of spatial disparities, the overall disparity in the efficiency of China's digital cultural industry development shows a fluctuating upward trend, with inter-regional disparities being the dominant factor in spatial disparities in the efficiency of China's digital cultural industry development, with a contribution rate ranging from 26.25% to 47.10%. Based on the results of the Gini coefficient decomposition, during the statistical period, the Gini coefficient of digital cultural industry development efficiency among China's four major regions showed an overall fluctuating downward trend, with the internal imbalance of digital cultural industry development efficiency in the western region becoming more pronounced.

Based on the above conclusions, the following recommendations are proposed:

(1) Strengthen the application of technological innovation to promote the quality and efficiency of the digital cultural industry [19]. Under the national strategy of cultural digitization, new technologies such as digital technology, cloud computing, big data, and artificial intelligence are upgrading from cultural dissemination tools to industrial innovation engines. This requires the accelerated establishment of a tracking and monitoring system for the development efficiency of the digital cultural industry to achieve precise alignment between policy tools and industrial cycles. In addition, it is necessary to significantly improve the pure technical efficiency of the digital cultural industry, enhance the efficiency of input and output utilization, break through the barriers of management inefficiency [20], expand the talent chain, innovation chain, and value chain of the digital cultural industry, and maximize the source function of the digital cultural industry to promote the upgrading of the digital cultural industry.

(2) Leverage regional comparative advantages and formulate digital cultural industry development strategies and measures based on local conditions [21]. The regional disparities in the development efficiency of China's digital cultural industry are widening. When formulating digital cultural industry development strategies and measures, all regions must focus on highlighting their industrial characteristics and leveraging their comparative advantages, accurately positioning themselves within the broader context of the high-quality development of the national cultural industry, and meeting demand, while strengthening planning coordination [22]. Eastern regions should regard the layout of the digital cultural industry as an important lever for accelerating the construction of a modern industrial system, strengthening the coordination and integration of the digital cultural industry with the digital economy, and providing a model for the development of the digital cultural industry in other regions [23]. Central regions should strengthen the overall planning of the digital cultural industry, focus on the forward-looking layout of digital cultural industry formats, and enhance the conversion and application of digital cultural value in various economic sectors. Western regions should rely on industry-leading platforms such as the Western Digital Publishing Alliance, the Western Digital Publishing Annual Conference, China Western Cultural Industry Expo, and other high-end industry platforms to gain a deep understanding of the bottlenecks and obstacles constraining the development of the digital cultural industry and explore development policies for improving the quality and efficiency of the digital cultural industry. The northeastern region should increase research and development of digital infrastructure equipment and application technologies, take multiple measures to build a digital content production belt, industrial heritage digital

revitalization demonstration zone, and cross-border digital cultural trade corridor, and gradually narrow the spatial gap between regions in the digital cultural industry.

(3) Break through regional barriers in the digital cultural industry and resolve barriers to regional agglomeration. It is necessary to accelerate the pilot program for the registration and trading of digital cultural data elements, break down existing regional barriers and restrictions on the flow of elements, and promote the value of data assets in different regions to empower the development of the digital cultural industry [24]. We should also take the layout of digital cultural industry business models as a starting point to strengthen the coordinated improvement of regional digital cultural industry development efficiency [25]. In addition, we should establish a compensation mechanism for positive externalities in the digital cultural industry space at the appropriate time, formulate technical spillover assessment and incentive plans for "high-high" agglomeration zones, and accelerate the formation of a good ecological pattern of spatial linkage in the digital cultural industry.

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## Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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