



# Gray Association Analysis of the Integration of Sports, Culture, and Tourism Industries under the Drive of New Quality Productive Forces

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**Abstract.** This study develops an analytical framework for the integration of “new quality productive forces” with the sports, culture, and tourism industries (SWCT), utilizing comprehensive development data from China spanning 2015 to 2022. Empirical analysis is conducted using the entropy weight method, coupling coordination degree model, and grey relational analysis. Key findings reveal: (1) The overall level of integration of sports, culture, and tourism shows a fluctuating upward trend; (2) Driving effects of various elements of new quality productive forces display significant structural disparities—digital development emerges as the core driver with the highest contribution; there are significant differences in ecological and environmental factors; while scientific and technological talent support remains relatively weak and requires further strengthening. Based on these insights, the study proposes pathways for achieving high-quality integration, including accelerating digital infrastructure construction, increasing green ecological investment, and deepening the cultivation of scientific and technological talent, thereby providing theoretical support and policy recommendations for sustainable development in these sectors.

**Keywords:** New Quality Productive Forces; Integration of Sports, Culture, and Tourism; Grey Relational Analysis; Coupling Coordination Degree

## 1 Introduction

The integration of sports, culture, and tourism (“SWCT”) serves as a crucial measure in “building a modern industrial system” and a key pathway for the sports industry <sup>[1]</sup>. In recent years, from the “14th Five-Year Plan” to related specialized plans, the state has emphasized SWCT integration as a vital lever for constructing a new development pattern and promoting high-quality development. The “Work Plan for Restoring and Expanding Sports Consumption” (2023) explicitly states: “Promote the integrated development of sports with culture and tourism, empowering rural revitalization and unleashing consumption potential” <sup>[2]</sup>. Thus, advancing high-quality SWCT industrial integration has become a prominent research focus.

The concept of industrial integration abroad originated in the 1960s, initially centered on the fusion of computers and communications [3]. SWCT integration studies emerged in the 1990s, primarily employing qualitative methods [4][5], focusing on binary fusions such as sports event tourism [6][7], film and cultural tourism [8], and creative themed tourism [9], with scant research on SWCT or other ternary integrations [10]. In China, the industrial integration concept was introduced in the early 21st century [11]. Since 2000, studies on binary fusions like culture-tourism, sports-tourism, and sports-culture have dominated, combining theoretical analysis with empirical validation, covering aspects such as concepts [12], drivers [13], mechanisms [14], models [15], and pathways [16]. As research deepened, ternary and multi-element fusions like SWCT and sports-tourism-agriculture-commerce emerged [17], mainly concentrating on theoretical connotations [18], status analyses [19], action mechanisms [20], and implementation paths [21] of SWCT industries.

With the deepening of industrial development research, new directions and drivers for promoting integration continue to emerge. In 2023, General Secretary Xi Jinping proposed the concept of "new quality productive forces" [22], emphasizing fusion in the digital era as an innovation-driven leap from quantitative to qualitative transformation in productivity [23]. As a high-potential sector, the sports industry inevitably forms a key component of new quality productive forces [24], which can highly align and interdepend with culture and tourism industries [25], thereby advancing high-quality SWCT integration.

In summary, current research predominantly focuses on binary fusions, with deficiencies in ternary SWCT integration studies [26] and an urgent need to advance research on multidimensional elements of new quality productive forces in industrial integration. Therefore, this study constructs a "new quality productive forces-SWCT integration" framework to expand the boundaries of industrial integration theory and enrich research on its core drivers.

## 2 Data and Methods

### 2.1 Data Source

This article selects the period from 2015 to 2022 as the research period, and the relevant data comes from the "China Statistical Yearbook", "National Renewable Energy Power Development Monitoring and Evaluation Report", "Ecological Environment Statistical Yearbook", etc. The data on sports, culture, tourism, and new quality productivity are collected, organized, and analyzed.

### 2.2 Research Methods

#### Entropy Weight Method.

The entropy weight method effectively captures the importance of individual indicators, minimizing subjective judgment and uncertainty, thereby enhancing decision-making credibility [27]. This approach determines indicator weights based on entropy values derived from SWCT indicators, reflecting their relative contributions to

the system. Prior to weighting, all indicators undergo standardization to eliminate dimensional differences and ensure consistency in model computations.

**Coupling Coordination Degree Model.**

Coupling coordination theory originates from physics and is now widely applied in socioeconomic domains [28]. Given that this study encompasses three systems—sports, culture, and tourism—the model is defined as follows:

$$C = 3 \times \sqrt[3]{\frac{U_1 \cdot U_2 \cdot U_3}{(U_1 + U_2 + U_3)^3}}; \quad T = \beta_1 \cdot U_1 + \beta_2 \cdot U_2 + \beta_3 \cdot U_3; \quad D = \sqrt{C \cdot T}$$

C denotes the coupling degree; T represents the comprehensive coordination index; D indicates the coupling coordination degree; U1,U2,U3 are the comprehensive indices of the respective systems;β1,β2 andβ3 are undetermined weights. Assuming equal importance for sports, culture, and tourism, set β1=β2=β3=1/3.

**Grey Relational Analysis.**

By computing the grey relational coefficients between individual factors of new quality productive forces and the coupling coordination degree of SWCT, the association strength of each factor with SWCT integration can be identified. Calculations are performed after standardization, followed by ranking.

The relational coefficient is calculated as:

$$\xi_i(k) = \frac{\min_i \min_k |y(k) - x_i(k)| + \beta \max_i \max_k |y(k) - x_i(k)|}{|y(k) - x_i(k)| + \beta \max_i \max_k |y(k) - x_i(k)|}$$

Calculation and Ranking of Association Degrees:

$$r_i = \frac{1}{n} \sum_{k=1}^n \xi_i(k), \quad k = 1, 2, \dots, n$$

**2.3 Data Description**

**Evaluation Indicator System for Comprehensive Development Level of SWCT Industries.**

Indicator construction draws on the research findings of Zhang Yufei [26], adopting an input-output analytical approach from economics, encompassing factor inputs and benefit outputs, while adhering to principles of scientific rigor, representativeness, and data availability. Weights for indicators in the sports, culture, and tourism industries, calculated via the entropy weight method, are presented in Table 1.

**Table 1.** Evaluation Indicator System for Comprehensive Development Level of SWCT Industries

System Layer	Criterion Layer	Indicator Layer	Weight
Sports	Factor Inputs	Number of sports administrative agencies (units)	0.06535
		Number of sports project management departments (units)	0.07732
		Number of sports venues (units)	0.07980
		Number of sports research institutions (units)	0.08726
		Employment in sports administrative agencies (persons)	0.10201
	Benefit Outputs	Employment in sports project management departments (persons)	0.10319
		Employment in sports venues (persons)	0.10248
		Employment in sports research institutions (persons)	0.12964
		Added value of sports services (billion yuan)	0.08415
		Added value of sports goods and related manufacturing (billion yuan)	0.07674
Culture	Factor Inputs	Added value of sports venue construction (billion yuan)	0.09206
		Number of public libraries (units)	0.14513
		Number of cultural centers (stations) (units)	0.12234
		Number of museums (units)	0.10227
		Number of performing arts groups (units)	0.08390
	Benefit Outputs	Number of performing arts venues (units)	0.11459
		Operating revenue of cultural manufacturing (million yuan)	0.19057
		Operating revenue of cultural wholesale and retail (million yuan)	0.12416
		Operating revenue of cultural services (million yuan)	0.11703
		Number of travel agencies (units)	0.17714
Tourism	Factor Inputs	Number of star-rated hotels (units)	0.14607
		Number of accommodation enterprises (units)	0.20243
		Year-end employment in accommodation sector (persons)	0.12195
	Benefit Outputs	Operating revenue of accommodation sector (billion yuan)	0.07943
		Domestic tourist arrivals (hundred million person-times)	0.13111
		Total domestic tourism expenditure (billion yuan)	0.14186

### Indicators of New Quality Productive Forces.

This study, grounded in the connotation of new quality productive forces, examines three dimensions—laborers, objects of labor, and means of production. Drawing on indicator construction approaches from scholars such as Wang Jue <sup>[29]</sup> and Hou Yuxia <sup>[30]</sup>, while considering data availability, an evaluation indicator system for new quality

productive forces is developed. Indicators and their grey relational degrees with rankings are presented in Table 2.

### 3 Results and Analysis

#### 3.1 Coupling Coordination Degree of SWCT Integration and Analysis

The coupling coordination degree among sports, culture, and tourism is calculated using the coupling coordination degree model. As shown in Figure 1.

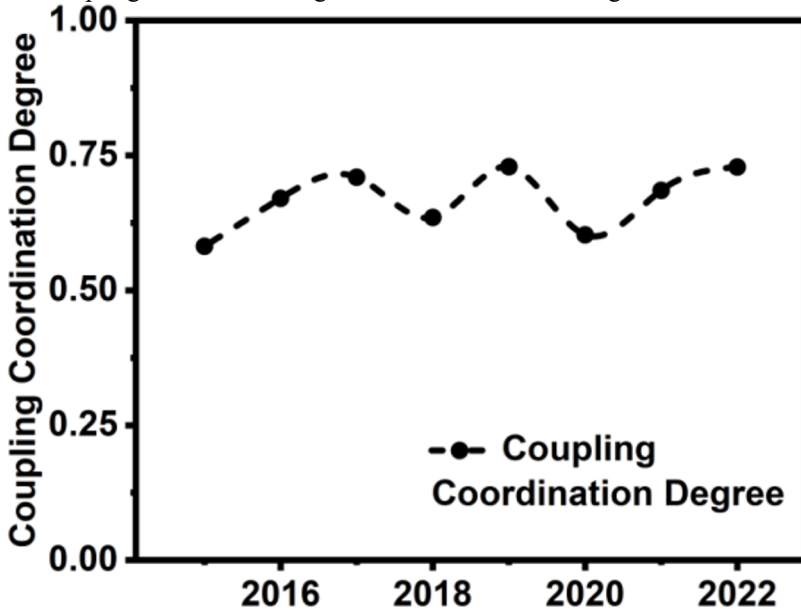


Fig. 1. Coupling Coordination Degree of SWCT Integration

As depicted in Figure 1, the integrated development of SWCT from 2015 to 2022 exhibits an overall fluctuating upward trend, divisible into three stages: steady increase from 2015 to 2017; fluctuating decline from 2018 to 2020; and recovery rise from 2021 to 2022.

#### 3.2 Grey Relational Analysis of New Quality Productive Forces and SWCT Integration, and Driving Mechanisms

Grey relational coefficients between individual indicators of new quality productive forces and the coupling coordination degree of SWCT are calculated using grey relational analysis. See Table 2.

Based on grey relational analysis results, the association mechanisms between elements of new quality productive forces and the coupling coordination degree of SWCT industries exhibit multi-layered, structured driving characteristics.

**Table 2.** Grey Relational Coefficients between New Quality Productive Forces and SWCT Integration

Evaluation Item	Association Degree	De-Ranking
Number of internet broadband access ports	0.675	1
Investment completion in forestry and grassland	0.674	2
Optical fiber access ports	0.671	3
Energy consumption / GDP	0.665	4
Per capita output	0.610	5
E-commerce transaction volume	0.607	6
Industrial solid waste generation	0.601	7
Industrial water consumption / GDP	0.596	8
National cumulative installed capacity of renewable energy power generation	0.592	9
Average wage of employed persons in urban non-private units	0.584	10
Investment in waste gas treatment	0.577	11
Completed afforestation area	0.573	12
Railway mileage	0.556	13
Highway mileage	0.556	14
Total number of students per 100,000 population at all education levels	0.553	15
R&D expenditure of industrial enterprises above designated size / GDP	0.552	16
Technology market transaction volume	0.551	17
In-school student situation	0.549	18
Total afforestation area	0.545	19
Full-time equivalent R&D personnel	0.541	20
Number of authorized patents / total population	0.527	21
Investment in wastewater treatment	0.515	22
Investment in solid waste treatment	0.486	23

## 4 Conclusions and Recommendations

### 4.1 Conclusions

From 2015 to 2022, the coupling coordination degree of China's SWCT exhibits an overall fluctuating upward trend.

Grey relational degree rankings indicate that digital development-related indicators play a core driving role in empowering SWCT integrated development through new quality productive forces; ecological environment-related indicators display significant

ranking disparities with high dispersion; whereas scientific and technological innovation and human capital exhibit generally low association degrees.

## 4.2 Recommendations

To promote comprehensive and in-depth empowerment of SWCT integrated development by new quality productive forces, the following recommendations are proposed based on the foregoing study:

In digital development: Prioritize full coverage of 5G, gigabit optical networks, and the Internet of Things in national-level cultural-tourism clusters and key sports industry bases to construct a new digital infrastructure system. Develop industrial internet platforms, guide digital-intelligent transformation of industries, promote integration of digital and real economies, and unleash the empowering potential of new quality productive forces<sup>[31]</sup>.

In ecological environment development: Establish specialized green ecological development funds to enrich financial supply for SWCT new quality productive forces<sup>[32]</sup>; promote green transformation of cultural-tourism infrastructure and plan "ecology + SWCT" integration projects. Drawing on advanced experiences, build systems for "low-carbon scenic areas"<sup>[33]</sup> and "green events"<sup>[34]</sup> to guide green and low-carbon consumption, achieving efficient conversion from "lucid waters and lush mountains" to "golden mountains and silver hills."

In scientific-technological innovation and talent cultivation: For human capital, adhere to the objectives of "effective cultivation, successful attraction, strong retention, and optimal utilization." Establish "SWCT+" disciplinary courses, implement targeted training programs and a "dual-mentor" system to develop innovative composite talents. In evaluation mechanisms, incorporate diversified assessments, including conversion rates, cross-industry project contributions, and benefit indicators. Establish specialized SWCT research topics and funds to direct scientific-technological innovation outcomes toward SWCT applications.

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