

Study on the Modernization Measurement of the Coordination between Material Civilization and Cultural-Ethical Civilization in China

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Abstract: Based on data from 11 provinces and cities in the Yangtze River Economic Belt from 2013 to 2022, this paper measures the modernization progress of material and spiritual civilization and their degree of coordinated development. The Dagum Gini coefficient and kernel density estimation are used to analyze regional differences and dynamic trends, while structural equation modeling and a spatial Markov chain model are employed to explore impact paths and development transitions. The results indicate steady improvements in various indices across the Yangtze River Economic Belt, with decreasing inequality, though regional disparities remain significant and the trend of polarization intensifies. Technological innovation has promoted cultural life and social progress, and although there is a phenomenon of status lock-in, there is potential for modest improvements. This research provides theoretical support and policy recommendations for the coordinated development of material and spiritual civilization.

Keywords: Material Civilization; Spiritual Civilization; Statistical Measurement; Dynamic Evolution; Path Analysis.

1. Introduction

Chinese modernization is characterized by the coordination between material and spiritual civilization, which not only preserves the rich cultural heritage of the Chinese nation but also reflects the development path of socialism. Since the founding of the People's Republic of China, the Communist Party of China (CPC) has promoted the construction of spiritual civilization alongside national modernization, introducing policies such as "grasping both hands, both must be strong." However, during the early stages of reform and opening-up, the development of material civilization was prioritized, while cultural construction lagged behind, creating an ideological vacuum (Kallio & Jyrki, 2015). Since the 18th National Congress of the CPC, president Xi Jinping has placed great emphasis on the joint development of material and spiritual civilization, advancing the cause of socialism with Chinese characteristics. During this period, China made significant progress in material civilization, with its per capita GDP reaching 89,358 RMB in 2023, surpassing \$12,000 for three consecutive years (Lin et al., 2022; Lü & Chen, 2022; Hu, 2023), and is expected to approach the level of moderately developed countries by 2035.

However, measuring spiritual civilization remains challenging due to its abstract nature and the lack of unified standards. How can we objectively measure spiritual civilization? What is its current level of development? Is it in harmony with material civilization? As an integral part of Chinese modernization, scientifically answering these questions will help better understand the dynamics of coordinated development between material and spiritual civilization, thus contributing to China's modernization efforts. Therefore, this paper aims to quantitatively assess the development level of spiritual civilization and evaluate its coordination with material civilization by integrating relevant indicators. This research not only seeks to offer a new approach for quantifying spiritual civilization but also

explores the interaction between the two in the context of Chinese modernization. It aims to identify key factors that influence their coordinated development and provide theoretical and empirical support for policy formulation.

2. Literature Review

Since the founding of the People's Republic of China, the Party and the state have prioritized spiritual civilization. In 1979, Ye Jianying introduced the concept of building socialist spiritual civilization, and the 12th Plenary Session of the Party's Central Committee formally initiated this effort. Xue (1982) noted that it can progress even without advanced material civilization, while Wang (2023) stressed the importance of coordinating material and spiritual civilization. These studies provide the theoretical basis for spiritual civilization construction.

Huang (1983) was among the first to argue that statistical involvement is crucial for constructing spiritual civilization, suggesting the development of indicators reflecting people's material and cultural life. Zhou (1987) recommended using cultural construction statistics and surveys on living conditions to track progress, while Feng (1987) proposed dividing spiritual civilization into spiritual production and spiritual life and comparing China's progress with developed countries. These studies have provided essential support for the quantitative assessment of spiritual civilization. Recent discussions on the coordinated development of material and spiritual civilization, especially following the 20th Party Congress report, have drawn renewed scholarly attention. Hao (2022) explored the pathways for their coordination within the Chinese modernization framework, while Sun (2023) analyzed the internal logic and value implications of this coordination. Sun and Deng (2023) further examined the modern connotations and governance methods. Although these studies have deepened our understanding, research on quantifying this coordination remains limited, with most focusing solely on spiritual civilization and lacking a

comprehensive approach to both.

As China's modernization goals have gained prominence, attention to the coordinated development of material and spiritual civilization has grown. Li and Yu (2022) incorporated spiritual life indicators into their study on common prosperity statistics, while Pei and Qu (2023) developed a six-dimensional framework emphasizing cultural development in spiritual civilization. Zou et al. (2023) used a tri-coordinated index to measure the balance between material and spiritual wealth, and Yuan et al. (2023) built an index system to assess the coordination level in Shandong Province. However, research on the coordination between material and spiritual civilization remains limited, with most studies briefly addressing material civilization when focusing on spiritual aspects.

In summary, while existing research has explored the relationship between material and spiritual civilization and provided measurement methods, there are still gaps in evaluation frameworks and indicator construction. Some systems have become outdated due to historical changes, others focus too narrowly on culture, neglecting material civilization, and some are overly complex, reducing indicator accuracy. This paper aims to contribute by 1) discussing evaluation dimensions and establishing a comprehensive indicator system, 2) quantifying spiritual civilization with micro-level data, 3) setting reference values based on China's 2035 modernization goals and assessing development trends, and 4) measuring the coordination between material and spiritual civilization, analyzing regional inequalities and dynamics.

3. Indicator System Construction and Data Sources

3.1. Defining the Concepts of Material and Spiritual Civilization

Before measuring material and spiritual civilization, their definitions must be clarified. According to the 12th National Congress of the Communist Party of China, material civilization is reflected in production advancements and improved living standards, while spiritual civilization is seen in the development of education, culture, thought, and morality. A developed material civilization is marked by large-scale, efficient production driven by technological progress and improved social security (Wu & Cao, 1983). Meanwhile, spiritual civilization is demonstrated through cultural prosperity, moral improvement, and alignment with

socialist core values, emphasizing the integration of culture and thought. Based on these definitions, this paper builds an indicator system for both material and spiritual civilization. For material civilization, it selects economic scale, living standards, and technological innovation as key indicators. For spiritual civilization, it includes cultural life, values, social civility, and spiritual life as secondary indicators.

3.2. Principles for Selecting Indicators

When selecting evaluation indicators for material and spiritual civilization, the following principles should be followed: 1) Ensure indicators align with the core definitions of material and spiritual civilization. 2) Match indicators to the appropriate level of analysis (national, provincial, etc.). 3) Balance conditional indicators for comparison with outcome-based indicators to assess achievements. 4) Ensure data have sufficient discriminatory power to reflect differences. 5) Use real, objective, and accessible data, avoiding excessive processing. 6) Align the indicator system with China's specific modernization challenges.

3.3. Construction of the Indicator System

The indicator system includes multiple dimensions. For economic scale, per capita GDP is the primary indicator, along with per capita value-added from primary and secondary industries, household savings, and capital stock to reflect wealth accumulation. Urbanization rate and local government debt ratio assess infrastructure and economic wealth (Table 1). Living standards focus on per capita retail sales, disposable income, and consumption, with the Engel coefficient, healthcare availability, life expectancy, and urban-rural income ratio measuring quality of life and disparities (Table 2). Technological innovation is captured through R&D expenditure, patents, productivity improvements, and service sector contributions (Table 3). Cultural indicators include employment in cultural industries, fiscal spending on culture, and personal education and entertainment expenditure (Table 4). Values are assessed at national, societal, and individual levels, considering patriotism, political participation, moral standards, legal awareness, and perceptions of fairness (Table 5). Social civility measures mutual trust, government integrity, social tolerance, environmental satisfaction, and health (Table 6). Spiritual life indicators focus on mental health, happiness, security, and satisfaction with life and work, reflecting subjective well-being and the broader impact of social and economic progress (Table 7).

Table 1. Economic Scale

Tier-3 Indicators	Indicator Explanation	2035 Target Value
Per Capita GDP	GDP / Permanent Population (Annual)	150,000 RMB
Per Capita Value Added of Primary and Secondary Industries	Value Added of Primary and Secondary Industries / Permanent Population (Annual)	64,000 RMB
Per Capita Household Savings	Household (Personal) Savings / Permanent Population (Annual)	150,000 RMB
Per Capita Capital Stock	Capital Stock / Permanent Population (Annual)	250,000 RMB / person
Local Government Debt Ratio	Local Government Debt Balance / Regional GDP	Below 60%
Urbanization Rate	Urban Population / Total Population at Year-End	Above 75%

Table 2. People's Livelihood

Tier-3 Indicators	Indicator Explanation	2035 Target Value
Per capita total retail sales of consumer goods	Total retail sales of consumer goods / population	53,000 RMB
Per capita disposable income	Residents' disposable income / population	67,000 RMB
Per capita consumption expenditure	Residents' consumption expenditure / population	44,000RMB
Engel coefficient	Ratio of food expenditure to total consumption expenditure	25%
Number of practicing (assistant) physicians per 10,000 people	Number of licensed doctors per 10,000 people	47
Life expectancy	Average life expectancy in years	82 years
Urban-rural per capita income ratio	Ratio of urban to rural per capita income	1.84
Private car ownership per 100 people	Number of privately owned cars per 100 people	40

Table 3. Technological Innovation

Tier-3 Indicators	Indicator Explanation	2035 Target Value
R&D expenditure as a percentage of GDP	Ratio of research and development (R&D) expenditure to GDP	2.5%-3%
Number of invention patents per 10,000 people	Number of invention patents held per 10,000 people	50
Energy consumption per unit of GDP	Energy consumption per unit of GDP (tonnes of standard coal per 10,000 yuan)	0.29 tonnes of standard coal per 10,000 yuan
Total labor productivity	Total output divided by total labor input (labor productivity increase)	250,000 yuan per person
Total factor productivity (TFP)	Measurement of output growth not explained by labor and capital inputs	3.0
Value-added ratio of service industry	Proportion of value-added services to total GDP	50%-70%
Employment ratio in the service sector	Proportion of workers employed in the service sector	70%

Table 4. Cultural Life

Tier-3 Indicators	Indicator Explanation	2035 Target Value
Employment ratio in cultural and related industries	Proportion of people employed in cultural and related industries	3%
Value-added ratio of cultural industries to GDP	Proportion of cultural industries' value-added to GDP	7%
Government expenditure on culture, sports, and media	Ratio of government spending on cultural, sports, and media services to total public spending	3%
Cultural facilities per 10,000 people	Cultural facilities area per 10,000 people (e.g., libraries, museums, cultural centers)	830square meters
Per capita expenditure on education, culture, and entertainment	Proportion of average individual spending on education, culture, and entertainment	15%
Average years of education per person	Average number of years individuals spend in formal education	12years

Table 5. Values and Beliefs

Tier-3 Indicators	Indicator Explanation	2035 Target Value
Patriotism	Measure of citizens' sense of national pride, cultural identity, and collective responsibility	100%
Political participation	Proportion of citizens actively involved in political processes (e.g., voting, community action)	100%
Moral standards	Reflects societal adherence to ethical standards, norms, and principles	100%
Legal awareness	Citizens' respect for and adherence to laws, and their understanding of social order	100%
Fairness and justice	Evaluation of public perception regarding equity in resource distribution and social justice	100%
Economic mindset	Reflects individual attitudes toward wealth, resource allocation, and material success	100%

Table 6. Social Civilization Level

Tier-3 Indicators	Indicator Explanation	2035 Target Value
Social trust	Level of mutual trust between members of society	100%
Government integrity	Reflects the honesty and trustworthiness of government officials	100%
Social tolerance	Degree of acceptance and inclusivity towards cultural, religious, and social diversity	100%
Environmental satisfaction	Citizens' satisfaction with living conditions and ecological environment	100%
Physical health	Overall physical health status of the population, reflecting medical services and public health	95%
Confidence in the future	Measure of individual optimism and confidence about personal and societal future	100%

Table 7. Spiritual Life

Tier-3 Indicators	Indicator Explanation	2035 Target Value
Depression level	Measures psychological health and emotional well-being	<5%
Sense of gain	Reflects individuals' recognition of improvements in their material life	100%
Happiness level	Reflects overall satisfaction and emotional positivity in life	100%
Sense of security	Measures individuals' trust in safety and stability in their environment	100%
Life satisfaction	Reflects subjective evaluation of personal living standards and quality of life	100%
Job satisfaction	Reflects subjective evaluation of job income and work-life quality	100%

3.4. Research Subjects and Data Sources

This paper selects 11 provinces and cities along the Yangtze River Economic Belt as research subjects: Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Guizhou, and Yunnan. These regions are categorized into downstream (Shanghai, Jiangsu, Zhejiang, Anhui), midstream (Jiangxi, Hubei, Hunan), and upstream (Chongqing, Sichuan, Guizhou, Yunnan) areas. As of 2020, the Yangtze River Economic Belt accounted for approximately 606 million people, or 42.9% of the national population, and a GDP of about 47.08 trillion yuan, representing 46.83% of the national total. Given its significant national representation and notable economic and cultural diversity, the Yangtze River Economic Belt is an ideal region for studying the relationship between material foundations and spiritual civilization. Material civilization data are sourced from the National Bureau of Statistics, statistical bulletins, and local yearbooks, while spiritual civilization data come from the EPS platform, CFPS, and CSS surveys. These datasets comprehensively cover the Yangtze River Economic Belt, which is a key reason for selecting this region for analysis.

4. Introduction to Research Methods

4.1. Indicator Standardization Method

For each indicator in the evaluation system, data can be standardized using target values to convert them into the actual achievement level of the indicator. The achievement level should be calculated separately for positive, negative, and moderate indicators (Li & Yu, 2022). The specific formulas are as follows:

Formula for calculating positive indicators:

$$z_i = \begin{cases} \frac{x_i}{x_{il}}, & \text{if } \frac{x_i}{x_{il}} < 1 \\ 1, & \text{if } \frac{x_i}{x_{il}} \geq 1 \end{cases} \quad (1)$$

Formula for calculating negative indicators:

$$z_i = \begin{cases} \frac{x_{il}}{x_i}, & \text{if } \frac{x_{il}}{x_i} < 1 \\ 1, & \text{if } \frac{x_{il}}{x_i} \geq 1 \end{cases} \quad (2)$$

Formula for calculating interval indicators:

$$z_i = \begin{cases} 0, & \text{if } x_i \notin [m_1, m_2] \\ \left(-\frac{1}{(n_1 - m_1)^2} x_i^2 + \frac{2n_1}{(n_1 - m_1)} x_i + \frac{m_1^2 - 2n_1 m_1}{(n_1 - m_1)^2} \right), & \text{if } x_i \in [m_1, n_1] \\ 1, & \text{if } x_i \in [n_1, n_2] \\ \left(-\frac{1}{(m_2 - n_2)^2} x_i^2 + \frac{2n_2}{(m_2 - n_2)} x_i + \frac{m_2^2 - 2n_2 m_2}{(m_2 - n_2)^2} \right), & \text{if } x_i \in [n_2, m_2] \end{cases} \quad (3)$$

4.2. Method for Determining Indicator Weights -- Global Entropy Method

The entropy method is an objective approach for determining indicator weights. Since the traditional entropy method can only handle cross-sectional data, this paper employs the global entropy method, which is suitable for

panel data (Li & Zhang, 2021). Assume there are N individuals, M indicators, and T years of data. The global entropy method is used to calculate the weight of each indicator. The basic steps are as follows:

(1) Calculate the proportion of the value of the i-th sample under the j-th indicator (Z_{ij}) to the total value for that

indicator

$$p_{ijt} = \frac{z_{ijt}}{\sum_{t=1}^T \sum_{i=1}^N z_{ijt}}, i=1, \dots, N; j=1, \dots, M; t=1, \dots, T \quad (4)$$

(2) Calculate the Entropy Value for the j-th Indicator

$$e_j = -(1/\ln(NT)) \sum_{t=1}^T \sum_{i=1}^N p_{ijt} \ln(p_{ijt}), i=1, \dots, N; j=1, \dots, M; t=1, \dots, T \quad (5)$$

(3) Calculate the Information Redundancy for the j-th Indicator

$$d_j = 1 - e_j, j=1, \dots, M \quad (6)$$

(4) Calculate the Weight of the j-th Indicator

$$\omega_j = \frac{d_j}{\sum_{j=1}^M d_j}, j=1, \dots, M \quad (7)$$

(5) Calculate the Comprehensive Score for Each Individual

$$F_i = \sum_{j=1}^M \omega_j z_{ij}, i=1, \dots, N; j=1, \dots, M \quad (8)$$

4.3. Coupling Coordination Degree Measurement Method

For each province or city, we can calculate a comprehensive score for material civilization ($Score_1$) and a score for spiritual civilization ($Score_2$). Based on these scores, we can establish a coupling coordination degree model that measures the degree of coordination between material and spiritual civilization.

$$C = \frac{2\sqrt{S_1 \times S_2}}{S_1 + S_2} \quad (9)$$

$$T = \alpha \times S_1 + \beta \times S_2 \quad (10)$$

$$D = \sqrt{C \times T} \quad (11)$$

In this model, C represents the coupling degree between the material and spiritual civilization indices. A larger C value indicates closer development levels between the two, while a smaller value shows a greater gap. T is the comprehensive development index, calculated as the weighted average of both civilizations. D, the coupling coordination degree, reflects both coordination and development levels. Since material and spiritual civilizations are considered equally important, their weights α and β are both set to 0.5. The value of D ranges from 0 to 1, with values closer to 1 indicating higher coordination between the two.

4.4. Dagum Gini Coefficient and Its Decomposition

In this paper, the 11 provinces and cities of the Yangtze River Economic Belt are divided into upstream, midstream, and downstream regions. The downstream region includes Shanghai, Jiangsu, Zhejiang, and Anhui; the midstream region includes Jiangxi, Hubei, and Hunan; and the upstream region includes Chongqing, Sichuan, Guizhou, and Yunnan. In the grouping variable, the downstream, midstream, and upstream regions are represented by 1, 2, and 3, respectively. The Dagum Gini coefficient is used to calculate the overall disparity in civilization development G among the provinces of the Yangtze River Economic Belt, and it is then decomposed into three parts: within-group differences, between-group differences, and transvariation density (Dagum, 1997; Zhanget al., 2022). For brevity, refer to Zhanget al. (2022) for further details.

5. Calculation and Decomposition of the Coordinated Development Index for Material and Spiritual Civilization

5.1. Determining Target Values for Material and Spiritual Civilization by 2035

(1) Basic Principles for Determining Target Values

To ensure scientific, objective, and comparable evaluations of material and spiritual civilization development, target values must be defined. These can be set using: 1) International Standards, based on leading global indicators; 2) National Standards, derived from government policy goals (e.g., Five-Year Plans); 3) Empirical Indicators, adjusted to national conditions and experience, allowing flexibility beyond foreign standards.

(2) Specific Target Value Determination

For objective indicators, target values are determined based on the "14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035" and related domestic and international data. For instance, per capita GDP, as the core material civilization indicator, is estimated based on existing data and exchange rates. By 2035, the target is set at 150,000 yuan, approximately \$25,000 USD. For subjective indicators, they are categorized into two types: most are set at 100%, while certain indicators that cannot reach 100% (e.g., health, depression level) are set at 95% and 5%, respectively.

5.2. Calculation and Decomposition of the Material Civilization Index

Table 8. Material Civilization Index of the Yangtze River Economic Belt

Year	Shanghai	Jiangsu	Zhejiang	Anhui	Jiangxi	Hubei	Hunan	Chongqing	Sichuan	Guizhou	Yunnan
2013	0.6313	0.4774	0.4811	0.2817	0.1811	0.3288	0.2687	0.3028	0.2737	0.1298	0.1834
2014	0.6645	0.5094	0.5086	0.3093	0.1939	0.3582	0.2959	0.3264	0.3021	0.1371	0.2013
2015	0.7056	0.5522	0.5435	0.3519	0.2136	0.3913	0.3216	0.3724	0.3377	0.1492	0.2195
2016	0.7585	0.5949	0.5808	0.3841	0.2632	0.4172	0.3531	0.4131	0.3679	0.1635	0.2319
2017	0.8092	0.6360	0.6124	0.4172	0.3104	0.4501	0.3916	0.4510	0.3914	0.1797	0.2472
2018	0.8649	0.6761	0.6519	0.4482	0.3548	0.4851	0.4257	0.4831	0.4174	0.2074	0.2657
2019	0.8930	0.7198	0.6955	0.4959	0.4100	0.5308	0.4616	0.5203	0.4568	0.2248	0.2922
2020	0.8949	0.7645	0.7348	0.5434	0.4420	0.5495	0.4942	0.5442	0.4944	0.2214	0.3079
2021	0.9063	0.8302	0.8031	0.5927	0.4695	0.6016	0.5337	0.5813	0.5288	0.2373	0.3396
2022	0.8897	0.8805	0.8562	0.6248	0.4932	0.6313	0.5664	0.6050	0.5432	0.2420	0.3611

Table 8 shows an overall upward trend in the material civilization index across the Yangtze River Economic Belt, with regional disparities narrowing, reflecting improvements in economic development and living standards. Apart from slight declines in Guizhou and Shanghai in 2020 and 2022, all regions saw significant improvements. Jiangsu had the largest increase (0.4031), followed by Zhejiang and Anhui. In terms of growth rates, Jiangxi, Anhui, and Hunan grew by 172.36%, 121.80%, and 110.79%, respectively. By 2022, Shanghai had the highest index (0.8897). The Jiangsu-Zhejiang-Shanghai area forms the first tier, Anhui the second, and other provinces the third.

The Gini coefficient analysis in Table 9 shows that disparities in material civilization across the Yangtze River Economic Belt have steadily decreased, with the Gini coefficient dropping from 0.2434 in 2013 to 0.1804 in 2022, a 25.88% decline. Intra-regional disparities in the downstream and midstream areas have narrowed, while the upstream areas saw initial increases followed by fluctuations. The inter-regional gaps between downstream, midstream, and upstream regions have continued to shrink, though disparities between midstream and upstream regions have fluctuated. Overall, intra-regional disparities decreased, but inter-regional gaps widened.

Table 9. Decomposition of the Gini Coefficient for the Material Civilization Index

Year	Overall Gini Coefficient	1	2	3	1-2	1-3	2-3	Inter-group Gini Coefficient	Intra-group Gini Coefficient	Super variance Density
2013	0.2434	0.1406	0.1265	0.1712	0.2972	0.3594	0.1654	20.65%	72.52%	6.83%
2014	0.2374	0.1338	0.1292	0.1729	0.2862	0.3493	0.1686	20.76%	72.17%	7.06%
2015	0.2309	0.1242	0.1278	0.1825	0.2786	0.3356	0.1701	20.94%	71.19%	7.87%
2016	0.223	0.1226	0.0993	0.1881	0.2604	0.3309	0.1649	20.98%	71.97%	7.05%
2017	0.2149	0.1212	0.0809	0.1887	0.2395	0.3265	0.1621	21.06%	72.91%	6.03%
2018	0.2071	0.1207	0.0686	0.1781	0.226	0.3201	0.1566	20.90%	73.77%	5.33%
2019	0.195	0.1084	0.0574	0.1759	0.2049	0.3076	0.1545	20.51%	74.99%	4.50%
2020	0.1892	0.0922	0.0483	0.1842	0.1953	0.3041	0.1549	19.69%	76.91%	3.40%
2021	0.1843	0.0772	0.0549	0.181	0.1894	0.2999	0.1564	18.83%	77.67%	3.50%
2022	0.1804	0.063	0.0545	0.1815	0.1818	0.2998	0.159	17.82%	79.06%	3.12%

5.3. Measurement and Decomposition of the Spiritual Civilization Index

Table 10 shows a general rise in the Spiritual Civilization Index across the Yangtze River Economic Belt, reflecting greater emphasis on culture, morality, and social responsibility, though at a slower pace than material

civilization. Zhejiang saw the largest absolute increase (0.1889), while Hubei had the highest growth rate (56.77%). Shanghai, Jiangsu, and Zhejiang lead in the first tier (scores above 0.7), followed by Jiangxi, Hubei, and Hunan in the second tier (0.5 to 0.7), with the remaining provinces in the third tier (below 0.5). Spiritual civilization development has been slower overall, with notable progress only in Chongqing, Jiangxi, and Zhejiang from 2013 to 2016.

Table 10. Spiritual Civilization Index of the Yangtze River Economic Belt

Year	Shanghai	Jiangsu	Zhejiang	Anhui	Jiangxi	Hubei	Hunan	Chongqing	Sichuan	Guizhou	Yunnan
2013	0.7229	0.6268	0.5610	0.3509	0.3630	0.3314	0.4331	0.3791	0.3422	0.2683	0.3144
2014	0.7280	0.6422	0.5792	0.3555	0.3742	0.3498	0.4420	0.3773	0.3400	0.2742	0.3140
2015	0.7545	0.6680	0.6171	0.3657	0.3968	0.3693	0.4585	0.3957	0.3626	0.2905	0.3219
2016	0.7771	0.6900	0.6446	0.3779	0.4268	0.3960	0.4822	0.4160	0.3862	0.3241	0.3406
2017	0.8104	0.6912	0.6567	0.3937	0.4354	0.4262	0.4768	0.4237	0.4073	0.3518	0.3481
2018	0.7757	0.6919	0.6739	0.4080	0.4513	0.4894	0.4942	0.4663	0.4224	0.3690	0.3634
2019	0.8061	0.7276	0.7015	0.4148	0.4809	0.5128	0.5025	0.4717	0.4262	0.3689	0.3668
2020	0.8278	0.7471	0.7026	0.4309	0.4942	0.4964	0.5093	0.4808	0.4459	0.3696	0.3768
2021	0.8403	0.7884	0.7311	0.4609	0.5164	0.5099	0.5413	0.4882	0.4619	0.3928	0.3869
2022	0.8442	0.8079	0.7499	0.4888	0.5377	0.5195	0.5718	0.4939	0.4777	0.4050	0.3988

The Gini coefficient for spiritual civilization has steadily declined over the past decade, with a cumulative drop of 17.98% and an annual average decline of 1.96%. Within-region disparities have narrowed, indicating more balanced development. While between-region Gini coefficients have also decreased, showing reduced regional gaps, the

proportion of between-region differences has increased, suggesting that regional disparities persist despite shrinking internal differences. This highlight deepening cultural exchanges and a growing sense of regional civilization community.

Table 11. Decomposition of Spiritual Civilization Gini Coefficient

Year	Overall Gini Coefficient	1	2	3	1-2	1-3	2-3	Inter-group Gini Coefficient	Intra-group Gini Coefficient	Supervariance Density
2013	0.1713	0.1306	0.0601	0.0691	0.2181	0.2726	0.0888	19.74%	75.81%	4.45%
2014	0.1715	0.1280	0.0527	0.0642	0.2125	0.2799	0.0943	18.87%	77.63%	3.50%
2015	0.1702	0.1265	0.0485	0.0650	0.2124	0.2780	0.0931	18.71%	77.35%	3.93%
2016	0.1619	0.1248	0.0440	0.0548	0.2042	0.2644	0.0893	18.53%	76.40%	5.07%
2017	0.1546	0.1259	0.0252	0.0461	0.2012	0.2555	0.0765	18.10%	77.54%	4.36%
2018	0.1405	0.1099	0.0199	0.0559	0.1741	0.2313	0.0855	18.11%	75.00%	6.89%
2019	0.1477	0.1132	0.0142	0.0569	0.1772	0.2453	0.0996	17.42%	75.76%	6.82%
2020	0.1462	0.1140	0.0067	0.0602	0.1798	0.2437	0.089	17.63%	76.61%	5.75%
2021	0.144	0.1059	0.0133	0.0539	0.1739	0.2428	0.0944	16.82%	78.78%	4.40%
2022	0.1405	0.0972	0.0214	0.0504	0.1634	0.2396	0.1005	16.31%	80.25%	3.45%

5.4. Relative Priority of Civilization

To study the relative development of material and spiritual civilization, this paper adopts the method of Yuan et al. (2023) by defining the relative priority of civilization as $P=S_2/S_1$, where S_1 represents the material civilization index and S_2 represents the spiritual civilization index. A value of $P>1.1$ indicates that spiritual civilization is ahead, $0.9\leq P\leq 1.1$ suggests the two are progressing synchronously, and $P<0.9$ indicates that material civilization is leading. According to Table 12, combined with the results from Tables

8 and 10, in 2013, most provinces in the Yangtze River Economic Belt had significantly higher spiritual civilization relative to material civilization, particularly in Jiangxi and Guizhou, where PPP values reached 2. As material civilization developed, the PPP values gradually declined. By 2022, some regions saw material civilization surpass spiritual civilization, with spiritual development lagging behind. In contrast, Shanghai, Jiangsu, and Zhejiang maintained a relatively balanced development of both civilizations, while Anhui, Hubei, and Chongqing showed significant lagging in spiritual civilization.

Table 12. Relative Priority of Civilization

Year	Shanghai	Jiangsu	Zhejiang	Anhui	Jiangxi	Hubei	Hunan	Chongqing	Sichuan	Guizhou	Yunnan
2013	1.15	1.31	1.17	1.25	2.00	1.01	1.61	1.25	1.25	2.07	1.71
2014	1.10	1.26	1.14	1.15	1.93	0.98	1.49	1.16	1.13	2.00	1.56
2015	1.07	1.21	1.14	1.04	1.86	0.94	1.43	1.06	1.07	1.95	1.47
2016	1.02	1.16	1.11	0.98	1.62	0.95	1.37	1.01	1.05	1.98	1.47
2017	1.00	1.09	1.07	0.94	1.40	0.95	1.22	0.94	1.04	1.96	1.41
2018	0.90	1.02	1.03	0.91	1.27	1.01	1.16	0.97	1.01	1.78	1.37
2019	0.90	1.01	1.01	0.84	1.17	0.97	1.09	0.91	0.93	1.64	1.26
2020	0.92	0.98	0.96	0.79	1.12	0.90	1.03	0.88	0.90	1.67	1.22
2021	0.93	0.95	0.91	0.78	1.10	0.85	1.01	0.84	0.87	1.66	1.14
2022	0.95	0.92	0.88	0.78	1.09	0.82	1.01	0.82	0.88	1.67	1.10

5.5. Measurement and Decomposition of Coupling Coordination Degree

The coupling coordination model reflects the alignment between material and spiritual civilization. In 2017, Shanghai's indices were nearly equal, showing high coordination. By 2022, the gap widened, but the overall

development index increased, enhancing the coordination degree. Table 13 shows most regions experienced growth between 0.1 and 0.2, with Jiangxi growing the fastest at 41.72%, followed by Anhui and Hubei. By 2022, all provinces in the Yangtze River Economic Belt had reached coordinated development, with Shanghai, Jiangsu, and Zhejiang nearing "optimal coordination," while Yunnan and Guizhou remained at lower coordination levels.

Table 13. Coupling Coordination Degree of Material and Spiritual Civilization in Provinces of the Yangtze River Economic Belt

Year	Shanghai	Jiangsu	Zhejiang	Anhui	Jiangxi	Hubei	Hunan	Chongqing	Sichuan	Guizhou	Yunnan
2013	0.8219	0.7396	0.7208	0.5607	0.5063	0.5745	0.5841	0.5821	0.5532	0.4320	0.4900
2014	0.8340	0.7563	0.7367	0.5758	0.5190	0.5950	0.6013	0.5924	0.5661	0.4403	0.5014
2015	0.8542	0.7793	0.7610	0.5990	0.5396	0.6166	0.6197	0.6196	0.5915	0.4563	0.5156
2016	0.8762	0.8004	0.7822	0.6173	0.5789	0.6375	0.6424	0.6439	0.6139	0.4797	0.5301
2017	0.8999	0.8143	0.7963	0.6366	0.6063	0.6618	0.6573	0.6612	0.6319	0.5014	0.5416
2018	0.9050	0.8270	0.8141	0.6539	0.6326	0.6980	0.6773	0.6889	0.6480	0.5260	0.5574
2019	0.9211	0.8507	0.8357	0.6734	0.6664	0.7223	0.6940	0.7038	0.6643	0.5367	0.5721
2020	0.9277	0.8693	0.8477	0.6956	0.6836	0.7227	0.7083	0.7152	0.6852	0.5349	0.5836
2021	0.9342	0.8995	0.8754	0.7230	0.7017	0.7442	0.7331	0.7299	0.7030	0.5525	0.6021
2022	0.9309	0.9184	0.8951	0.7434	0.7176	0.7568	0.7544	0.7393	0.7137	0.5595	0.6160

The Gini coefficient for the coupling coordination degree has steadily decreased, dropping by 20.73% over ten years. As shown in Table 14, intra-regional Gini coefficients for downstream and midstream regions fell by 40.51% and 62.38%, indicating balanced development within these areas.

However, coordination in upstream regions remained unstable, reflecting challenges in achieving balanced growth. Overall, intra-regional disparities and hypervariability have shrunk, but inter-regional gaps have widened, indicating increasing differences between regions.

Table 14. Gini Coefficient Decomposition of Coupling Coordination Degree

Year	Overall Gini Coefficient	1	2	3	1-2	1-3	2-3	Inter-group Gini Coefficient	Intra-group Gini Coefficient	Supervariance Density
2013	0.1018	0.0706	0.0311	0.0624	0.1280	0.1625	0.0583	20.02%	74.85%	5.13%
2014	0.1010	0.0684	0.0320	0.0620	0.1244	0.1621	0.0609	19.83%	75.30%	4.87%
2015	0.0990	0.0655	0.0301	0.0648	0.1215	0.1586	0.0604	19.94%	74.93%	5.12%
2016	0.0949	0.0646	0.0228	0.0635	0.1131	0.1538	0.0596	19.93%	75.28%	4.79%
2017	0.0917	0.0642	0.0192	0.0609	0.1068	0.1502	0.0586	19.91%	75.95%	4.14%
2018	0.0871	0.0599	0.0217	0.0599	0.0966	0.1419	0.0613	20.21%	74.70%	5.09%
2019	0.0856	0.0578	0.0179	0.0599	0.0909	0.1423	0.0631	19.81%	76.20%	3.99%
2020	0.0842	0.0537	0.0123	0.0638	0.0889	0.1419	0.0613	19.47%	77.84%	2.69%
2021	0.0823	0.0479	0.0130	0.0612	0.0864	0.1409	0.0615	18.53%	79.64%	1.83%
2022	0.0807	0.0420	0.0117	0.0606	0.0824	0.1405	0.0639	17.57%	81.19%	1.24%

5.6. Kernel Density Estimation

This study uses kernel density estimation to explore the dynamic evolution of material and spiritual civilization and their coordinated development. The material civilization index shows steady growth, but with increasing polarization and some regions lagging. The spiritual civilization index exhibits a persistent bifurcation, with regional disparities remaining pronounced despite gradual improvements. The coupling coordination degree shows the most striking change, evolving from significant differences into multiple peaks, indicating a "tripolar" polarization trend. Overall, while indices have improved, regional disparities and polarization are becoming more evident.

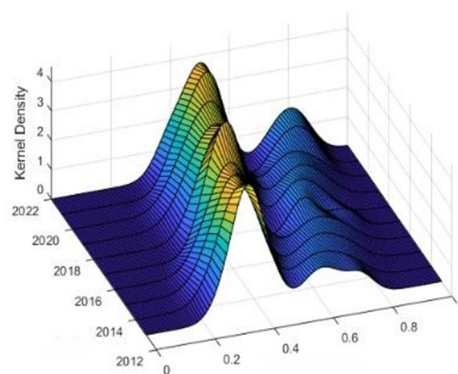


Figure 3. Kernel Density Estimation of Coupling Coordination Degree

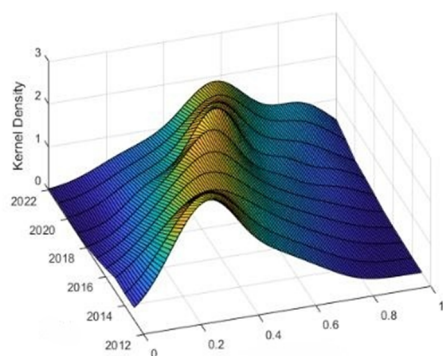


Figure 1. Kernel Density Estimation of Material Civilization Index

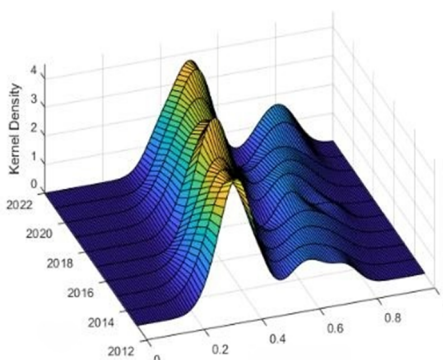


Figure 2. Kernel Density Estimation of Spiritual Civilization Index

6. Analysis of the Interaction Pathways Between Material and Spiritual Civilization

6.1. Path Analysis

This study uses a Structural Equation Model (SEM) to explore the causal relationships between variables like economic scale, people's livelihood, technological innovation, cultural life, values, social civilization, and spiritual life. After identifying the influence paths, SEM was applied to estimate the model parameters. Model fit was assessed using CFI, RMSEA, and SRMR, with results showing good fit: SRMR at 0.023, RMSEA at 0.089, and CFI at 0.994, with all path coefficients being significant.

The study found that technological innovation has the strongest impact on cultural life and values, promoting both material prosperity and shifts in societal values. Economic scale, values, and enriched cultural life further influence livelihoods, with spiritual life and cultural life contributing to social civilization. However, the impact of cultural life on values and social civilization is negative, likely due to certain cultural products conveying negative or superficial values.

6.2. Transition Path Analysis

This paper uses a Markov chain model to analyze the

transition paths and forecast the evolution of material civilization, spiritual civilization, and their coordination. Considering spatial spillover effects, the Moran's I index was calculated using a geographical adjacency matrix. The results

show a significantly positive Moran's I, indicating strong spatial correlation among provinces in the Yangtze River Economic Belt for material civilization, spiritual civilization, and their coordination.

Table 15. Evaluation Metrics and Standards for SEM Model Fit

Index	Meaning	Evaluation Standard	Result
CFI	Comparative Fit Index (CFI)	>0.8(Acceptable),>0.9(Good Fit),>0.95(Excellent Fit)	0.994
RMSEA	Root Mean Square Error of Approximation (RMSEA)	<0.1(Acceptable),<0.08(Good Fit),<0.05(Excellent Fit)	0.089
SRMR	Standardized Root Mean Square Residual (SRMR)	<0.1(Acceptable),<0.08(Good Fit),<0.05(Excellent Fit)	0.023
NC	Chi-Square to Degrees of Freedom Ratio (χ^2/df)	1<NC<3(Model is parsimonious),5<NC(Model requires revision)	1.859

Table 16. Global Moran's I for Coordinated Development of Material and Spiritual Civilization in the Yangtze River Economic Belt

Moran's I	2014	2016	2018	2020	2022
Material Civilization	0.5047***	0.5132***	0.5324***	0.5629***	0.5799***
Spiritual Civilization	0.5934***	0.5887***	0.5725***	0.5970***	0.6296***
Coupling Coordination	0.5462***	0.5538***	0.5554***	0.5790***	0.6026***

The results highlight the importance of spatial factors in the Markov chain model. Applying the spatial Markov chain model, weighted by the geographical adjacency matrix, reveals transition patterns of neighboring provinces' development. For material civilization, the traditional model shows strong stability, with a minimum probability of 0.6250

for remaining in the same state and a maximum of 1, indicating "status lock-in." The spatial model reveals spillover effects, with higher development levels showing stronger stability and varying transition probabilities depending on neighboring conditions.

Table 17. Markov Transition Probability Matrix of Material Civilization Development Level (S=5)

	Spatial Lag Type	t/t+1	State 1	State 2	State 3	State 4	State 5	N
Traditional Model	No Lag	State 1	0.6250	0.3750	0	0	0	8
		State 2	0	0.8333	0.1667	0	0	36
		State 3	0	0	0.8571	0.1429	0	35
		State 4	0	0	0	0.7692	0.2308	13
		State 5	0	0	0	0	1	7
Spatial	State 1	State 1	0	0	0	0	0	0
		State 2	0	0	0	0	0	0
		State 3	0	0	0	0	0	0
		State 4	0	0	0	0	0	0
		State 5	0	0	0	0	0	0
	State 2	State 1	0.6250	0.3750	0	0	0	8
		State 2	0	0.8519	0.1481	0	0	27
		State 3	0	0	1	0	0	11
		State 4	0	0	0	0	0	0
		State 5	0	0	0	0	0	0
	State 3	State 1	0	0	0	0	0	0
		State 2	0	0.7778	0.2222	0	0	9
		State 3	0	0	0.8095	0.1905	0	21
		State 4	0	0	0	0.8571	0.1429	7
		State 5	0	0	0	0	0	0
	State 4	State 1	0	0	0	0	0	0
		State 2	0	0	0	0	0	0
		State 3	0	0	0.6667	0.3333	0	3
		State 4	0	0	0	0.6667	0.3333	6
		State 5	0	0	0	0	1	6
	State 5	State 1	0	0	0	0	0	0
		State 2	0	0	0	0	0	0
		State 3	0	0	0	0	0	0
		State 4	0	0	0	0	0	0
		State 5	0	0	0	0	1	1

7. Conclusion and Suggestions

This paper analyzes data from 11 provinces in the Yangtze River Economic Belt (2013-2022), using the global entropy method to calculate material and spiritual civilization indices and their coupling coordination degree. Dagum's Gini coefficient and kernel density estimation assess regional differences, dynamic evolution, and transition paths. The results show steady growth in material civilization, with downstream regions outperforming and upstream regions lagging behind. Spiritual civilization has improved but at a slower rate, with some regions showing significant gaps. The coupling coordination degree between the two has increased, though disparities between upstream and other regions remain large, reflecting a "three-polar differentiation" trend. Technological innovation positively impacts both civilizations, while cultural life negatively affects value systems and social civilization, suggesting some modern cultural products may have adverse effects. Markov chain analysis indicates regional development stability, with a "status lock-in" effect and spatial spillover across regions.

Based on these findings, policy recommendations include increasing investment in technological innovation and promoting regional coordination, particularly narrowing the material gap between upstream and developed downstream regions. Industrial cooperation and infrastructure development should stimulate growth in the mid- and upstream Yangtze River areas. Simultaneously, spiritual civilization should be strengthened by addressing mental health and cultural education needs across regions and demographic groups, while correcting negative social trends. Ultimately, coordinated progress of material and spiritual civilization should be promoted at individual, community, and regional levels to enhance overall civilization across the Yangtze River Economic Belt.

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