

The Practice of Modern Service Industry Evaluation System: From the Perspective of Life Service Industry

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Abstract In the context of rapid globalization and technological innovation, this study introduces a novel evaluation standard system designed for the modern service industry. Utilizing the DPSIR (driving forces, pressures, states, impacts, responses) framework, this study categorizes pertinent characteristics to elucidate their roles within the service sector, enhancing understanding of the complex dynamics between environmental factors and human activities. Meanwhile, the application of the entropy weight method significantly reduces subjectivity, thereby improving the reliability and effectiveness of assessment outcomes by quantifying the informational contribution of various indicators. Furthermore, incorporating the technique for order preference by similarity to ideal solution (TOPSIS), analysis fosters a robust index system for assessing the developmental levels of China's life service industry. This study's innovative approach and its practical implications mark a significant leap in strategic decision-making and understanding of the modern service industry, offering a novel and adaptable tool for industry analysis.

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1 Introduction

Within the scholarly discourse on economics, the modern service sector is recognized as a fundamental element, critical for the functioning of modern economic systems, as evidenced by the work of researchers such as Refs [1–3]. From information technology services that drive innovation and efficiency to financial services that facilitate investment and ensure economic stability, the modern service industry is at the forefront of economic transformation. It also includes educational and health services, which play crucial roles in improving the quality of life and workforce productivity, further highlighting its critical position in sustaining economic vitality and social welfare^[4,5].

In essence, the modern service industry is a dynamic and integral component of the global economy, whose influence permeates various aspects of economic and social development^[6,7]. The continued evolution and expansion of this sector are imperative for meeting the challenges of the 21st century, making its study and understanding a priority for economic scholars and policymakers alike^[8,9]. Furthermore, the evolution and dynamism of the modern service industry are significantly influenced by self-organization theory and the principle of regional competitive advantage. This theoretical framework underscores the importance of internal mechanisms within the service sector that allow for spontaneous order and adaptation, facilitating innovation and efficiency in response to external market forces and competitive pressures^[10,11].

China's modern service industry vividly demonstrates the synergy of technological advancement and service diversification. The sector is increasingly marked by its integration of cross-domain services^[12–15]. The integration of advanced technology not only boosts service efficiency and delivery but also promotes cultural exchanges and innovations^[16,17]. This evolution signifies the pivotal role of the service industry in spurring economic and social progress in the contemporary era^[18,19]. Furthermore, the life service industry, a core component of the modern service sector, has seen rapid growth due to rising living standards and evolving consumer expectations. This industry, covering areas such as catering, accommodation, and cultural services, significantly enhances the quality of life and drives consumption upgrading^[20,21].

In the field of academic research on the development and assessment of modern services, the existing literature can be categorized into several areas. Each area explores the complexity and diversity of the industry from unique perspectives, enriching our understanding and enabling detailed analysis. One key focus is the classification and analysis of the internal structure of the modern service industry, essential for unveiling the sector's intricate relationships and developmental patterns^[22]. Another critical aspect is evaluating competitiveness and performance, pivotal for understanding the industry's economic impact globally^[23].

Building on this broad academic landscape, our study specifically hones in on the methodologies employed to evaluate development indicators within this sector. This more focused analysis is crucial as, despite the extensive promotion and development of modern service industries

in China, a comprehensive evaluation system for assessing their development level, including the life service industry, remains underdeveloped. We categorize the existing literature on this evaluation into three distinct methodologies^[23,24]. The first category of research methodology utilizes factor analysis or principal component analysis (PCA) to evaluate the development level of the modern service industry^[25,26]. This approach involves identifying underlying variables (factors or components) that explain the variance in a set of observed variables related to the industry's performance. This method is particularly useful for uncovering hidden patterns in the data, enabling researchers to identify key drivers of industry growth and areas requiring policy intervention or managerial focus.

The second category employs the linear weighting method as a means to evaluate the industry^[27,28]. This approach assigns weights to different indicators based on their perceived importance or contribution to the development level of the service industry. The sum of these weighted indicators provides a composite score that reflects the overall development status of the industry. The linear weighting method is straightforward, allowing for easy interpretation and comparison across different regions or time periods. However, the selection of indicators and the determination of their respective weights require careful consideration and justification to ensure the evaluation's relevance and accuracy. The third approach is the gray trend correlation method, which is used to analyze the development trend of the modern service industry and its correlation with various factors influencing growth^[29,30]. This method is particularly effective in dealing with uncertain, incomplete, or limited data, which is a common challenge in the dynamic and rapidly evolving service sector. By analyzing the trend and its correlation with different developmental factors, this method provides insights into potential future trajectories of the industry and the impact of various policies or market conditions.

The assessment of the development level of the modern service industry, particularly in China, has gained attention from various scholars, resulting in notable scholarly contributions and evaluations^[14,22,23,31]. Despite these efforts, the methodologies employed in these evaluations vary widely, often relying on traditional index systems. Moreover, there exists a significant gap in the literature regarding the measurement and evaluation of the development level of China's modern service industry specifically. To address this gap and build upon previous research, this study proposes a novel evaluation system aimed at assessing the development status of the living service industry across seven representative provinces in China^[12,17,32].

The evaluation system introduced in this paper leverages the DPSIR (driving forces, pressures, state, impact, response) framework for classifying relevant features into distinct levels, thereby elucidating their respective roles within the living service industry. This model facilitates a comprehensive understanding of the interactions between the environment and human activities, making it particularly suitable for analyzing the complex dynamics of the service industry. Following the classification of features, the entropy weighting method is employed to assign objective weights to these features. The entropy weighting method is advantageous as it reduces subjectivity in the weighting process, thereby enhancing the reliability and validity

of the evaluation results. This method calculates the weights based on the degree of dispersion or variability of each indicator, reflecting the information contribution of each indicator to the overall evaluation system. Finally, the study integrates the technique for order preference by similarity to ideal solution (TOPSIS) analysis method to construct a robust indicator system for measuring the development level of China's living service industry. TOPSIS is a multi-criteria decision-making method that ranks alternatives based on their geometric distance from an ideal solution, enabling the evaluation of each province's performance relative to the best possible outcome.

By applying this comprehensive evaluation system to data from the period 2005–2020, the study calculates an integrated score for the development level of the modern service industry in the selected provinces. This approach not only highlights the current state of the industry's development but also uncovers trends, disparities, and areas of potential improvement across different regions. The findings from this study contribute to both theoretical and practical knowledge by offering a detailed analysis of the development level and capacity of China's modern service industry. Furthermore, by providing a clear and systematic evaluation framework, this research serves as a valuable reference for policymakers, industry stakeholders, and academics interested in fostering the growth of the modern service industry in China.

The structure of this paper is outlined as follows: Section 2 presents the research framework and methodologies utilized in this study. Section 3 describes in detail the construction of the evaluation index system and data processing, which includes descriptions of data sources, data handling, and weight calculations. Section 4 provides an evaluation of the development level of modern service industries, focusing on the life services sector. Finally, in Section 5, we present conclusions and future prospects.

2 Methodology

2.1 The Framework

This study endeavors to amalgamate the DPSIR framework, entropy weight methodology, and the TOPSIS technique to formulate a contemporary, comprehensive index for the service industry, thereby bolstering decision-making and administrative processes. The methodology unfolds as follows: initially, data is meticulously gathered and preprocessed, sourced from established statistical office databases. These datasets are methodically categorized and nuanced in accordance with the DPSIR framework, accentuating their distinct contributions. Subsequently, in the second phase, the determination of weights takes place. This involves the integration of the entropy weight method with standardized procedures, allocating varied weights to each characteristic, thus facilitating a refined, scientific calibration within the evaluation framework. The third phase is dedicated to constructing the comprehensive index for the modern service industry. Here, the TOPSIS method is employed to compute both the optimal and least favorable solutions, alongside the Euclidean distance for each proposition, culminating in the final comprehensive index, denoted as the 'C value'. Lastly, the fourth stage encompasses analysis and

synthesis. By leveraging empirical findings, an in-depth examination and interpretation of the current service industry system is conducted, culminating in strategic policy recommendations aimed at fostering further growth and development. Meanwhile, the framework of this research can be seen in Figure 1.

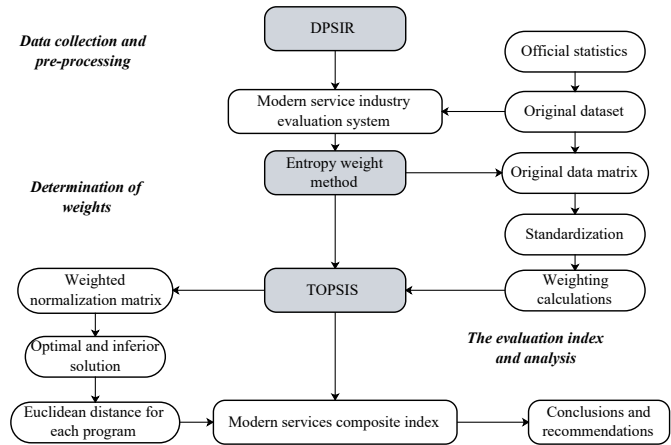


Figure 1 Research framework for evaluating modern service industries

2.2 DPSIR

The DPSIR (driving forces-pressures-state-impacts-responses) framework is a widely used model for assessment and management^[33]. Originating from systems analysis, it provides a structured approach to understand the complex interplay of various factors in systems^[34,35].

The DPSIR framework consists of five interconnected components:

- **Driving forces (D)**: Economic, societal, and environmental factors that initiate processes leading to target change.
- **Pressures (P)**: Direct mechanisms through which driving forces exert their influence on the target.
- **State (S)**: The condition of the target at a given time, resulting from both natural variability and pressures.
- **Impacts (I)**: The effects of target state changes on ecosystems, human health, and the economy.
- **Responses (R)**: Actions or strategies adopted to manage or mitigate the impacts on the target.

The interactions between these components are provided later in the context of the data. This model aids in identifying causal relationships and developing targeted environmental policies and strategies. The DPSIR framework’s adaptability makes it applicable across diverse environmental and sustainability contexts.

2.3 Entropy Weighting Method

The entropy weight method, rooted in the concept of information entropy, emerges as a pivotal quantitative tool for evaluating criteria in modern service industries. This method excels in scenarios involving multiple, possibly less correlated indicators, where it decides the weight of each indicator based on the amount of ‘information’ or ‘distinctiveness’ it contributes to the overall assessment^[36–38]. The methodology’s allure lies in its objectivity, flexibility, and universality, rendering it indispensable for comprehensive and unbiased evaluations.

Consider an evaluation matrix $\mathbf{X} = [x_{ij}]$ of dimensions $m \times n$ where m represents the number of entities under evaluation and n is the number of indicators. The element x_{ij} denotes the performance of the i -th entity on the j -th indicator.

1) Normalization process: Each indicator’s value is divided by the sum of all indicators’ values, ensuring that the data range between 0 and 1, making different indicators comparable. For positive indicators (higher is better):

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}}. \quad (1)$$

For negative indicators (lower is better):

$$r_{ij} = \frac{\sum_{i=1}^m x_{ij} - x_{ij}}{\sum_{i=1}^m x_{ij}}. \quad (2)$$

2) Entropy calculation for the j -th indicator e_j , a measure of the indicator’s diversity or variability. High entropy suggests less influence in distinguishing between different options, while low entropy indicates a significant role in the evaluation.

$$e_j = -\frac{1}{\ln(m)} \sum_{i=1}^m r_{ij} \ln(r_{ij}). \quad (3)$$

Note: $0 \ln 0$ is treated as 0.

3) Determination of entropy weights w_j . This assigns more weight to indicators with lower entropy, emphasizing their importance in the decision-making process.

$$w_j = \frac{1 - e_j}{\sum_{j=1}^n (1 - e_j)}. \quad (4)$$

The entropy weight method, as an effective tool for multi-criteria evaluation, holds a promising application scope in modern service industry evaluations. Its blend of objectivity and flexibility makes it an essential instrument in decision-making and analytical assessments.

While the DPSIR framework provides a systematic structure for analyzing complex socio-environmental interactions, it may oversimplify the dynamic and non-linear relationships among drivers, pressures, states, impacts, and responses. This simplification could lead to potential biases in interpreting the causality of observed phenomena. Similarly, the entropy weight method, despite its objectivity in determining indicator weights, is sensitive to the variability and distribution of input data. This sensitivity may influence the stability of the results, particularly

when dealing with datasets exhibiting significant variability. We acknowledge these limitations and have carefully interpreted the results within these methodological constraints to ensure the robustness of our conclusions.

2.4 TOPSIS

TOPSIS is an eminent multi-criteria decision-making method. Predicated on the concept that the optimal alternative should have the shortest geometric distance from the positive ideal solution (PIS) and the farthest from the negative ideal solution (NIS), TOPSIS stands out for its computational efficiency and clarity in ranking alternatives^[39–42].

Consider a decision matrix $\mathbf{X} = [x_{ij}]$ of dimensions $m \times n$, where m is the number of alternatives and n is the number of criteria. The decision matrix is normalized to form a matrix $\mathbf{R} = [r_{ij}]$ helping to standardize comparisons across different criteria.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}}. \quad (5)$$

Assign weights w_j to each criterion to form the weighted normalized decision matrix $\mathbf{V} = [v_{ij}]$ where

$$v_{ij} = w_j \cdot r_{ij}. \quad (6)$$

The positive $\mathbf{A}^+$ and negative $\mathbf{A}^-$ ideal solutions are identified as the best (positive ideal) and worst (negative ideal) possible outcomes for each criterion based on the weighted criteria, providing benchmarks for comparison.

$$A_j^+ = \max_i v_{ij}, A_j^- = \min_i v_{ij}. \quad (7)$$

for benefit criteria and

$$A_j^+ = \min_i v_{ij}, A_j^- = \max_i v_{ij}. \quad (8)$$

for cost criteria. The separation from the ideal solutions is calculated using the Euclidean distance:

$$S_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - A_j^+)^2}, S_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - A_j^-)^2}. \quad (9)$$

Finally, the relative closeness of each alternative to the ideal solution is determined by determining each alternative's proximity to the ideal solution, enabling a ranking of the options based on their overall desirability.

$$C_i^* = \frac{S_i^-}{S_i^+ + S_i^-}. \quad (10)$$

TOPSIS's ability to consider the best and worst possible outcomes provides a comprehensive framework for evaluating alternatives, making it a favored choice in various decision-making scenarios.

3 Evaluation Index System Construction and Data Processing

3.1 Data Sources and Standardized Processing

The original sample data were obtained by analyzing and organizing the relevant data from the statistical yearbooks of each province and the MARK data network. As the indicators have different connotations and properties and are not comparable with each other, the raw data were standardized and converted into pure dimensionless values to make the indicators comparable with each other, as indicated in Eq. (11).

$$X_{\min\max} = \frac{X - X_{\min}}{X_{\max} - X_{\min}}, \quad (11)$$

where $X_{\max}$ represents the maximum value in the sequence and $X_{\min}$ represents the minimum value in the sequence. X represents the data before normalization, and $X_{\min\max}$ represents the data after normalization.

This study selects seven emblematic economic regions across China, namely the Southern Coast, Eastern Coast, Northeast, Northwest, Southwest, the central reaches of the Yellow River, and the central reaches of the Yangtze River. From each of these zones, one city is chosen to represent the sample set. The ultimately selected provinces corresponding to these regions are Guangdong, Shanghai, Liaoning, Xinjiang, Chongqing, Henan, and Anhui, respectively.

3.2 Evaluation Index System Construction

The evaluation index system for assessing the development level of China's modern service industry is an intricate framework comprising numerous evaluative indicators. The influence of each indicator on the modern service industry is diverse, making the precise determination of each evaluative indicator paramount, as it directly impacts the accuracy of the evaluation outcomes.

This research categorizes the indicator system into three hierarchical levels, reflecting the essence of the modern service industry and the specific developmental circumstances of each province in China. These levels are arranged in descending order of abstraction: the objective level, the elemental level, and the indicator level. The target level is the highest level, i.e. the first-level indicator of the development level of modern service industry; the element level includes five types of second-level indicators, namely wellsprings of service innovation, forces of market competition, operational dynamics, socio-economic reverberations and blueprints for adaptation and ingenuity; and the third level is the indicator level, which contains 38 third-level indicators to comprehensively evaluate the development level of China's modern service industry, as delineated in Table 1.

In Table 1, integrated with the DPSIR model, we bestow upon the ensuing elements the distinction of secondary indicators, each endowed with its own unique implications. These interconnections are depicted in Figure 2. As follows:

1) Drivers: Wellsprings of service innovation, embodying the quintessential propellants such as technological breakthroughs and managerial ingenuity.

Table 1 Original feature list

Service Innovation sources (drivers)
Per capita consumption expenditure of urban residents
Retail sales of consumer goods
Total population
Number of industrial enterprises above scale
Number of students in general higher education institutions
Market competitive pressures (pressure)
Turnover of accommodation enterprises
Total profit of accommodation enterprises
Turnover of catering enterprises
Total profit of catering enterprises
Turnover of catering chain enterprises
Number of urban residents with minimum subsistence guarantee
Minimum subsistence guarantee for rural residents
Foreign exchange earnings from international tourism
Sulfur dioxide emissions
Volume of domestic garbage removal
Operational conditions (status)
Basic pension insurance fund revenue
Unemployment insurance fund
Revenue of urban employees' medical insurance fund
Income of workers' compensation insurance fund
Original insurance premium income
Value added of tertiary industry (billion)
Value added of transportation, warehousing and postal industry (billion)
Value added of wholesale and retail trade (billion)
Value added of financial industry (billion)
Value added of real estate industry (billion)
Value added index of tertiary industry (previous year=100)
Fixed assets output rate
Socio-economic effects (impact)
Number of employees in the accommodation sector
Number of employees in the catering industry
Total number of outlets of chain restaurant enterprises
Number of employees at the end of the year of chain restaurant enterprises
Number of social organization units
Adaptation and Innovation actions (response)
AW
AWAFA
AWITC
AWSRT

Notes: AW: Average wage of employed persons in urban units; AWAFA: Average wage of employed persons in urban units in agriculture, forestry, animal husbandry and fishery industries; AWITC: Average wage of employed persons in urban units in information transmission, computer services and software industry; AWSRT: Average wage of employed persons in urban units of scientific research, technical services and geological survey industry.

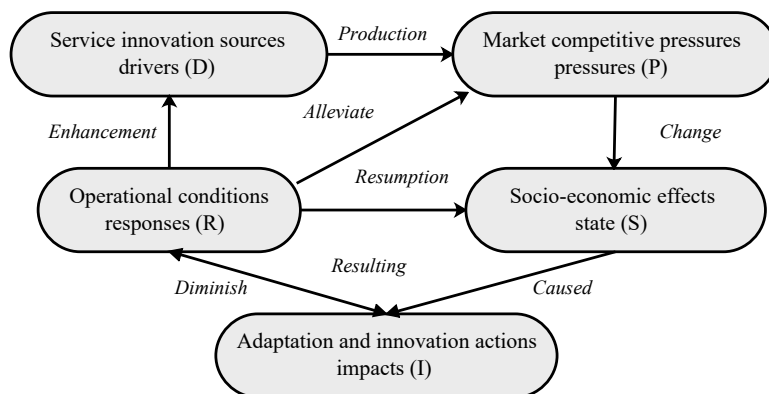


Figure 2 Dynamic framework of DPSIR model for modern service analysis (outlining how external pressures influence operational conditions and lead to strategic adaptations within the service industry)

2) Pressures: Forces of market competition, epitomizing the immediate repercussions of shifts in market demands and the intensity of industrial contestation within the service domain.

3) State: Operational dynamics, meticulously delineating the current operational ethos of the service industry, inclusive of the caliber of infrastructure and the proficiency in service dispensation.

4) Impacts: Socio-economic reverberations, vividly portray the extensive imprint of the service sector on economic proliferation and employment patterns.

5) Responses: Blueprints for adaptation and ingenuity, embracing the service industry's anticipatory maneuvers like policy metamorphosis, innovative service conceptualizations, and other forward-thinking stratagems.

3.3 Evaluation Index Weight

Weight signifies the relative significance of each indicator within the evaluation index system, and the judicious assignment of weights to each indicator is crucial for a methodical and scientific assessment. The methods of determining weights mainly include subjective assignment method (hierarchical analysis method, Delphi method) and objective assignment method (entropy value method, coefficient of variation method, etc.). And this paper adopts the entropy method to determine the weights of the evaluation indicators of China's modern service industry. Utilizing the entropy weighting method, we determine the individual weights of each dataset, alongside the aggregate weights, which are meticulously presented in Tables 2 and 3. The unique feature weights for each province are shown in Table 2; Table 3 represents the weights implied by all current datasets.

Analyzing the distribution of weights from the vantage point of the life service industry, it becomes apparent that 'foreign exchange income from international tourism' and 'turnover of catering chain enterprises' wield the most substantial influence on the modern service industry, with weights of 0.0545 and 0.0459, respectively. In contrast, the 'value added index of tertiary

Table 2 Feature weights for different provinces

Indicators	Guangdong	Shanghai	Liaoning	Xinjiang	Chongqing	Henan	Anhui
Per capita consumption expenditure of urban residents	0.0257	0.0271	0.0292	0.0295	0.0284	0.0243	0.0221
Sulfur dioxide emissions	0.0257	0.0221	0.0414	0.0285	0.0335	0.0341	0.0112
Retail sales of consumer goods	0.0278	0.0289	0.0294	0.0269	0.034	0.0301	0.0371
Volume of domestic garbage removal	0.0313	0.028	0.0277	0.0201	0.0371	0.0347	0.0356
Original insurance premium income	0.0328	0.0267	0.0312	0.0324	0.031	0.0316	0.0307
Main business cost	0.0249	0.0436	0.0238	0.0115	0.0078	0.0253	0.0326
Main business income	0.0198	0.0144	0.0238	0.0375	0.0405	0.0223	0.0229
Total population	0.0223	0.0187	0.0168	0.0225	0.0327	0.0157	0.0137
Fixed assets output rate	0.0172	0.0198	0.0106	0.0073	0.0123	0.0163	0.024
Value added of tertiary industry (billion)	0.0307	0.026	0.03	0.0336	0.0344	0.0343	0.0353
Value added of transportation, warehousing and postal industry (billion)	0.0246	0.0224	0.0259	0.043	0.0245	0.0311	0.026
Value added of wholesale and retail trade (billion)	0.0269	0.0253	0.0292	0.0275	0.0336	0.0331	0.0276
Value added of financial industry (billion)	0.0287	0.0334	0.0385	0.0304	0.038	0.036	0.0374
Value added of real estate industry (billion)	0.0376	0.0242	0.028	0.0295	0.0407	0.0324	0.0365
Value added index of tertiary industry (previous year=100)	0.0094	0.0122	0.0111	0.008	0.0093	0.0078	0.0069
Number of industrial enterprises above scale	0.029	0.0524	0.0377	0.0291	0.0164	0.0149	0.0146
Number of students enrolled in general higher education institutions	0.0184	0.0095	0.0164	0.026	0.0216	0.0195	0.0151
Number of employees in accommodation enterprises	0.0206	0.0347	0.0175	0.0459	0.0179	0.01	0.0158
Turnover of accommodation enterprises	0.0171	0.0299	0.0273	0.0227	0.0248	0.0191	0.0187
Total profit of accommodation enterprises	0.011	0.0102	0.014	0.0113	0.0171	0.0161	0.0134
Number of employees in catering industry	0.0208	0.0164	0.0319	0.0234	0.0116	0.0162	0.017
Turnover of catering enterprises	0.0237	0.0287	0.0156	0.031	0.0264	0.0157	0.0295
Total profit of catering enterprises	0.0171	0.0235	0.0146	0.0177	0.0352	0.0255	0.038
Total number of outlets of chain restaurant enterprises	0.031	0.0468	0.0373	0.0112	0.0173	0.0352	0.0332
Number of employees of catering chain enterprises at the end of the year	0.0248	0.0274	0.0339	0.0195	0.014	0.0192	0.0255
Turnover of catering chain enterprises	0.0377	0.0451	0.0231	0.0261	0.0203	0.0287	0.0371

Table 2 (Continued)

Indicators	Guangdong	Shanghai	Liaoning	Xinjiang	Chongqing	Henan	Anhui
Number of urban residents with minimum living standard guarantee	0.0224	0.0187	0.0327	0.0488	0.0177	0.0422	0.0306
Number of rural residents with minimum subsistence guarantee	0.0196	0.0138	0.0299	0.0123	0.0196	0.0343	0.0276
Number of social organization units	0.033	0.0302	0.0253	0.0199	0.0251	0.039	0.0264
Income of basic pension insurance fund	0.0392	0.0316	0.0324	0.0362	0.0345	0.0349	0.0357
Revenue of unemployment insurance fund	0.0346	0.0237	0.0216	0.0258	0.0235	0.0294	0.0242
Income of medical insurance fund for urban employees	0.0361	0.0407	0.0274	0.0265	0.0389	0.0322	0.034
Income of workers' compensation insurance fund	0.0205	0.0301	0.0266	0.0268	0.0291	0.0259	0.027
Foreign exchange income from international tourism	0.0209	0.0181	0.0238	0.0346	0.0339	0.0185	0.0316
AW	0.0301	0.0256	0.0275	0.0272	0.0297	0.0234	0.0229
AWAFA	0.0446	0.0206	0.0292	0.0314	0.0295	0.0331	0.0268
AWITC	0.0355	0.0283	0.0322	0.031	0.0324	0.0277	0.0292
AESRT	0.0269	0.0211	0.0253	0.0273	0.0261	0.0299	0.0266

industry' and 'fixed assets output rate' exert minimal impact on the development of the modern service industry, with weights of 0.0039 and 0.0017, respectively. Overall, within the realm of lifestyle services, sectors such as tourism, food and beverage, and accommodation play a pivotal role in influencing the overall evaluation system.

4 Evaluation of the Development Level of Modern Service Industry

Combining the weights of the features and the TOPSIS method, we obtain the comprehensive evaluation score of the modern service industry in each province (As shown in Table 4). At the same time, we visualize the results of the composite index, as shown in Figure 3.

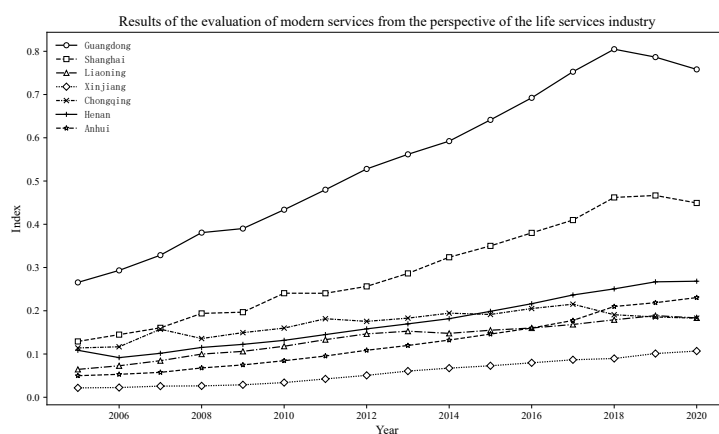
From an evolutionary perspective, between 2005 and 2020, China's service sector has demonstrated a consistent and steady upward trajectory. The data reflect in the 'C' value of Figure 3 reveal that among seven provinces (and cities), Guangdong leads in the development of its modern service industry, closely followed by Shanghai. Conversely, Xinjiang lags at the bottom, with Anhui and Liaoning trailing due to their relatively underdeveloped service sectors. This evidence conspicuously highlights the significant disparities in the development levels of the modern service industry across these seven provinces (and cities), with the coastal regions of the east markedly outpacing the central and western areas. A further analysis of the spatial pattern in the development of the provincial modern service industry from 2005 to 2020 shows no substantial change. The pattern consistently depicts a gradual decrease from the eastern coastal regions towards the central and western inland areas, mirroring the spatial distribution of China's overall economic development.

Table 3 Total feature weights of the dataset

Indicators	Weights
Foreign exchange income from international tourism	0.0545
Turnover of catering chain enterprises	0.0459
Number of employees of catering chain enterprises at the end of theyear	0.0435
Number of employees in accommodation enterprises	0.0433
Total number of outlets of chain restaurant enterprises	0.0433
Total profit of catering enterprises	0.0423
Value added of real estate industry (billion)	0.0412
Turnover of catering enterprises	0.0404
Value added of financial industry (billion)	0.0398
Turnover of accommodation enterprises	0.0396
Number of employees in catering industry	0.0355
Value added of wholesale and retail trade (billion)	0.0348
Original insurance premium income	0.0338
Value added of tertiary industry (billion)	0.0334
Income of medical insurance fund for urban employees	0.0307
Volume of domestic garbage removal	0.029
Number of industrial enterprises above scale	0.0287
Retail sales of consumer goods	0.0278
Total population	0.0278
Income of basic pension insurance fund	0.0273
Number of social organization units	0.0256
Income of workers' compensation insurance fund	0.0242
Revenue of unemployment insurance fund	0.0227
AWAFA	0.0215
Value added of transportation, warehousing and postal services (billion)	0.0214
AWITC	0.0214
AWSRT	0.0202
AW	0.0195
Number of students in general tertiary schools	0.0186
Per capita consumption expenditure of urban residents	0.0178
Total profit of accommodation enterprises	0.0147
Number of urban residents with minimum living standard guarantee	0.0092
Number of rural residents with minimum subsistence guarantee	0.0083
Sulfur dioxide emissions	0.0067
Value added index of tertiary industry (previous year=100)	0.0039
Fixed assets output rate	0.0017

Table 4 Comprehensive evaluation score of the modern service industry in each province

Year	Guangdong	Shanghai	Liaoning	Xinjiang	Chongqing	Henan	Anhui
2005	0.26556	0.12908	0.064459	0.021675	0.114031	0.108608	0.04986
2006	0.293364	0.144843	0.072798	0.022485	0.116716	0.091663	0.053037
2007	0.328546	0.160557	0.084565	0.025798	0.15734	0.101605	0.057604
2008	0.380692	0.193915	0.099846	0.026291	0.135763	0.115205	0.067771
2009	0.39008	0.196751	0.106137	0.028818	0.149453	0.122315	0.074801
2010	0.43367	0.240618	0.117965	0.033973	0.159918	0.131593	0.084531
2011	0.479925	0.24045	0.13323	0.042397	0.181573	0.144963	0.095385
2012	0.527934	0.256393	0.146555	0.050642	0.175497	0.15813	0.108685
2013	0.561753	0.286409	0.152772	0.060546	0.182979	0.169702	0.119728
2014	0.592258	0.323761	0.147783	0.067354	0.194462	0.181673	0.132267
2015	0.641411	0.350012	0.154988	0.072798	0.191492	0.198694	0.146074
2016	0.6924	0.380094	0.16013	0.079665	0.205168	0.216305	0.160063
2017	0.752742	0.409754	0.168298	0.086665	0.215232	0.23652	0.177644
2018	0.804822	0.46208	0.179148	0.089669	0.190845	0.250619	0.209892
2019	0.786536	0.466624	0.188713	0.101069	0.185593	0.266901	0.218685
2020	0.75815	0.44926	0.183468	0.106871	0.182905	0.268337	0.230477

**Figure 3** Trend analysis of modern services development index by province

The reason for such a development pattern is that since the initiation of reform and opening-up policies, the eastern regions of China have predominantly embarked on the development of basic raw materials, energy, and light industrial production. This not only results in a substantial economic output but also the fastest growth in the service sector. In the course of economic development, these eastern areas have focused on adjusting urban industrial structures to spur the rapid advancement of services. Consequently, there has been a decline in the business scale and proportion of industries like transportation, postal and telecommunications services, and wholesale and retail trade. In contrast, the shares of knowledge and technology-intensive

sectors such as scientific research, computer software, cultural entertainment, and education have continuously risen. Coastal regions, with their higher levels of economic development and openness to the outside world, coupled with dense populations and advanced technology, exert a strong attraction for talent, thus fostering the progress and evolution of the modern service industry. Inland areas, however, lack these inherent advantages. Furthermore, the disparate economic policies adopted by various regions, based on their own developmental foundations, resource endowments, and industrial structures, have led to uneven levels of service industry development across the country.

Observing from the time dimension, the inflection point of the development level of modern service industry in 7 provinces (cities) occurred before the outbreak of the epidemic in 2019. Analyzing the results of the weights obtained by the entropy weighting method, it is known that the hotel and accommodation industry had a downward trend in turnover before the outbreak of the epidemic. The reason is: on the one hand, affected by the national policy of limiting the consumption of “three publics” and the “eight provisions of the central government”, the consumption demand for luxury hotels represented by five-star hotels is shrinking rapidly, and at the same time, due to the high operation cost and the peak of real estate investment, the development speed of luxury hotels is decreasing. Chain hotels as a representative of the economic hotel in the peak of high-speed growth, due to serious homogenization and oversupply, have long entered the reshuffle stage.

Secondly, since 2020, due to the fluctuation of the epidemic and the impact of prevention and control policies, the movement of people in China has been restricted, and the performance of the tourism and hotel markets has further declined, which in turn has caused the level of development of China’s modern service industry to decrease and stagnate. During the epidemic, due to the outbreak of the epidemic, each province’s modern service industry development level has been affected to varying degrees, as can be seen from the figure, the more developed cities in the eastern coastal region are more affected by the epidemic, and even the situation of the modern service industry development level decreased. The service industry is the most directly impacted by the epidemic in the field, due to the eastern region of the north-south spanning a large, and intensive, high population density, the severity of the epidemic and the probability of occurrence of the epidemic is generally higher than that of the central and western regions, which is one of the main reasons that led to China’s eastern region affected by the epidemic is greater.

In the system of indicators constructed, there are also many indicators that are not directly related to the life services sector, such as those related to insurance and real estate, because they are related to infrastructure development. The government’s support for the development of the modern service industry is primarily manifested in the state of infrastructure development. The quality of infrastructure significantly impacts the scale and efficiency of social production. Due to the non-tradable nature of service products, the service industry demands high-quality infrastructure, resulting in a substantial dependency on it. Regions with superior infrastructure are

more likely to attract capital inflows and have the advantage of reducing costs due to efficient productive infrastructure. Thus, for any region, a robust infrastructure is a crucial pillar for the growth of the service industry. It not only creates an attractive external environment for the industry's development but also reduces transaction costs. However, in China, particularly in the less economically developed central and western regions, infrastructure remains relatively underdeveloped. Consequently, inadequate government investment in infrastructure construction has led to insufficient supply and improper allocation of infrastructure. This issue is one of the significant obstacles impeding the development of China's modern service industry.

It is worth mentioning that in the life service industry, there are few corresponding education and training industries or enterprises in China, and the relevant talents rely on the service units to train themselves. Therefore, the lag in China's educational and skill training programs has resulted in an insufficient accumulation of human capital, leading to a mismatch in quantity, quality, and structure of talent in accordance with the developmental needs of the modern service industry. This has led to a scarcity of high-quality professionals in the service sector. Particularly for the modern service industry, high-quality specialized professionals are crucial for propelling its industrial growth. Consequently, the current state of human capital supply in China has led to a shortage of high-quality practitioners in the modern service industry. This shortage undermines the driving force necessary for the development of the industry, consequently restricting the overall advancement level of the modern service industry.

5 Conclusions and Policy Recommendations

This research evaluates and analyzes the development level of China's modern service industry and the development level of China's modern service industry in each region respectively, which has the following research significance: First, understanding regional disparities: The research contributes to the understanding of regional disparities in China's economic development, particularly in the modern service industry. Second, evolution of service industry: The study provides insights into the evolving nature of the service industry in China, reflecting the shift from traditional to knowledge and technology-intensive services. Third, impact of policies and pandemics: The research sheds light on how national policies and global events like pandemics can significantly impact economic sectors, offering a basis for future policy formulation in similar scenarios.

Taking into account the findings of this research, we offer the following policy recommendations: First, regional development strategy: Formulate and implement targeted economic policies for underdeveloped regions, focusing on infrastructure development and human capital accumulation. Second, infrastructure investment: Increase government investment in infrastructure, especially in the central and western regions, to create a conducive environment for the growth of the service industry. This includes improving transportation, telecommunications, and technological infrastructures. Third, human capital development: Strengthen educational and vocational training programs tailored to the needs of the modern service industry. Fourth,

innovation and technology adoption: Encourage innovation and the adoption of new technologies in the service sector. Support research and development in areas such as digital services, e-commerce, and artificial intelligence to foster modern service industry growth. Finally, pandemic recovery measures: Implement targeted measures to support the recovery of the service industry post-pandemic, with particular attention to the most affected sectors like tourism, hotels, and accommodation.

Despite the fact that this research has made a contribution to the evaluation system of the modern service industry, there are still some shortcomings in this research: First, limited regional focus: The study focuses on seven provinces and cities, which may not fully represent the diverse economic landscapes across all of China. Second, dynamic economic changes: The rapidly changing global and domestic economic environment, including technological advancements and international trade dynamics, might limit the applicability of the findings over time. Third, impact of external factors: Factors like international trade tensions, global economic fluctuations, and unforeseen events like pandemics can rapidly alter the service industry landscape, posing a challenge to the stability and relevance of the findings. Finally, data constraints: Availability and accuracy of data might pose limitations, especially in rapidly changing sectors or less developed regions.

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