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Research on the comprehensive evaluation of economic development in Henan Province

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Abstract. Against the backdrop of the in-depth advancement of regional coordinated development and the strategy of accelerating the rise of Central China, high-quality economic development has become a core issue for Henan Province to overcome traditional growth constraints and achieve transformation and upgrading. From the perspective of multidimensional factors, this study constructs a comprehensive evaluation indicator system from four dimensions: overall economic scale, economic structure, economic efficiency, and economic growth momentum. The comprehensive index method is employed to evaluate the overall development level of Henan Province from 2019 to 2023. The results indicate that the comprehensive economic development level of Henan Province has shown a steady upward trend overall; however, prominent issues remain, including lagging structural optimization, unstable growth drivers, and insufficient efficiency transformation. Among the four dimensions, overall economic scale makes the greatest contribution, while the economic growth momentum dimension exhibits the largest fluctuations. Accordingly, targeted optimization pathways are proposed from four aspects: consolidating economic scale, upgrading economic structure, improving economic efficiency, and strengthening growth momentum. This study provides theoretical references and practical insights for promoting high-quality economic development in Henan Province and other comparable provinces in Central China.

Keywords: economic development, comprehensive evaluation, comprehensive evaluation index

1. Introduction

China's economy has transitioned from a stage of rapid growth to one of high-quality development. As a key component of the national strategy for coordinated regional development, the quality of economic development in Central China not only concerns internal regional balance but also affects the overall progress of high-quality national development. As the province with the largest economic aggregate in Central China, Henan Province has long faced the structural dilemma of being "large in size but relatively weak in strength", making it imperative to shift its economic development model from scale expansion toward quality and efficiency improvement. Since 2019, Henan Province's economic development has undergone multiple stages, including the adjustment period brought about by the transformation and upgrading of traditional industries, the impact period of the COVID-19 pandemic, and the recovery and revitalization period following the pandemic. Under the combined influence of various factors, economic development has exhibited complex

and changing stage-specific characteristics. Existing studies on regional economic development have mainly focused on single dimensions, while systematic research on the synergistic driving effects of multidimensional factors remains relatively insufficient. Against this background, a systematic examination of the comprehensive level and evolutionary patterns of Henan Province's economic development from a multidimensional perspective is of significant theoretical and practical value.

Domestic scholars have accumulated substantial research achievements in the field of regional economic development evaluation. Wang Yening et al. constructed an evaluation indicator system for high-quality development in Henan Province from five dimensions: innovation, coordination, green development, openness, and sharing. Their findings revealed that the level of high-quality development in Henan Province exhibited a radiation pattern centered on Zhengzhou City [1]. This multidimensional evaluation approach provides important insights for the present study. Ren Hua applied the entropy weight–TOPSIS model to measure the high-quality development level of 18 cities in Henan Province and found that open development, innovation-driven development, and green development constituted the major bottlenecks [2]. This study revealed the internal imbalance in Henan Province's development. Ma Chengwen and Ma Guanghai established an evaluation indicator system for high-quality regional economic development and comprehensively applied the analytic hierarchy process and principal component analysis to evaluate the level of high-quality economic development in different regions of China. They found that regional disparities were significant and exhibited a decreasing pattern from eastern to central and western regions [3]. These studies provide methodological references for the present research; however, previous studies have paid insufficient attention to the dimension of "economic growth momentum", which reflects development stability, and have mainly focused on horizontal comparisons among prefecture-level cities, with relatively limited systematic analysis of longitudinal provincial-level development patterns.

Research by foreign scholars on regional economic development evaluation began earlier, with its core focus gradually shifting from simply examining economic aggregate growth to multidimensional assessments of development quality, stability, and sustainability. The neoclassical growth theory proposed by Solow identified capital accumulation, labor input, and technological progress as the three major sources of economic growth [4], providing a direct theoretical foundation for evaluating overall economic scale. The endogenous growth theory developed by Romer further incorporated endogenous factors such as technology and human capital into growth models, explaining the underlying causes of growth disparities among regions [5]. These classical theories collectively provide the theoretical foundation for constructing the indicator system in this study.

A review of domestic and international studies shows that comprehensive evaluations of regional economic development have achieved considerable progress in terms of methodology and evaluation dimensions. Nevertheless, two major limitations remain. First, insufficient attention has been paid to the dimension of "economic growth momentum", which reflects the stability of development. Second, longitudinal analyses of the temporal evolution of Henan Province's provincial-level economic development are relatively scarce. To address these gaps, this study constructs a four-dimensional framework of "scale–structure–efficiency–growth" and focuses on the temporal changes in Henan Province from 2019 to 2023, aiming to provide a more comprehensive understanding of its economic development trajectory.

This study consists of five main aspects. First, it reviews theories related to regional economic growth, industrial structure optimization, and sustainable development, and defines the core concepts of the research. Second, it constructs a comprehensive evaluation indicator system for Henan Province's economic development, consisting of four primary dimensions and 11 secondary indicators. Third, the Analytic Hierarchy Process (AHP), range standardization method, and weighted index method are employed to conduct

a comprehensive measurement and evaluation of the dynamic changes in Henan Province's economic development from 2019 to 2023. Fourth, based on the comprehensive evaluation results, the study identifies existing weaknesses and constraints affecting Henan's economic development. Fifth, targeted policy recommendations are proposed to optimize economic development, while the limitations of the study are also discussed.

This study constructs a comprehensive evaluation indicator system from four dimensions: overall economic scale, economic structure, economic efficiency, and economic growth momentum, thereby overcoming the limitations of evaluations based on single or limited indicators. It provides a four-dimensional analytical framework of "scale–structure–efficiency–growth" for comprehensive regional economic development evaluation. Meanwhile, the application of the Analytic Hierarchy Process (AHP), which combines subjective expert judgment with quantitative mathematical constraints, enriches the methodological framework for regional economic evaluation.

2. Multi-perspective analysis of the current economic development status of Henan Province

2.1. The diversification of economic development

2.1.1. Theoretical explanation

Traditional perceptions often equate economic development simply with an increase in GDP. However, modern regional economic theories argue that the two concepts are fundamentally different. Economic growth only reflects the expansion of economic scale, whereas economic development is a multidimensional and comprehensive process encompassing economic scale, industrial structure, input-output efficiency, and growth stability. This distinction also provides the theoretical foundation for constructing the four-dimensional evaluation system adopted in this study. The core theoretical support can be summarized into three categories:

First, regional economic growth theory. This theory provides the fundamental logic for explaining the driving forces of economic development. Neoclassical growth theory and endogenous growth theory together constitute the theoretical basis for selecting indicators related to the dimensions of overall economic scale and economic efficiency.

Second, industrial structure optimization theory. Liu Wei and Zhang Hui demonstrated that changes in industrial structure are closely related to economic growth. As the level of economic development improves, labor and output gradually shift from low-productivity sectors to high-productivity sectors, and industrial restructuring has made a significant contribution to economic growth [6]. Based on this theory, this study selects three indicators in the economic structure dimension: the proportion of the tertiary industry, the proportion of tertiary industry investment, and the proportion of tertiary industry employment, thereby reflecting the process of industrial structure optimization from the perspectives of output value, capital allocation, and employment.

Third, sustainable development theory. Sustainable development theory emphasizes the importance of improving resource utilization efficiency and maintaining ecological sustainability while pursuing economic growth [7]. The establishment of the economic efficiency dimension in this study directly responds to the requirement of this concept to "effectively utilize resources and improve output efficiency".

2.1.2. Research methods

This study adopts three quantitative evaluation tools to support subsequent empirical analysis:

First, the subjective weighting method. This method determines the relative importance of evaluation factors and assigns weights based on research objectives, economic theories, and existing literature. Traditional subjective weighting methods rely heavily on personal judgment and lack mathematical support. In contrast, the Analytic Hierarchy Process (AHP), as an improved and standardized subjective weighting method, retains the advantage of incorporating expert knowledge while reducing subjective bias through judgment matrices and consistency tests. It has become one of the most widely used weighting methods in comprehensive regional economic evaluation [8].

Second, the Analytic Hierarchy Process (AHP). AHP decomposes a complex evaluation system into a three-level structure consisting of the target layer, criterion layer, and indicator layer. The overall evaluation objective is first divided into several criterion dimensions and then further refined into specific quantitative indicators. The relative importance of factors within the same level is compared pairwise and quantified to construct a judgment matrix. The weights of indicators are calculated using the eigenvector method, while consistency tests are conducted to eliminate logically inconsistent judgments [9]. The final weights of all indicators are obtained by multiplying the weights of higher-level criteria by those of lower-level indicators.

Third, the weighted index method. After eliminating differences in measurement units through indicator normalization, this method uses the subjective weights optimized by AHP as coefficients and calculates the weighted sum of standardized indicator values to generate a single comprehensive index. This enables horizontal comparisons across different years and serves as the key model connecting indicator weighting with comprehensive evaluation results.

2.1.3. Construction of the multidimensional economic evaluation indicator system

(1) Principles of indicator selection: First, the principle of scientific validity. All indicators correspond to the three economic theories discussed above. Indicators related to economic scale, structure, efficiency, and growth rate are mutually complementary rather than overlapping, enabling an objective reflection of the multidimensional nature of economic development. Second, the principle of systematicity. The four dimensions complement each other and comprehensively cover the core elements of regional economic development. Third, the principle of operability. All indicators are derived from officially published statistical data, with consistent statistical standards and complete data availability throughout the five-year period from 2019 to 2023.

(2) Four-dimensional indicator framework: This study takes Henan Province as the research sample and selects five years of panel data from 2019 to 2023. The time span covers the transition into a new development stage, the post-pandemic recovery period, and the critical period of economic transformation, allowing a comprehensive reflection of the dynamic changes in Henan Province's economic development from a multidimensional perspective. The sample period is appropriate for conducting longitudinal analysis. Based on four major dimensions, 11 specific indicators are selected to construct a comprehensive evaluation system:

First, the overall economic scale dimension: This dimension reflects the foundation of regional economic volume. The selected indicators include total GDP, total fixed asset investment, and total labor force size (year-end employment).

Second, the economic structure dimension: This dimension reflects the level of industrial structure optimization. The selected indicators include the proportion of the tertiary industry, the proportion of tertiary industry investment, and the proportion of tertiary industry employment.

Third, the economic efficiency dimension: This dimension reflects economic output efficiency. The selected indicators include labor productivity and investment-output ratio.

Fourth, the economic growth momentum dimension: This dimension reflects growth stability and resilience. The selected indicators include GDP growth rate, fixed asset investment growth rate, and labor

employment growth rate.

Total GDP represents Henan Province's annual gross regional product and reflects the overall economic scale. Total fixed asset investment represents the scale of capital input, while the total labor force size (year-end employment) reflects the foundation of population and employment factors. Together, these three indicators constitute the core support of the overall economic scale dimension. Within the economic structure dimension, the proportion of the tertiary industry, tertiary industry investment, and tertiary industry employment respectively measure the degree of industrial structure optimization from the perspectives of industrial output, capital allocation, and employment structure. Within the economic efficiency dimension, labor productivity reflects output efficiency per unit of labor, while the investment-output ratio represents the conversion efficiency of fixed asset investment. Together, these indicators characterize the quality and efficiency of economic development. Within the economic growth momentum dimension, GDP growth rate, fixed asset investment growth rate, and labor employment growth rate respectively reflect the annual growth trends of economic output, capital input, and the labor market, thereby capturing the stability and resilience of regional economic development. All indicators are based on official annual statistical data from Henan Province, covering the period from 2019 to 2023. The statistical standards remain consistent, with no changes in statistical definitions or measurement methods.

2.2. Dimensions of economic development in Henan Province

The original data used in this study are derived from the *Henan Statistical Yearbook (2020–2024)*, the *Statistical Communiqués on National Economic and Social Development of Henan Province (2019–2023)*, and the official website of the Henan Provincial Bureau of Statistics (http://tjj.henan.gov.cn/). All data are authoritative publicly available statistics, ensuring the authenticity and reliability of the empirical analysis. The research period covers 2019–2023, representing a complete recent stage of Henan Province's economic development and reflecting its latest dynamic changes.

2.2.1. Overall economic scale

The aggregate indicators in Table 1 clearly demonstrate the changing characteristics of Henan Province's economic scale from 2019 to 2023. Total GDP continued to increase from 2019 to 2022, rising from 537.17 billion yuan to a five-year peak of 613.45 billion yuan. In 2023, GDP declined to 591.32 billion yuan. Overall, the economic foundation continued to expand, although the output scale experienced a contraction in 2023. Fixed asset investment showed a trend of "initial decline followed by recovery". Affected by the COVID-19 pandemic, it fell to a low point of 468.53 billion yuan in 2020. From 2021 to 2023, it recovered steadily for three consecutive years, indicating that capital investment continued to provide support for regional economic development. The total labor force declined continuously from 2019 to 2022, decreasing from 49.34 million persons to 47.82 million persons, indicating a sustained contraction in labor supply. Although it slightly recovered to 48.28 million persons in 2023, the total employment population remained below the initial level of the research period. The decline in labor force size represents a prominent weakness in Henan Province's economic scale development.

Table 1. Comprehensive evaluation indicator system for economic development in Henan Province

Primary Dimension	Secondary Indicator	Unit	2019	2020	2021	2022	2023
Overall Economic Scale	Total GDP	Billion yuan	53,717	54,997	58,887	61,345	59,132
	Total Fixed Asset Investment	Billion yuan	47,920	46,853	48,116	49,275	50,892
	Total Labor Force (Year-end Employment)	Ten thousand persons	4,934	4,884	4,840	4,782	4,828
Economic Structure	Proportion of Tertiary Industry	%	48.0	48.7	49.1	49.0	52.3
	Proportion of Tertiary Industry Investment	%	51.3	52.0	52.7	53.5	54.2
	Proportion of Tertiary Industry Employment	%	36.0	45.2	45.9	44.0	45.4
Economic Efficiency	Labor Productivity	Ten thousand yuan/person	10.89	11.26	12.17	12.83	12.25
	Investment Output Ratio	—	1.12	1.17	1.22	1.25	1.16
Economic Growth Momentum	GDP Growth Rate	%	6.8	1.3	6.3	3.1	4.1
	Fixed Asset Investment Growth Rate	%	8.0	4.3	2.7	2.4	3.3
	Labor Employment Growth Rate	%	0.6	-0.3	0.8	0.4	0.7

2.2.2. Economic structure

Based on the three indicators related to the tertiary industry in Table 1, the optimization process of Henan Province's industrial structure exhibits differentiated characteristics. The proportion of tertiary industry output value generally showed an upward trend, increasing from 48.0% in 2019 to 49.1% in 2021. Although it slightly declined by 0.1 percentage points to 49.0% in 2022, it increased significantly to 52.3% in 2023. The service sector's share exceeded half of the total economic output, indicating remarkable progress in optimizing the industrial output structure. The proportion of tertiary industry investment increased continuously year by year, rising steadily from 51.3% to 54.2%. This indicates that social capital has increasingly shifted toward the service sector and that the investment structure has continued to improve. The proportion of tertiary industry employment experienced relatively large fluctuations. It was only 36.0% in 2019, then rose sharply to 45.2% in 2020, increased slightly to 45.9% in 2021, declined to 44.0% in 2022, and recovered to 45.4% in 2023. The transfer of labor toward the service sector experienced periodic fluctuations, indicating insufficient stability in the employment structure.

2.2.3. Economic efficiency

The two efficiency indicators, labor productivity and investment output ratio, both exhibited a trend of initially increasing and then decreasing over the five-year period. Labor productivity continued to rise from 2019 to 2022, increasing from 108,900 yuan/person to a peak of 128,300 yuan/person. Industrial upgrading and technological diffusion contributed to continuous improvements in output efficiency per unit of labor. However, it declined to 122,500 yuan/person in 2023, indicating a temporary decrease in labor utilization efficiency. The investment output ratio increased steadily from 2019 to 2022, rising from 1.12 to 1.25. This indicates that the economic output generated by each unit of fixed asset investment continued to increase and capital utilization efficiency improved. However, the ratio declined to 1.16 in 2023, suggesting a significant weakening in the conversion efficiency of capital input. Overall, Henan Province experienced continuous

improvement in factor utilization efficiency during the first four years, with characteristics of high-quality development gradually emerging. However, the simultaneous decline in economic efficiency indicators in 2023 indicates that development quality faced temporary pressure.

2.2.4. Economic growth momentum

The three growth indicators presented in Table 1 show significant fluctuations, indicating that external environmental factors exerted strong short-term impacts on Henan Province's economic growth momentum. In 2020, affected by the COVID-19 pandemic, all growth indicators declined to their lowest levels during the five-year period. GDP growth rate fell to only 1.3%, fixed asset investment growth rate decreased to 4.3%, and labor employment growth rate dropped to -0.3%. Economic activity in production, investment, and employment weakened simultaneously. In 2021, the economy achieved rapid recovery. GDP growth rebounded to 6.3%, and labor employment growth recovered to 0.8%, demonstrating a significant recovery trend. However, fixed asset investment growth declined to 2.7%, indicating insufficient momentum for capital expansion. From 2022 to 2023, GDP growth remained within the range of 3.1% to 4.1%, while fixed asset investment growth recovered slightly to 3.3%. Overall, economic growth remained below the high level of 8.0% achieved in 2019 for an extended period. This suggests that endogenous growth momentum within the region remains relatively weak, and the stability of economic growth requires further enhancement.

3. Comprehensive evaluation analysis of economic development in Henan Province

A single economic indicator cannot fully and objectively reflect the actual comprehensive level of regional economic development. Economic development is a multidimensional process involving the coordinated interaction of overall economic scale, economic structure, economic efficiency, and economic growth momentum. Since different indicators vary greatly in terms of measurement units and numerical ranges, direct horizontal and longitudinal comparisons are not feasible. Therefore, it is necessary to construct a multi-indicator comprehensive evaluation system. Through unified standardization, scientific weighting, and the synthesis of a comprehensive index, this study quantitatively measures the dynamic changes in Henan Province's economic development from 2019 to 2023, distinguishes the relative contributions of the four dimensions, and accurately identifies regional development weaknesses. This provides quantitative empirical support for proposing optimization strategies in subsequent sections. Therefore, comprehensive evaluation is both theoretically and practically necessary. This chapter presents the analysis from three aspects: the index evaluation method, the construction of indicator weights, and empirical measurement analysis.

3.1. Index evaluation method

This study adopts the weighted index method for comprehensive evaluation. This method features clear logic and facilitates economic interpretation, making it suitable for the four-dimensional indicator system established in this research. Before calculating the index, the original indicators must first undergo standardized and dimensionless processing to eliminate differences in measurement units and numerical scales. Subsequently, the final evaluation index is obtained through weighted summation based on indicator weights.

3.1.1. Explanation of range standardization calculation

The evaluation indicator system in this study includes two major categories: positive indicators and moderate indicators. To unify indicator scales and eliminate dimensional differences, all positive indicators are

processed using the range standardization method, which transforms the original data into a dimensionless interval of $[0, 1]$, ensuring that all indicators have comparable evaluation effects.

Since the indicators involve different units, including billion yuan, ten thousand persons, percentages, and ten thousand yuan/person, they cannot be directly aggregated through weighting. All indicators in this study are positive indicators, and range standardization is applied. The range standardization formula for positive indicators is shown in Equation (1):

$$Z_{ij} = \frac{X_{ij} - min(X_j)}{max(X_j) - min(X_j)} \tag{1}$$

where X_{ij} represents the original value of the j-th indicator in the i-th year; max and min represent the maximum and minimum values of the indicator during the five-year period, respectively; and Z_{ij} represents the standardized value, ranging from $[0, 1]$. This process eliminates the influence of different measurement units and provides the basis for subsequent index calculations.

Based on the original data in Table 1, the range standardization method is applied to all positive indicators to eliminate differences in measurement units and numerical magnitude. The standardized results are presented in Table 2.

Table 2. Standardized results of all indicators

Primary Dimension	Secondary Indicator	2019	2020	2021	2022	2023
Overall Economic Scale	Total GDP	0.0000	0.1053	0.6539	1.0000	0.6881
	Total Fixed Asset Investment	0.2642	0.0000	0.3127	0.5996	1.0000
	Total Labor Force Size	1.0000	0.6711	0.3816	0.0000	0.3026
Economic Structure	Proportion of Tertiary Industry	0.0000	0.1628	0.2558	0.2326	1.0000
	Proportion of Tertiary Industry Investment	0.0000	0.2414	0.4828	0.7586	1.0000
	Proportion of Tertiary Industry Employment	0.0000	0.9293	1.0000	0.8081	0.9495
Economic Efficiency	Labor Productivity	0.0000	0.1959	0.6603	1.0000	0.7005
	Investment Output Ratio	0.0000	0.4464	0.8616	1.0000	0.3393
Economic Growth Momentum	GDP Growth Rate	0.9649	0.0000	0.8772	0.3158	0.4912
	Fixed Asset Investment Growth Rate	1.0000	0.3393	0.0536	0.0000	0.1607
	Labor Employment Growth Rate	0.8182	0.0000	0.1364	0.0000	1.0000

3.1.2. Explanation of indicator type classification

First, positive indicators. In this study, all indicators corresponding to the dimensions of overall economic scale, economic efficiency, and economic growth momentum are classified as positive indicators. These include total GDP, total fixed asset investment, total labor force size, labor productivity, investment output ratio, GDP growth rate, fixed asset investment growth rate, and labor employment growth rate. A higher value of these indicators indicates a larger economic scale, higher efficiency, and stronger growth momentum. Therefore, these indicators are directly processed using positive range standardization, where an increase in standardized values represents an improvement in development level.

Second, moderate indicators. The three indicators under the economic structure dimension—the proportion of tertiary industry, the proportion of tertiary industry investment, and the proportion of tertiary industry employment—are classified as moderate indicators. Unlike positive indicators, higher values do not necessarily indicate better economic development quality, nor do lower values necessarily represent a more

reasonable structure. Industrial structure optimization depends on whether the structure matches the current stage of regional economic development. If these indicators are excessively low, it indicates lagging service industry development and a relatively traditional and undiversified industrial structure. Conversely, excessively high values may lead to the hollowing-out of the real economy and insufficient industrial support. Therefore, these indicators are mainly used to reflect the adaptability and optimization degree of industrial structure.

3.1.3. Weighted comprehensive index model

This study adopts the weighted comprehensive index method to construct a comprehensive evaluation model for Henan Province's economic development. As one of the most commonly used linear synthesis methods in multi-indicator comprehensive evaluation, this method can quantitatively measure and dynamically compare regional economic development levels by combining indicator weights after eliminating differences in indicator dimensions.

The construction of the model is based on the completion of indicator weighting and data standardization:

(1) Indicator weighting: The Analytic Hierarchy Process (AHP) is applied to construct judgment matrices. Through single-level weight calculation, consistency testing, and hierarchical total ranking, the final weights of secondary indicators are obtained. The Consistency Ratio (CR) of all judgment matrices is less than 0.1, indicating that the weighting results are valid and reliable and can be used for subsequent comprehensive index calculations.

The total weights of the indicators are calculated using Equation (2):

$$W_{all\ j} = W_{criteria} \times W_{within} \tag{2}$$

where $W_{criteria}$ represents the weight of the primary dimension, and W_{within} represents the weight of the secondary indicator within its corresponding dimension. Their product gives the final combined weight of each indicator.

(2) Data standardization: To eliminate differences in indicator dimensions and numerical scales and prevent large-scale indicators from masking the contributions of smaller-scale indicators, the range standardization method is applied to transform all indicators into the interval $[0, 1]$, generating dimensionless standardized values Z_{ij}.

(3) Construction of the weighted comprehensive index model: Based on the weights and standardized data, the weighted comprehensive index model is constructed as shown in Equation (3):

$$S_i = \sum_{j=1}^{11} W_{all\ j} \cdot Z_{ij} \tag{3}$$

where S_i represents the comprehensive evaluation index of Henan Province's economic development in year i; $W_{all\ j}$ represents the final weight of the j-th indicator obtained through AHP hierarchical total ranking; and Z_{ij} represents the standardized value of the j-th indicator in year i.

A higher value of the comprehensive index S_i indicates a higher level of comprehensive economic development in Henan Province during that year. Based on this model, longitudinal comparative analysis of Henan Province's economic development from 2019 to 2023 can be conducted, allowing the dynamic evolution trend of regional economic development to be directly identified.

3.2. Construction of indicator weights

3.2.1. Construction of AHP judgment matrix and related formulas

(1) Hierarchical structure

Target layer: comprehensive economic development level of Henan Province.

Criterion layer: A1 Overall Economic Scale, A2 Economic Structure, A3 Economic Efficiency, and A4 Economic Growth Momentum.

Indicator layer: Eleven specific indicators, namely B1–B11.

(2) Definition of pairwise comparison judgment matrix

This study adopts the general 1–9 scale system of AHP: 1 indicates equal importance, 3 indicates slight importance, 5 indicates obvious importance, 7 indicates strong importance, and 9 indicates extreme importance. The diagonal elements of the matrix are set as 1, and cross-elements are reciprocal to each other.

Based on the theoretical framework of high-quality economic development, the subjective importance ranking is determined as follows:

Economic efficiency > Overall economic scale > Economic growth momentum > Economic structure

The judgment matrix among elements at the same hierarchical level is defined as: $A = (a_{ij})_{n\times n}$.

Subject to the following constraints: $\begin{cases} a_{ii} = 1 \\ a_{ij} = \frac{1}{a_{ji}} \end{cases}$.

The value of a_{ij} is assigned according to the nine-point scale method.

(3) Single-level hierarchical weight calculation

Step 1: Normalize each column of the judgment matrix. The calculation process is shown in Equation (4):

$$\overline{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \tag{4}$$

Step 2: After completing the column normalization of the matrix, sum the values in each row of the matrix to obtain the intermediate weight vector. The calculation rule is shown in Equation (5):

$$\overline{W}_i = \sum_{j=1}^{n} \overline{a}_{ij} \tag{5}$$

Step 3: Normalize the row sums again to obtain the single-level weights of the indicators at the same hierarchical level. The specific calculation is shown in Equation (6):

$$W_i = \frac{\overline{W}_i}{\sum_{k=1}^{n} \overline{W}_k} \tag{6}$$

(4) Consistency test

To perform the matrix consistency test, the maximum eigenvalue of the judgment matrix must be calculated. The calculation formula is shown in Equation (7):

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(AW)_i}{W_i} \tag{7}$$

where (AW) represents the product of the judgment matrix and the weight vector, and $(AW)_i$ represents the i-th component of the vector.

The Consistency Index (CI) is calculated based on the maximum eigenvalue and the order of the matrix. The specific expression is shown in Equation (8):

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{8}$$

where (n) represents the order of the matrix.

The Consistency Ratio (CR) is calculated in combination with the Random Consistency Index (RI) to determine the validity of the judgment matrix. The calculation is shown in Equation (9):

$$CR = \frac{CI}{RI} \tag{9}$$

where RI represents the random consistency index (obtained from standard reference tables). The judgment criterion is: $CR < 0.1$, indicating that the matrix passes the consistency test and is valid.

(5) Overall hierarchical weight calculation

In the hierarchical total ranking, the final weight of each indicator is obtained by multiplying the dimension weight by its within-dimension weight. The calculation formula is shown in Equation (10):

$$W_{allj} = W_{criteria} \times W_{within} \tag{10}$$

where $W_{criteria}$ represents the weight of the criterion-level dimension, and W_{within} represents the single-level weight of the indicator within its corresponding dimension.

3.2.2. Construction of pairwise comparison matrices and weight calculation

A criterion-level judgment matrix is constructed, and weights are calculated followed by consistency testing. To determine the weight coefficients of the indicators within the four-dimensional evaluation system, the 1–9 scale method is used to conduct pairwise comparisons of the importance of indicators at the same hierarchical level, thereby constructing the criterion-level judgment matrix. The specific comparison values are shown in Table 3:

Table 3. Pairwise comparison judgment matrix of the criterion layer

	A1	A2	A3	A4
A1 Overall Economic Scale	1	2	1/2	3
A2 Economic Structure	1/2	1	1/3	2
A3 Economic Efficiency	2	3	1	4
A4 Economic Growth Momentum	1/3	1/2	1/4	1

Using the geometric mean method, the weights are calculated as: WA1 = 0.265, WA2 = 0.157, WA3 = 0.412, WA4 = 0.166

Interpretation of weights: Economic efficiency has the highest weight, indicating that it is the core dimension influencing the comprehensive economic development level of Henan Province. Overall economic scale ranks second. The weight of economic growth momentum is slightly higher than that of economic structure, while economic structure has the lowest weight among the four dimensions. This overall weight distribution is consistent with the theoretical logic of high-quality development, which emphasizes efficiency improvement while considering economic scale, and places greater importance on short-term growth momentum than on minor annual adjustments in industrial structure.

The calculation results are: $\lambda_{max} \approx 4.031, CI \approx 0.010, RI = 0.89, CR \approx 0.011 < 0.1$. Therefore, the judgment matrix passes the consistency test.

Judgment matrices are subsequently constructed for each dimension, and the indicator-level weights are calculated and subjected to consistency testing. After determining the relative importance of the criterion-level indicators, sub-judgment matrices are constructed for the secondary indicators within each of the four dimensions, and their single-level weights are calculated. The weight distribution of the indicators within each dimension is shown in Table 4.

Table 4. Single-level weights of indicators within each dimension

Primary Dimension	Secondary Indicator	Weight within Dimension
A1 Overall Economic Scale	B1 Total GDP	0.539
	B2 Total Fixed Asset Investment	0.297
	B3 Total Labor Force Size	0.164
A2 Economic Structure	B4 Proportion of Tertiary Industry	0.539
	B5 Proportion of Tertiary Industry Investment	0.297
	B6 Proportion of Tertiary Industry Employment	0.164
A3 Economic Efficiency	B7 Labor Productivity	0.667
	B8 Investment Output Ratio	0.333
A4 Economic Growth Momentum	B9 GDP Growth Rate	0.539
	B10 Fixed Asset Investment Growth Rate	0.297
	B11 Labor Employment Growth Rate	0.164

3.2.3. Final results of indicator weights

According to the calculations based on the analytic hierarchy process, the final weights of the 11 secondary indicators are presented in Table 5. The sum of all weights equals 1, indicating that the allocation is reasonable and suitable for subsequent weighted calculations.

Table 5. Final weights of indicators

Indicator	Total Weight	Indicator	Total Weight
B1	0.1428	B7	0.2748
B2	0.0787	B8	0.1372
B3	0.0435	B9	0.0895
B4	0.0846	B10	0.0493
B5	0.0466	B11	0.0272
B6	0.0257	Total	1.0000

3.3. Empirical analysis of the comprehensive evaluation of economic development in Henan Province

3.3.1. Calculation results of annual sub-indices

To further investigate the internal structural characteristics of economic development in Henan Province, this study calculates the annual sub-indices of four dimensions—overall economic scale, economic structure, economic efficiency, and economic growth momentum—based on standardized data and indicator weights. These sub-indices are used to analyze differences in the contributions and dynamic changes of each dimension to the overall development level. The sub-index calculation formula is shown in Equation (11):

$$S_{ik} = \sum_{j \in k} W_{allj} \cdot Z_{ij} \tag{11}$$

where S_{ik} represents the sub-index of the k-th primary dimension in year i; $W_{all\,j}$ represents the final combined weight of the j-th secondary indicator within that dimension; and Z_{ij} represents the standardized value of the corresponding indicator. A higher sub-index value indicates a higher development level of that dimension in the corresponding year and a stronger supporting effect on the comprehensive index.

The calculated results of the four-dimensional sub-indices for each year are presented in Table 6.

Table 6. Sub-indices of economic development in Henan Province, 2019–2023

Year	Overall Economic Scale Index	Economic Structure Index	Economic Efficiency Index	Economic Growth Momentum Index
2019	0.0643	0.0000	0.0000	0.1630
2020	0.0441	0.0593	0.1119	0.0202
2021	0.1345	0.0723	0.2849	0.0802
2022	0.1900	0.0817	0.4120	0.0188
2023	0.1901	0.1730	0.2189	0.0651

According to Table 6, the characteristics of the four dimensions are as follows:

Economic efficiency index: The scores of this dimension remained at a leading level among the four dimensions in most years. The index increased rapidly from a low level in 2019, reached its peak in 2022, and then declined to some extent. However, its overall contribution remained the most significant. This indicates that Henan Province's economic development has gradually shifted toward prioritizing quality and efficiency. Improvements in labor productivity and investment output efficiency have become important sources of support. Nevertheless, the stability of efficiency improvement requires further enhancement.

Overall economic scale index: The score of this dimension showed a steady upward trend. Except for a slight decline in 2020, it increased continuously in subsequent years and remained at a relatively high level in the later period. Its contribution ranked second only to economic efficiency. This dimension provided a solid foundation for the province's economic development, demonstrating the strong resilience and stable scale foundation of Henan's economy.

Economic structure index: The score of this dimension exhibited a steadily improving trend, with more significant growth occurring in the later stage of the study period. Its positive contribution to regional economic development continued to increase. This change reflects the gradual improvement of the tertiary industry proportion, investment allocation, and employment structure. The optimization of industrial structure has progressed steadily, and the compatibility between industrial development and local economic conditions has continuously improved.

Economic growth momentum index: The score of this dimension fluctuated considerably and remained relatively low overall. It was highly susceptible to external macroeconomic disturbances, resulting in unstable performance. Among the four evaluation dimensions, this indicator consistently ranked lower and had a relatively weak positive driving effect on the comprehensive economic development level. It represents one of the most prominent weaknesses in the current development process. This also indicates that the resilience of local economic growth momentum against external shocks remains insufficient. Therefore, future development should focus on strengthening the foundation of growth and continuously enhancing economic resilience.

According to Figure 1, the changing trends of the four dimensions can be summarized as follows:

Economic efficiency dimension: From 2019 to 2022, this dimension maintained rapid growth and became the core driving force behind the improvement of the comprehensive evaluation index. However, it experienced a significant decline in 2023, indicating that the stability of economic efficiency improvement still requires further enhancement.

Overall economic scale dimension: After experiencing slight fluctuations in the early stage, this dimension entered a stable upward trajectory and maintained a relatively high level during the later period of the study. It

provided fundamental support for regional economic development in terms of overall scale.

Economic structure dimension: Starting from a relatively low base, this dimension increased steadily year by year, with the growth rate accelerating in the later period. This change reflects that the optimization and adjustment of the regional industrial structure are progressing at an increasingly faster pace.

Economic growth momentum dimension: This dimension exhibited the largest fluctuations, with repeated rises and declines throughout the study period. Its ability to withstand external shocks was significantly weaker than that of other dimensions, making it a relatively prominent weakness in the current economic development of Henan Province.

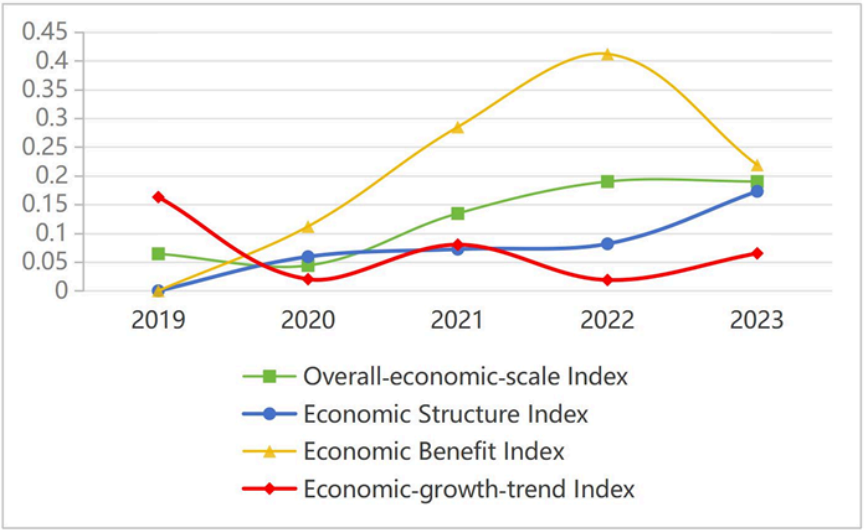

Figure 1. Trend of scores of the four dimensions of Henan Province's economic development, 2019–2023

3.3.2. Calculation results of annual comprehensive indices

The standardized indicator values for each year and the total indicator weights are substituted into the weighted comprehensive index model to calculate the comprehensive evaluation index of economic development in Henan Province from 2019 to 2023. The comprehensive scores for each year are summarized in Table 7:

Table 7. Comprehensive economic development index of Henan Province, 2019–2023

Year	Comprehensive Evaluation Index
2019	0.2273
2020	0.2355
2021	0.5719
2022	0.7025
2023	0.6471

2019–2020: The comprehensive index increased slightly from 0.2273 to 0.2355. Affected by the external shock of the COVID-19 pandemic, multiple indicators, including economic growth, investment expansion, and employment absorption, faced downward pressure. Social production activities slowed, while investment and consumption demand contracted to some extent. However, Henan Province's economy demonstrated a certain degree of resilience. The comprehensive score did not decline but instead increased slightly, indicating that overall economic operations remained stable.

2020–2021: The comprehensive index increased significantly from 0.2355 to 0.5719, representing a phased recovery after reaching the bottom. With improvements in pandemic prevention and control conditions and the effective implementation of policies supporting the resumption of work and production, economic scale gradually recovered, industrial structure continued to improve, and production efficiency steadily increased. The recovery of indicators across all dimensions jointly drove a rapid improvement in the comprehensive evaluation level.

2021–2022: The comprehensive index further increased from 0.5719 to 0.7025, continuing its steady upward trend. Regional economic development placed greater emphasis on both development quality and economic efficiency. Labor productivity and investment output efficiency continued to improve, industrial layout and employment structure were further optimized, and endogenous growth momentum gradually recovered. As a result, the overall comprehensive development level continued to strengthen and reached the highest point during the five-year observation period.

2022–2023: The comprehensive index declined from 0.7025 to 0.6471. Due to the temporary adjustment and contraction of economic scale, the economic efficiency dimension experienced a notable decline compared with the previous year. However, the regional industrial structure continued to improve, with the proportion of the tertiary industry increasing to 52.3%. The overall economic scale remained relatively stable, and the comprehensive index continued to maintain a high level, remaining above the levels recorded in 2021 and earlier years.

3.3.3. Comprehensive conclusions

From 2019 to 2023, the comprehensive economic development index of the research region exhibited an overall upward trend with fluctuations. The comprehensive score increased from 0.2273 in 2019 to 0.7025 in 2022, reaching the highest level during the five-year observation period. Although it declined slightly to 0.6471 in 2023, this value remained significantly higher than the levels recorded from 2019 to 2021. Overall, Henan Province's economic development followed a pattern characterized by "stable operation during the pandemic period, rapid phased recovery, and slight adjustment at a high level", which is consistent with the combined effects of the four evaluation dimensions.

From the perspective of the contribution of each dimension, the economic efficiency dimension served as the core driving force for regional economic development, making the most significant contribution to the comprehensive evaluation index and reaching its peak in 2022. However, its decline in 2023 also revealed insufficient stability in efficiency improvement. The overall economic scale dimension provided strong fundamental support and ranked second in terms of contribution. The economic structure dimension showed steady optimization and played a supporting role in economic development. The economic growth momentum dimension experienced relatively frequent fluctuations and weaker stability, making its overall contribution the lowest among the four dimensions.

According to the evaluation rules for positive indicators, higher indicator scores represent better regional development performance. At the current stage, Henan Province's economic development demonstrates the following characteristics: "leading performance in economic efficiency but with considerable fluctuations, a solid economic scale foundation, gradual improvement in industrial structure, and insufficient stability of growth momentum". In future development, efforts should focus on enhancing the sustainability of efficiency-driven growth while addressing weaknesses in economic growth momentum and continuously strengthening the foundation for regional economic development.

4. Development weaknesses and policy recommendations

4.1. Development weaknesses

Based on the comprehensive analysis of the trends of the comprehensive index, sub-indices, and differences in dimensional contributions, Henan Province's economic development from 2019 to 2023 revealed three major weaknesses in the process of multidimensional coordinated development, which directly constrained the progress toward high-quality development.

First, economic growth stability remains insufficient, with significant fluctuations. The economic growth momentum index exhibited a pronounced "W-shaped" fluctuation pattern over the five-year period, with repeated sharp rises and declines. Its ability to withstand external shocks was significantly weaker than that of other dimensions, indicating high sensitivity to external environmental changes and insufficient economic resilience. Weak growth stability directly contributed to fluctuations in the comprehensive development level and represents the most prominent weakness in Henan Province's economic operation. Relevant studies have shown that China's economic growth drivers have undergone a transition from "low-skilled labor + production capital" toward "high-skilled labor + R&D capital", with significant differences in the process of this transition among different regions [10]. Compared with some other regions, Henan Province has progressed relatively slowly in this transformation of growth drivers. Its economic growth still relies heavily on traditional factor inputs and faces considerable pressure in restructuring its growth momentum.

Second, insufficient coordination among multidimensional factors has resulted in prominent imbalances in development. Although the economic efficiency dimension had the highest weight and experienced rapid growth during certain periods, it showed a significant decline in the later stage, revealing the vulnerability of efficiency improvement. Meanwhile, the optimization of economic structure progressed relatively slowly, and the economic growth momentum dimension remained unstable. The four dimensions developed at different paces and showed insufficient coordination. Expansion in economic scale and improvements in efficiency have not effectively promoted industrial upgrading and stable growth momentum. The interaction among different development factors remains weak, making it difficult to establish a balanced and sustainable development pattern [7]. Although the overall quality of economic development in Central China has shown an upward trend, significant internal regional disparities remain. Wang Dong and Liu Xiaoyu measured the quality of economic development in Central China and found that Henan Province still lags behind other central provinces in terms of innovation capacity and openness [11].

Third, endogenous growth momentum is relatively weak, and the growth structure remains overly dependent on traditional drivers. According to the indicators of economic growth momentum, GDP growth and employment growth demonstrate insufficient stability. Economic development remains highly dependent on investment-driven growth, while endogenous driving forces such as consumption and innovation have made insufficient contributions. The rapid growth of fixed asset investment in Henan Province has increasingly strengthened its role in promoting economic growth, forming a typical investment-driven growth model. However, declining investment efficiency indicates that investment structure and industrial structure require urgent adjustment [12]. High dependence on traditional factors, insufficient cultivation of innovation factors, relatively low industrial levels, and limited product added value have weakened the sustainability of economic efficiency improvement and reduced the reserve of future growth momentum. Although Henan Province's level of economic modernization has gradually improved, further enhancement remains necessary. Strengthening innovation-driven development strategies and improving economic growth efficiency have become urgent priorities [13]. Li Yingying similarly pointed out that high-quality development in Central

China exhibits significant regional heterogeneity, with Henan Province scoring below the regional average in innovation-driven development and open development dimensions [14].

4.2. Optimization paths for high-quality development

4.2.1. Consolidating economic scale and strengthening development foundations

Henan Province should fully leverage its advantages in grain production, transportation hubs, and human resources, continuously expand effective investment, cultivate and strengthen the scale of market entities, and enhance the radiation-driven role of Zhengzhou as a national central city. These efforts will provide stable and reliable overall economic support for provincial development. Investment, consumption, and exports jointly constitute the driving structure of economic growth. Therefore, development strategies should be selected according to different stages and local conditions to optimize the structure of growth drivers.

4.2.2. Optimizing industrial structure and promoting transformation and upgrading

Henan Province should accelerate the transformation from a "secondary-tertiary-primary" industrial structure toward a more advanced "tertiary-secondary-primary" structure. Efforts should focus on vigorously developing modern services, enhancing the core competitiveness of manufacturing, promoting the high-end, intelligent, and green transformation of traditional industries, and cultivating strategic emerging industries. The optimization and upgrading of industrial structure can significantly promote improvements in economic growth rates.

4.2.3. Improving economic efficiency and strengthening quality-oriented development

Greater investment should be made in human capital development, while reforms toward market-oriented allocation of production factors should be advanced. These efforts should improve the mobility and allocation efficiency of production factors such as capital and labor, consolidate the sustainability of efficiency improvement, and avoid excessive dependence on short-term scale expansion for economic efficiency growth. The rationalization and upgrading of industrial structure can effectively improve economic efficiency and serve as an important institutional foundation for sustained improvements in economic performance.

4.2.4. Stabilizing growth momentum and enhancing development resilience

Henan Province should establish a demand-driven growth pattern featuring coordinated development of investment, consumption, and exports. It should stimulate household consumption potential, strengthen innovation-driven development to cultivate new growth engines, improve macroeconomic monitoring and risk early-warning mechanisms, and enhance the ability to respond to external shocks. Under the background of accelerating the construction of a new development paradigm, further efforts should be made to deepen institutional reforms and promote innovative institutional arrangements. These measures can effectively remove barriers to the free flow of production factors within the region and fully stimulate economic development vitality.

5. Conclusion

Based on statistical data from Henan Province for 2019–2023, this study constructs a four-dimensional evaluation system comprising economic scale, economic structure, economic efficiency, and economic growth trends. The Analytic Hierarchy Process (AHP) and the weighted comprehensive index method are employed to conduct quantitative calculations and comprehensively assess the characteristics and transformation pathways of regional economic development. The main conclusions are as follows:

First, the overall level of comprehensive economic development in Henan Province has risen over the past five years. Its economic scale has provided fundamental resilience, but the development process remains

vulnerable to external shocks. Overall development exhibits clear stage-specific differences, and short-term changes in the external environment can directly undermine development quality. This indicates that the regional economy has not yet established a long-term and stable endogenous support system, and its capacity for steady and sustainable development requires further improvement.

Second, there are significant differences in the contributions of the four supporting dimensions, and unbalanced development is the most prominent feature of Henan's economy at the current stage. Economic efficiency is the principal force driving comprehensive development, but improvements in factor efficiency have not been sustained over the long term. The continued expansion of economic scale has provided a stable foundation, while the persistent decline in the labor force constrains the potential for further scale growth. The economic structure is steadily shifting toward the service sector, but the pace of transformation in output value, capital, and employment remains inconsistent. The economic growth trend dimension has the weakest risk resistance and has become a key constraint on improvements in overall development.

Third, the various development constraints essentially arise from a dual imbalance in the growth-driving structure and the mechanism for coordinating production factors. Regional growth has long depended on capital investment, while endogenous drivers such as innovation and consumption have developed slowly. The four development dimensions lack mechanisms for coordinated interaction and mutual reinforcement, making it difficult for scale expansion to be continuously translated into structural optimization and efficiency improvement. The slow replacement of traditional industries by emerging industries, combined with a contraction in the population supply, restricts the release of long-term growth potential.

Fourth, achieving high-quality development requires coordinated measures across all four dimensions to establish a pattern of complementary support. Henan should consolidate its economic foundation by capitalizing on its advantages in transportation, agriculture, and population resources; promote the transformation of industries toward higher-end and service-oriented development and coordinate the simultaneous upgrading of output value, capital, and employment; optimize the mechanism for allocating production factors and maintain stable output efficiency of labor and capital; and establish a diversified growth model, improve risk-hedging mechanisms, and comprehensively strengthen the economy's resilience to shocks.

This study conducts only a longitudinal evaluation at the provincial time-series level and does not incorporate spatial differences among prefecture-level cities. In addition, the indicator system provides limited coverage of innovation and green development. Future studies may expand the indicators related to high-quality development, combine them with prefecture-level panel data to conduct spatiotemporal coupling analysis, and further improve research on economic transformation in China's central provinces.

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