Agricultural & Forestry Economics and Management (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/agrfem.2025.080114
ISSN 2616-2202 Vol. 8 Num. 1

Study on Assessing the High-Quality Development Level of Henan's Manufacturing Sector

Ye Luo, Manman Liu, Xiujuan Xie

Business School, Sias University, Zhengzhou, Henan, China

Keywords: Henan Province; High-Quality Development; Manufacturing

Abstract: This study is dedicated to gauging the high-quality development level of Henan Province's manufacturing industry. A multi-dimensional index system, which includes economic efficiency, innovation and development, green development, opening up and industrial structure, has been established. Based on this system, the entropy weight TOPSIS method is utilized to conduct a comprehensive evaluation of Henan's manufacturing industry. The research reveals regional disparities in the high-quality development level within Henan Province. Accordingly, targeted suggestions are put forward, such as increasing R&D investment, promoting industrial upgrading, and strengthening green development. These suggestions aim to provide decision-making references for Henan Province, thereby assisting it in enhancing industrial competitiveness and achieving sustainable economic development.

1. Introduction

Henan Province, a major economic hub in China, recorded a GDP of 6,359 billion yuan in 2024, ranking sixth nationwide. In 2023, its GDP was 5,913.2 billion yuan, with the secondary industry contributing 37.5% to the GDP, and the manufacturing industry accounting for over 85% of the secondary industry. The "14th Five-Year Plan" period is crucial for Henan to transform into a strong manufacturing province and achieve high-quality development. Despite its high total economic output, Henan's per capita GDP ranked 25th in the country, indicating that its economic development quality lags behind that of developed coastal provinces, making the demand for high-quality manufacturing development particularly prominent. However, the value added of manufacturing products in Henan is low, and its comprehensive competitiveness is weak. To address theseissues, this paper constructs an evaluation index system to measure the high-quality development level of Henan's manufacturing industry and proposes countermeasures to provide policy recommendations for promoting its high-quality development.

With the increasing emphasis on high-quality development, the scientific and rational construction of indicator systems and the measurement of the high-quality development level have become research hotspots. Scholars have constructed indicator systems from various dimensions and employed different models to assess the high-quality development level of the manufacturing industry. Liu et al. (2024)[1] examined the high-quality development of the manufacturing industry from three aspects: quality, efficiency, and power. Guo (2023)[2] developed an index system encompassing comprehensive information technology level, service guarantee, economic efficiency,

innovation drive, and green development, and determined the overall high-quality development index of the manufacturing industry using the Analytic Hierarchy Process (AHP) weighting method and the entropy value method. Han (2022)[3] utilized the entropy value method to construct the evaluation system and established a regression equation to explore the impact of the digital economy on the high-quality development of the manufacturing industry. Zhang (2024)[4] built an index for system assessing the development of the manufacturing industry based on comprehensive green development, talent concentration, innovation ability, quality and efficiency, and high-end industrial structure, and evaluated the level of high-quality development using the improved Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) evaluation model. Sun (2023)[5] measured the evaluation results of high-quality development of the manufacturing industry in six provinces in the central region from five dimensions: green, development technological innovation, economic efficiency, quality and brand, and informational level, using the difference test and conducted comparative analysis. Building on these studies, this paper takes the manufacturing industry in Henan Province as the research object, constructs a scientific evaluation index system, measures the development level of the manufacturing industry, and proposes targeted policy recommendations to promote the high-quality development of the manufacturing industry in Henan Province [6].

2. Construction of Evaluation System for High Quality Development of Manufacturing Industry

2.1 Selection of indicators

This study builds on the evaluation method of Lin and Qiao (2022), while considering the objective reality of the manufacturing industry's high-quality development. It constructs 15 indicators from five dimensions: "economic efficiency, innovation and development, green development, opening up, and industrial structure" to quantitatively assess the high-quality development of Henan Province's manufacturing industry. The index system is presented in Table 1.

Table 1 Evaluation indicator system for high-quality development of manufacturing

Primary indicators	Weights	Secondary indicators	Causality	Weights
Economic Efficiency	0.236	gross domestic production (GDP)	+	0.064
		Revenue from main operations	+	0.064
		Total assets contribution ratio	+	0.069
Innovation and Development	0.184	Internal expenditure on R&D funds	+	0.065
		Number of active patents	+	0.068
		Full-time equivalent of R&D personnel	+	0.064
Green Development	0.191	Airborne PM2.5 content	-	0.065
		Comprehensive energy consumption	-	0.069
		Sulphur dioxide consumption	-	0.066
Opening Up	0.174	Actual utilization of foreign capital	+	0.065
		Number of foreign enterprises at the end of the year	+	0.070
		Total investment in enterprises registered during the year	+	0.072
Industrial Structure	0.215	advancement	+	0.067
		Revenue from sales of new products	+	0.067
		Product sales rate	+	0.065

2.2 Methodological measurements

Based on the quantitative perspective to evaluate the quality of manufacturing development in Henan Province, this paper selects the measurement model combining the improved entropy value method and TOPSIS method. The specific steps are as follows:

(1) Standardized treatment

For positive indicators:

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

For negative indicators:

$$Z_{ij} = \frac{X_{\max} - X_{ij}}{X_{\max} - X_{\min}} \tag{2}$$

Where X_{ij} denotes the original *j-th* evaluation indicator value for the *i-th* evaluation object; and Z_{ij} denotes the standardized value.

(2) Constructing the forward normalization matrix

Let the original decision matrix be X:

$$X = (x_{ij})_{nm} (i = 1,2,..., n; j = 1,2,..., m) \tag{3}$$

$$\mathrm{X}=\begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix} \tag{4}$$

The forward normalized decision matrix is Z:

$$Z = (z_{ij})_{nm} (i = 1,2,..., n; j = 1,2,..., m) \tag{5}$$

$$\mathrm{Z}=\begin{bmatrix} z_{11} & \cdots & z_{1m} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nm} \end{bmatrix} \tag{6}$$

(3) Determine the set of positive and negative ideal solutions

The maximum values of the indicators in each column of the matrix constitute the set of positive ideal solutions, Z^+ is:

$$Z^+ = (\max\{z_{11}, z_{21},..., z_{n1}\}, \max\{z_{12}, z_{22},..., z_{n2}\},..., \max\{z_{1m}, z_{2m},..., z_{nm}\}) = (Z_1^+, Z_2^+,..., Z_m^+) \tag{7}$$

The minimum values of the indicators in each column of the matrix form the set of negative ideal solutions, Z^- for:

$$Z^- = (\min\{z_{11}, z_{21},..., z_{n1}\}, \min\{z_{12}, z_{22},..., z_{n2}\},..., \min\{z_{1m}, z_{2m},..., z_{nm}\}) = (Z_1^-, Z_2^-,..., Z_m^-) \tag{8}$$

(4) Calculate the distance between the *i-th* evaluation indicator and the positive and negative ideal solutions.

$$D_i^+ = \sqrt{\sum_j^n (z_{ij} - z_j^+)^2} \tag{9}$$

$$D_i^- = \sqrt{\sum_j^n (z_{ij} - z_j^-)^2} \tag{10}$$

(5) Calculate the relative closeness C_i

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{11}$$

Where C_i takes a value between [0,1], the larger the value, the higher the level of high-quality development of manufacturing in the city, and vice versa, the lower it is.

3. Empirical Analysis

3.1 Data sources

This study assesses the performance of 17 prefecture-level cities within Henan Province. The data utilized for this analysis are sourced from the Henan Provincial Statistical Yearbook, the Henan Provincial Bureau of Statistics' website, the Henan Provincial Statistical Bulletin on National Economic and Social Development, and the EPS database. Where data were missing, interpolation methods were employed to estimate the values.

3.2 Analysis of results

(1) Measurement results

The high-quality development index of the manufacturing industry in Henan Province's cities from 2016 to 2023 is detailed in Table 2.

Table 2 High-quality development index of manufacturing industry in Henan Province

City	2016	2017	2018	2019	2020	2021	2022	2023
Zhengzhou	0.66	0.63	0.84	0.64	0.70	0.73	0.73	0.75
Kaifeng	0.37	0.36	0.44	0.37	0.33	0.34	0.33	0.36
Luoyang	0.49	0.51	0.53	0.43	0.43	0.46	0.42	0.44
Pingdingshan	0.32	0.26	0.26	0.23	0.27	0.24	0.19	0.21
Anyang	0.29	0.21	0.30	0.19	0.25	0.29	0.26	0.28
Hebi	0.27	0.30	0.43	0.26	0.29	0.21	0.18	0.23
Xinxiang	0.35	0.33	0.32	0.30	0.31	0.27	0.27	0.30
Jiaozuo	0.35	0.35	0.34	0.27	0.32	0.32	0.30	0.33
Puyang	0.33	0.33	0.35	0.33	0.30	0.24	0.20	0.22
Xuchang	0.38	0.38	0.40	0.36	0.33	0.32	0.33	0.35
Luohe	0.40	0.40	0.40	0.34	0.37	0.34	0.34	0.36
Sanmenxia	0.26	0.37	0.37	0.30	0.31	0.29	0.23	0.28
Nanyang	0.39	0.37	0.41	0.38	0.39	0.34	0.40	0.42
Shangqiu	0.34	0.33	0.39	0.32	0.32	0.32	0.30	0.32
Xinyang	0.38	0.36	0.46	0.35	0.38	0.34	0.35	0.37
Zhoukou	0.37	0.41	0.51	0.4	0.4	0.41	0.36	0.39
Zhumadian	0.37	0.38	0.48	0.34	0.37	0.33	0.32	0.36

(2) Analysis of the type of high-quality development of manufacturing industry

Remember r_{ik} is the ordering of high quality development level of manufacturing industry in Henan Province, then it is called in $[t_1,t_n]$time period, $r_{max}(i)$ represents the maximum ordinal

difference of the ordering of high quality development level of manufacturing industry in Henan Province, i.e.:

$$r_{\max}(i) = \max_{k}\{r_{ik}\} - \min_{k}\{r_{ik}\}(i = 1,2,..., m; k = 1,2,..., n) \quad (12)$$

According to the variation range of the maximum ordinal deviation, the type of high-quality development of the manufacturing industry in Henan Province is classified into the following three types: (1) when $0 \leq r_{max}(i) \leq 2$, the manufacturing industry develops steadily; (2) when $3 \leq r_{max}(i) \leq 6$, the manufacturing industry develops fluctuatingly; (3) when $r_{max}(i) \geq 7$, the manufacturing industry develops jumpingly. Then, combined with the geographic location of the division area of Henan Province, the type of high-quality development of the manufacturing industry in Henan Province is classified, and the results are shown in Table 3.

Table 3 Types of high-quality development of manufacturing industry

Types	Eastern	Western	Southern	Northern	Central
Steady Development		Luoyang			Zhengzhou
Fluctuating Development	Kaifeng Shangqiu Zhoukou		Nanyang Xinyang Zhumadian	Anyang Xinxiang Jiaozuo Puyang	Pingdingshan Xuchang Luohe
Leapfrog Development		Sanmenxia		Hebi	

3.3 Analysis of results

As can be seen from the above calculation results, the high-quality development level of manufacturing industry in all regions of Henan Province during 2016-2023 shows obvious regional heterogeneity characteristics and fluctuation development trend. From the east Henan region, Kaifeng, Shangqiu and Zhoukou's high-quality development level of manufacturing industry have all fluctuated and increased, of which Zhoukou has the most obvious performance, climbing from the 7th place in 2016 to the 4th place in 2023, and has been stable in the position of the 3rd place from 2017 to 2021. In West Henan, Luoyang's manufacturing sector has been in a steady growth trend, and has remained in the 2nd position between 2016 and 2023. Meanwhile, the steady development of Luoyang city's manufacturing industry has also driven the development of Sanmenxia's manufacturing industry to a certain extent, making it show a jumping development trend. In the southern Henan region, the development of manufacturing industries in Nanyang, Xinyang and Zhumadian also all showed a fluctuating upward trend. Nanyang, in particular, ranked 8th in 2017 and jumped to the 3rd position by 2023. In the north of Henan, although all regions are basically in a fluctuating development trend, Hebi and Puyang have been in a lower position, and from 2021 onwards, the industrial transformation and upgrading and innovation-driven key areas and industrial frameworks of Anyang City and Jiaozuo City are more clear compared to the past, showing an upward momentum and highlighting the significant features of high-quality development. In the central Henan region, Zhengzhou City, as the core city of the central Henan region, has maintained the highest level of development in the province for seven consecutive years, ranking first in the province. Luohe City's ranking gradually rebounded after 2019 after a sharp drop from No. 3 in 2016 to No. 11 in 2018. Xuchang City's ranking fluctuated between 5th and 8th place, while Pingdingshan City hovered between 14th and 17th place. Overall, the development of the manufacturing sector in all regions of Henan Province has had its ups and downs, but the overall trend is positive, especially the rapid rise of some cities, such as Zhoukou and Nanyang, which demonstrates the new momentum of regional economic development.

4. Conclusions and recommendations for countermeasures

This study takes the manufacturing industry in Henan Province as the research object and constructs an evaluation index system for the high-quality development level from five dimensions: economic efficiency, innovative development, green development, opening up, and industrial structure. The evaluation aims to provide a scientific assessment of the high-quality development level in Henan Province. The findings indicate that the high-quality development level of the manufacturing industry in Henan Province exhibits significant regional differentiation. Specifically, the southeastern and western parts of Henan Province show higher levels of high-quality development, while the northern part is relatively weaker during the period from 2016 to 2023. Zhengzhou City, located in the central region, is identified as the primary focus for high-quality development of the manufacturing industry, with a pronounced central radiation role. In contrast, the other cities in the central region display varying degrees of decline.

Based on the findings, the following recommendations are proposed: First, increasing R&D investment and fostering technological innovation are crucial for driving the high-quality development of Henan Province's manufacturing industry. Henan should enhance financial support for corporate R&D, encourage the establishment of dedicated R&D funds, and promote cooperation between enterprises and academic institutions to create collaborative innovation platforms. The focus should be on key areas such as high-end equipment manufacturing, new materials, and electronic information, with an emphasis on solving several "bottleneck" technical issues. Accelerating the transformation of scientific and technological achievements into real productivity, promoting products to be high-end, intelligent, and green, and enhancing product value-added and market competitiveness are essential. Leading the transformation and upgrading of Henan's manufacturing industry through technological innovation and realizing the leap from a large manufacturing province to a strong manufacturing province are the ultimate goals. Secondly, prioritizing green manufacturing and sustainable development is imperative for the high-quality progression of Henan’s manufacturing sector. Henan should hasten the green transition of its manufacturing industry, encouraging firms to adopt energy-efficient and eco-friendly technologies and equipment. This initiative aims to reduce energy consumption and pollutant emissions, thereby establishing a green supply chain. Strengthening resource recycling and enhancing the comprehensive utilization rate of industrial solid waste are also crucial steps. Moreover, promoting the integrated development of manufacturing and service industries, expanding product life cycle services, and increasing industrial added value are essential for sustainable growth. Through policy guidance and financial support, Henan should cultivate several green manufacturing demonstration enterprises to drive industry-wide green development. Additionally, reinforcing environmental supervision and law enforcement to ensure enterprises meet emission standards is vital for achieving a harmonious balance between economic development and ecological protection, steering Henan’s manufacturing industry towards a sustainable trajectory. Thirdly, expanding into international markets and bolstering policy support are vital for the high-quality development of Henan’s manufacturing industry. Henan should actively create international exchange platforms, organize enterprises to participate in international exhibitions, assist enterprises in expanding overseas business, and enhance the international market share of products. The government needs to improve export tax rebates, trade facilitation and other policies to reduce the cost of enterprise exports. Set up special support funds to support enterprises to carry out international certification and brand building. Strengthen the protection of intellectual property rights to escort the overseas development of enterprises. Through the double-wheel drive of precise policy support and market expansion, promote the manufacturing industry in Henan Province to move towards the middle and high end in the global industrial chain and achieve high-quality development. Fourth, promoting

industrial upgrading and structural adjustment is the key path for the high-quality development of manufacturing industry in Henan Province. Henan Province should accelerate the intelligent and digital transformation of traditional industries, and promote the development of strategic emerging industries such as high-end equipment manufacturing and new energy vehicles. Henan Province should optimize its industrial structure by reducing the proportion of high-energy-consumption and high-pollution industries while increasing that of high-value-added and high-technology industries. It must strengthen industrial co-innovation, promote in-depth collaboration among upstream and downstream enterprises in industrial chains, and foster an innovation ecosystem. Through policy guidance, financial support, and factor protection, Henan will advance industries toward high-end, intelligent, and green development, enhance the overall competitiveness of its manufacturing sector, and achieve a transformation from scale expansion to quality improvement.

Acknowledgements

This paper was supported by General Project of Educational Reform at the School Level of Zhengzhou Sias University: Research on the Implementation Pathways for Digital Economy to Empower the High-Quality Development of Henan's Manufacturing Industry. (Grant NO.: 2024XKD035).

References

[1] Liu Y, He Z. Synergistic industrial agglomeration, new quality productive forces and high-quality development of the manufacturing industry[J]. International Review of Economics & Finance, 2024, 94: 103373.
[2] Guo Q, Su Z. The application of industrial robot and the high-quality development of manufacturing industry: From a sustainability perspective[J]. Sustainability, 2023, 15(16): 12621.
[3] Han Z, Liu Y, Guo X, et al. Regional differences of high-quality development level for manufacturing industry in China[J]. Math. Biosci. Eng, 2022, 19: 4368-4395.
[4] Zhang Z, Bai Y. Research on whether quality policies can promote the high-quality development of china's manufacturing industry and its configuration paths in the context of sustainable development[J]. Sustainability, 2024, 16(21): 9539.
[5] Sun W, Fang J. Does environmental governance matter to the relationship between digital transformation and high-quality development? Evidence from manufacturing sector in China[J]. Environmental Science and Pollution Research, 2023, 30(43): 97005-97024.
[6] Lin C, Qiao W. Statistical measurements and club effects of high-quality development in Chinese manufacturing[J]. International Journal of Environmental Research and Public Health, 2022, 19(23): 16228.