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DPSIR-TOPSIS Model-Based Assessment of Green Development Performance in Beijing, Tianjin, and Hebei

Jieting Yin*, Junfeng Yuan

Beijing Wuzi University

*yinjieting@bwu.edu.cn

Abstract: Green development is an important way to achieve sustainable development. In recent years, it has become one of the main research hotspots. Based on the principle of the DPSIR model, this paper constructed a green development evaluation index system including 17 second-level indicators from five first-level indicators, namely the driving force indicator, pressure indicator, state indicator, impact indicator, and response indicator, and used TOPSIS model to evaluate the green development of Beijing-Tianjin-Hebei region from 2010 to 2020. The results show that :(1) the closeness index of the driving force and pressure indicator layer generally shows a fluctuating trend of first rising and then falling, the closeness index of the state layer shows a fluctuating downward trend, the influence indicator layer shows an overall upward trend, and the closeness index of the response indicator layer shows a trend of first declining and then rising. (2) Due to the existence of regional heterogeneity, the green development of Beijing is higher than that of Tianjin, and the green development of Tianjin is slightly higher than that of Hebei. The Beijing-Tianjin-Hebei region needs to form cohesion in green development governance. (3) It is found that the economic growth rate of the Beijing-Tianjin-Hebei region is very fast, but in terms of green development, there is still an extensive development trend with high input and high consumption.

Keywords: Green development; DPSIR - TOPSIS model; The performance evaluation

1. Introduction

Green development is an important way to achieve sustainable development and has become one of the main research hotspots in recent years. Green development is not only the main development trend in the world nowadays, but also an important idea guiding our future development. To continue to lead, promote and implement green development, we need to further understand the connotation of green development so that green development reflects a more distinct green, symbiosis, precision, and long-term. Now, our development has arrived at the stage where we must accelerate the construction of ecological civilization. Building an ecological civilization is an inevitable requirement for accelerating the transformation of the economic development pattern and realizing green development. Should be based on China's basic national conditions and development of new stage characteristics, for the construction of beautiful China as the goal, to solve the ecological environment problems as the guidance, clear ecological civilization system reform must adhere to the guiding ideology, basic concept, the important principle, the overall objectives, tasks, and measures put forward reform, provide institutional guarantee for the construction of ecological civilization. The Beijing-Tianjin-Hebei region is an important development region in China. Although great progress has been made in many areas, such as urban construction, coordinated economic and social development, and improvement of people's livelihoods, regional ecological and environmental problems are still outstanding.

2. Literature Review

Green development is a mode of economic growth and social development aiming at efficiency, harmony, and sustainability. In today's world, green development has become an important trend. Many countries take the development of green industries as an important measure to promote economic restructuring, highlighting the concept and connotation of green. At present, domestic, and foreign scholars have abundant studies on the evaluation of green development efficiency. Fei

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Lun [1] et al. constructed an evaluation system for Beijing's green development based on the statistical data of Beijing from 2006 to 2016 and analyzed the spatial-temporal changes in Beijing's green development level by using the projection pursuit model and spatial analysis method. Cui Xiaolin et al. [2] evaluated the green development performance of 110 prefecture-level cities in the Yangtze River Delta from 2011 to 2017 based on the entropy weight method, and then analyzed the driving factors of urban green development performance by using the barrier degree model. By referring to various connotations related to the green development of coal-resource-based cities, Long Ruyin et al. [3] built an evaluation index system that meets the requirements of green development of coal-resource-based cities from four dimensions. TOPSIS method was used to evaluate the green development level of 30 coal-based cities in China. Gan Hui [4] et al., based on the theoretical connotation of green development and the actual development of Liuzhou City in Guangxi Zhuang Autonomous Region, built the evaluation index system of regional green development level from three aspects. The standard importance is adopted to measure and analyze the green development level of Liuzhou City by CRITIC method. Sun Jiqiong et al. [5] used the TOPSIS method and entropy method to measure the green development level of Chengdu from 2005 to 2019. Wei Zhenxiang et al. [6] used the entropy weight method to evaluate and analyze the development level of the green economy in Dongying City from 2007 to 2016. Xie Lei et al. [7] applied the DPSIR model in green development performance evaluation and determined index weights by analytic hierarchy process (AHP) and standardized processing by target progression method. Taking Guizhou Province as the research object, Xie Lei et al evaluated the green development level from 2009 to 2019. Qiu Lili [8] et al. constructed the evaluation index system of regional green development from five aspects. The weight of each index was determined by the entropy weight method, and the regional green development index of Yunnan Province from 2011 to 2015 was calculated by the TOPSIS method. Sun Zhenqing [9] et al. used the entropy weight TOPSIS method to measure the four dimensions of regional green innovation input capacity, green innovation output capacity, green innovation environment capacity, and green diffusion input capacity in China. Zeng Xiangang et al. [10] established a three-level index system and analyzed the development status of China's green economy from horizontal and vertical dimensions by using principal component analysis, cluster analysis, and multiple linear regression. Shi Anna [11] et al., based on the DPSIR principle, constructed an analysis framework from industrial dynamics, industrial ecology, industrial transformation, and industrial benefits. Based on panel data of 11 provinces and cities in the Yangtze River Economic Belt from 2008 to 2018, adopted the entropy method and PVAR model to analyze the level and impact of industrial green development.

From the existing research results, many studies on green development have achieved fruitful results. But at present, the efficient evaluation of green development in the Beijing-Tianjin-Hebei region is less. Therefore, based on previous studies and referring to the DPSIR model, this paper selected an evaluation index system suitable for the green development of the Beijing-Tianjin-Hebei region, applied the entropy weight method to assign values, and combined with the TOPSIS method to carry out empirical analysis on the green development level of Beijing-Tianjin-Hebei region, to provide a reference for improving the green development level of Beijing-Tianjin-Hebei region.

3. Construction and weight determination of the Beijing-Tianjin-Hebei regional green development index system

DPSIR model [12][13] was originally modified by OECD based on the PSR model and DSR model. It is a model constructed from the evaluation index system and widely used in the analysis of resources, environment, social economy, and other issues abroad. As shown in Table 1.

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Table 1 DPSIR model explanation

Specific meaning	The index name	Index meaning
D（driving）	Driving force index	The potential impact on social and economic activities in the region is the internal cause of ecological environment change and the future development trend.
P（pressure）	Pressure indicators	The normal production and life in the region require the acquisition of resources from the surrounding area or the direct impact on the surrounding environment
S（state）	Status indicators	Under the influence of driving force and pressure in the region, the ecological environment presents various conditions.
I（impact）	Impact indicators	The extent to which the various states of the ecosystem in the region reflect and influence the economy, society, resources, and environment.
R（response）	The response indicators	To realize the sustainable development of the economy and society and promote the benign development of the ecological environment, various active and effective countermeasures should be adopted.

Among the criteria level indicators, the driving force index (D) includes five positive factor level indicators, such as per capita GDP, per capita disposable income of rural residents, and urbanization rate, which mainly reflects the potential impact on social and economic activities in the region. Pressure index (P), including population density, industrial sulfur dioxide emissions, industrial wastewater emissions, and industrial soot emissions of four negative factor layer indicators, mainly reflects the influence of driving force and pressure in the region and the ecological environment presented by various conditions. State index (S) includes three positive factor layer indicators, namely forest coverage rate, per capita water resources, and per capita urban road area, which mainly reflects the various conditions of the ecological environment under the influence of driving forces and pressures in the region. Impact index (I) includes the proportion of tertiary industry in GDP and the area of the nature reserve as two positive factor level indicators, which mainly reflect the reflection and impact of the degree of various states of the ecosystem in the region on the economy, society, resources, and environment. The response index (R) includes the elasticity coefficient of energy consumption, the comprehensive treatment rate of industrial solid waste, and the harmless treatment rate of household waste, which mainly reflects the realization of the sustainable development of the economy and society, the promotion of the benign development of the ecological environment, and the adoption of various active and effective countermeasures.

In this paper, starting from the connotation of the development of green development, while fully combed, the same kind at home and abroad for reference, the evaluation index system based on the following scientific, objective, and representative indexes, the principle of validity and availability, constructed by a primary index, five secondary indexes and 17 three indicators of the index system, the development of green as shown in table 2.

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Table 2 Evaluation index system of green development in Beijing-Tianjin-Hebei region

Target layer Indicators	Criterion layer index	Factor level index	Nature of evaluation index	The corresponding weight
Level of green development in Beijing, Tianjin and Hebei	D(Driving force indicator)	Per capita GDP/yuan	Positive indicators	0.041
		Per capita disposable income of rural residents/yuan	Positive indicators	0.051
		Urbanization rate /%	Positive indicators	0.05
		Natural population growth rate (municipal district)/‰	Positive indicators	0.027
		Urban residents per capita disposable income/yuan	Positive indicators	0.054
	P(Stress indicator)	Population density /(people/km 2)	Negative indicators	0.13
		Industrial sulfur dioxide emissions/ton	Negative indicators	0.096
		Industrial wastewater discharge/ten thousand tons	Negative indicators	0.082
		Industrial soot emission/ton	Negative indicators	0.025
	S(Status indicator)	Forest coverage /%	Positive indicators	0.048
		Per capita water resources /(cubic meter/person)	Positive indicators	0.08
		Urban road area per capita/square meter	Positive indicators	0.038
	I(Impact indicator)	The proportion of tertiary industry in GDP /%	Positive indicators	0.075
		Area of nature reserve/ten thousand hectares	Positive indicators	0.042
	RThe response indicators	Elasticity coefficient of energy consumption /%	Negative indicators	0.048
		Comprehensive utilization rate of industrial solid waste /%	Positive indicators	0.051
		Harmless disposal rate of household garbage /%	Positive indicators	0.063

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4. Research methods and data sources

4.1 Research Methods

The entropy weight method is a method to objectively assign weight to evaluation indexes. It determines the weight of each index by the information provided by the observed value of the index. In information theory, entropy is a measure of the uncertainty of things. The larger the amount of information, the smaller the uncertainty and the smaller the entropy. The smaller the information entropy is, the more unbalanced the system structure is. The greater the difference coefficient, the greater the index weight, and vice versa. This provides a scoring basis for the comprehensive evaluation of multiple indicators.

This paper mainly evaluates the green development performance of the Beijing-Tianjin-Hebei region from 2010 to 2020. There are 17 main evaluation index systems. Therefore, 17 indicators are used as the analysis matrix of a comprehensive evaluation, and the specific weight calculation process is as follows:

(1) Determine the data matrix

$$X = \begin{pmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{m1} & \cdots & X_{mn} \end{pmatrix}_{n\times m} \tag{1}$$

Where: X_{ij} represents the value of the j th index of the i th sample.

(1) Non-negative processing of data.

(2) Calculate the proportion of the i sample scheme under the j index in the index, the calculation formula is as follows:

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} (j = 1, 2, \cdots, m) \tag{2}$$

(1) Determine the entropy value of j indicators, and the calculation formula is as follows:

$$e_j = -k \sum_{i=1}^{n} P_{ij} \log(P_{ij}) \tag{3}$$

Type: $k > 0$, $e_j \geq 0$ and at the same time, the constant k is related to the number of samples m. Generally, $k = \frac{1}{\ln m}$, and $0 \leq e_j \leq 1$.

(1) Calculate the difference coefficient of the index of j. For the index of j, if the difference of the index value of X_{ij} is greater, the effect on the evaluation of the scheme will be greater, and the calculated entropy value will be smaller. $g_i = 1 - e_j$. The higher the value, the higher the importance of the indicator.

(2) To calculate the weight, the formula is:

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$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j}, \quad j = 1, 2, \cdots, m \tag{4}$$

TOPSIS method. TOPSIS method is a common method in multi-objective decision analysis, also known as the good and bad solution distance method. It sorts the evaluation objects by detecting the distance between them and "ideal solution" and "negative ideal solution". If the evaluation object is closest to the "ideal solution" and furthest from the "negative ideal solution", it is the best. Otherwise, it is the worst. This ranking technique approximating the "ideal solution" can conduct horizontal and longitudinal comparative analysis on the evaluation object, which is conducive to grasping the comprehensive level of the evaluation object. The specific calculation steps are as follows:

First, establish the weighted normalized matrix V. $V = (A_{ij})_{m \times n} = Y_{ij} \times W_j = \{ y_{ij} \times w_j \}_{m \times n}$. where W_j is the weight diagonal matrix, Y_{ij} is the standardized matrix, $i = (1, 2, \cdots, m)$, $j = (1, 2, \cdots, n)$.

Second, determine the "positive ideal solution" and "negative ideal solution". In this paper, the maximum value and minimum value of the weighted programming matrix are respectively regarded as "positive ideal solution" and "negative ideal solution", where the positive ideal solution is: $V_j^+ = \max(A_{1j}, A_{2j}, \cdots, A_{mj})$, and the negative ideal solution is: $V_j^- = \min(A_{1j}, A_{2j}, \cdots, A_{mj})$.

Third, the Euclidean distance between each evaluation object and the positive and negative ideal value in different years was calculated.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} (A_{ij} - V_j^+)^2}, \quad i = (1, 2, \cdots, m) \tag{5}$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} (A_{ij} - V_j^-)^2}, \quad i = (1, 2, \cdots, m) \tag{6}$$

Fourth, calculate the paste progress between the evaluation object and the ideal C_i. $C_i = d_i^- / (d_i^+ + d_i^-)$ $0 < C_i < 1$ The larger C_i is, the farther is the dynamic comprehensive evaluation value of the evaluation object from the "negative ideal solution" and the closer is the distance from the "positive ideal solution", that is, the better is the overall performance and the higher is the ranking. And vice versa.

4.2 Data Sources

From 2010 to 2020, the green development efficiency of the Beijing-Tianjin-Hebei region was evaluated. The data mainly came from Beijing Statistical Yearbook, Tianjin Statistical Yearbook, Hebei Statistical Yearbook, China Statistical Yearbook on Energy, China Statistical Yearbook on Environment, and China Ecological and Environmental Bulletin.

5. Result Analysis

5.1 Analysis of evaluation index of overall green development in Beijing-Tianjin-Hebei region

The evaluation results of Beijing-Tianjin-Hebei region can be obtained according to the TOPSIS model, as shown in Table 3.

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Table 3 Calculation results of TOPSIS model evaluation

Year	Positive ideal solution distance (D+)	Distance of negative ideal solution (D-)	Composite score index	The sorting
2010	0.42658	0.23575	0.35594	10
2011	0.39204	0.24191	0.3816	8
2012	0.35106	0.31251	0.47095	6
2013	0.34902	0.23476	0.40214	7
2014	0.39635	0.2056	0.34156	11
2015	0.38303	0.21391	0.35835	9
2016	0.28978	0.3207	0.52532	4
2017	0.30656	0.31362	0.5057	5
2018	0.20748	0.36744	0.63912	1
2019	0.31658	0.36587	0.53611	3
2020	0.24577	0.41833	0.62992	2

By analyzing the relative closeness degree of the Beijing-Tianjin-Hebei region, the results of the comprehensive evaluation of green development of the Beijing-Tianjin-Hebei region from 2010 to 2020 are shown in Figure 4.

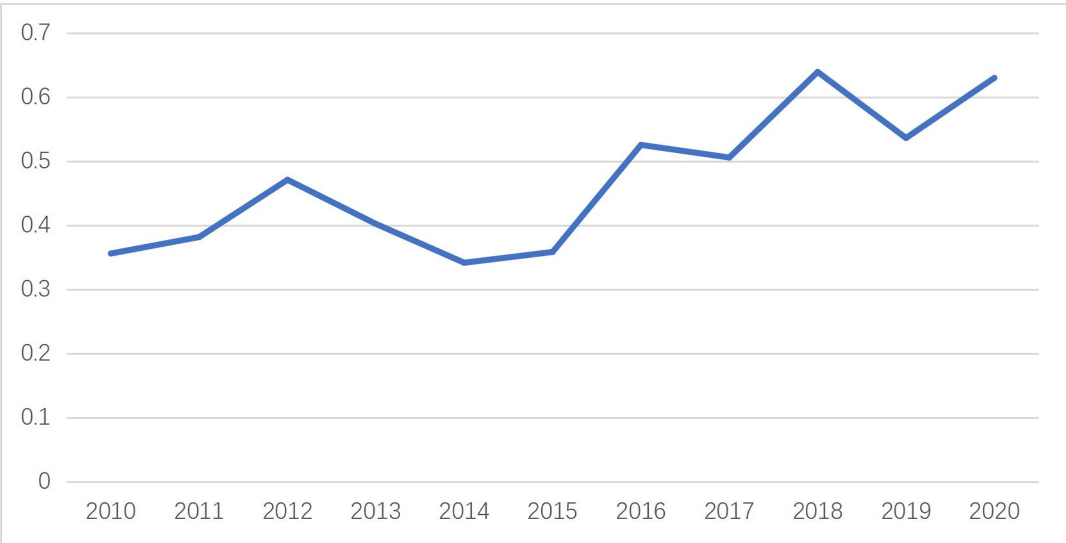

FIG. 4 Change curve of comprehensive evaluation of green development in Beijing-Tianjin-Hebei region

According to the change curve of the comprehensive evaluation of green development in the Beijing-Tianjin-Hebei region, the green development of the Beijing-Tianjin-Hebei region is constantly improving, and the overall situation shows an upward trend. The relative closeness index increased from 0.36 in 2010 to 0.63 in 2020, and there is a relatively high improvement overall. This is due to the Beijing-Tianjin-Hebei region's careful implementation of national ecological environmental governance policies, as well as the improvement of the effective utilization of resources and government support policies.

The curve of the distance from the evaluation object to the ideal solution of the green development energy of the Beijing-Tianjin-Hebei region from 2010 to 2020 is shown in FIG. 5.

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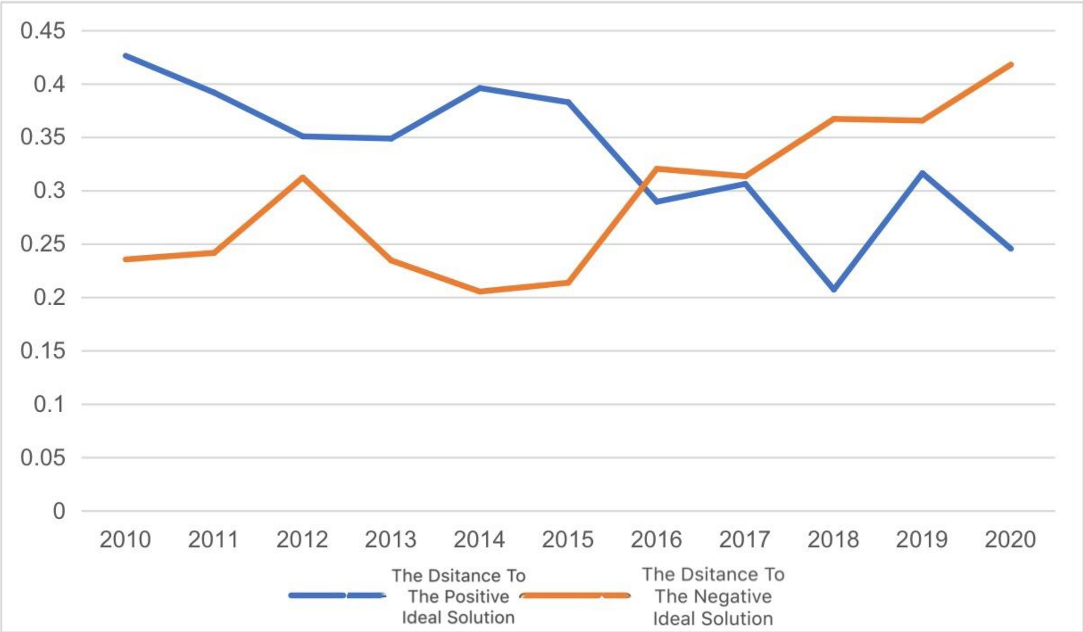

FIG. 5 Change curve of distance between evaluation objects and ideal solution in Beijing-Tianjin-Hebei region

Figure 5 shows the curve of the distance from the evaluation object to the ideal solution. From 2010 to 2020, the green development of the Beijing-Tianjin-Hebei region showed an overall upward trend. The distance from the evaluation object to the positive ideal solution gradually decreased from 0.43 to 0.25, and gradually tended to the positive ideal solution. The distance between the evaluation object and the negative ideal solution gradually increased from 0.24 to 0.42, and gradually tended to the negative ideal solution. The closeness degree calculated according to the positive and negative ideal solution values is between [0,1], and the evaluation object is optimal. According to the observation of the closeness degree values, it shows a rising trend, increasing from 0.36 in 2010 to 0.63 in 2020, and all of them are located between [0,1]. Therefore, it is of practical significance to evaluate the green development of the Beijing-Tianjin-Hebei region.

In recent years, the green development of the Beijing-Tianjin-Hebei region has shown a trend of improvement. Ecological and environmental governance has been improved to a great extent. However, in future development, we should pay more attention to the balanced development of all aspects of indicators, jointly promote the green development of the Beijing-Tianjin-Hebei region and play a more active role in promoting the overall construction of ecological civilization in the country.

According to the DPSIR-TOPSIS model, according to the 2010-2020 Beijing-Tianjin-Hebei Green development evaluation index and relative closeness analysis, Figure 6 can be obtained:

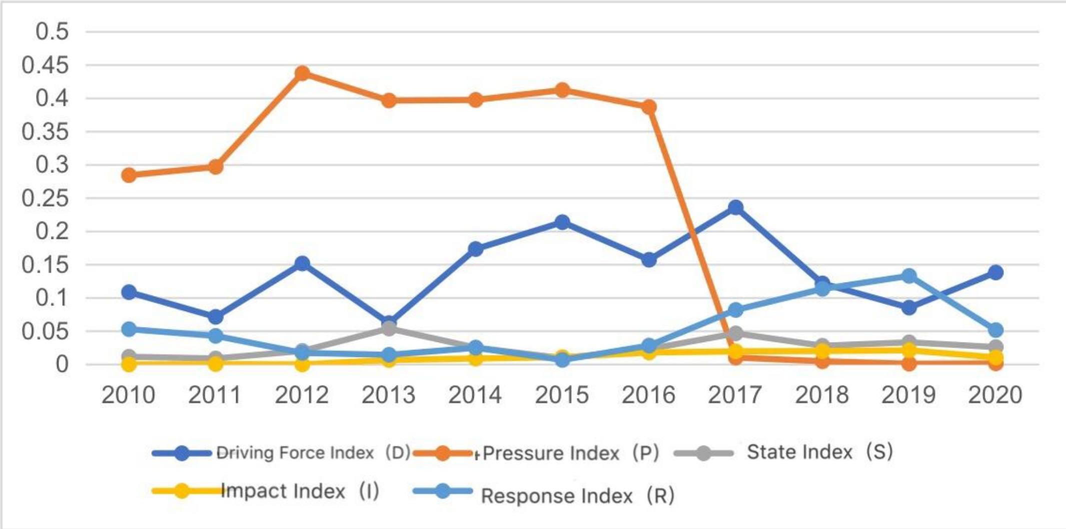

FIG. 6 Specific analysis of criteria layer indicators

Driving force indicator layer (D): During the green development of the Beijing-Tianjin-Hebei region from 2010 to 2020, the closeness index of the driving force indicator layer generally increased first and then decreased. This is mainly influenced by economic development, the urbanization process, population growth, urban residents' per capita disposable income, and other factors. Among them, the per capita GDP of the Beijing-Tianjin-Hebei urban agglomeration showed an increasing trend year by year. With the continuous promotion of ecological civilization construction, the green ecological environment system has become a necessary way to achieve high-quality economic development. The urbanization level of the Beijing-Tianjin-Hebei region is relatively high, and the urbanization rate shows a trend of the increasing year by year, which also benefits from the deepening of the concept of ecological environmental protection. The natural growth rate of the population shows a downward trend. With the continuous improvement of people's requirements for material and cultural living standards, people's awareness of environmental protection is also gradually strengthened, and the per capita disposable income of urban residents is gradually rising. To sum up, the Beijing-Tianjin-Hebei regional driving force level index is mainly affected by four factors, showing a fluctuating trend of development, but from the overall analysis, the Beijing-Tianjin-Hebei regional driving force index plays a positive role in promoting green development.

Pressure index level (P): From 2010 to 2020, the closeness index of the pressure index level in the Beijing-Tianjin-Hebei region showed a trend of increasing first and then decreasing, which indicates that with the national attention to the construction of ecological civilization and the continuous increase of financial support, most of the rapid economic growth in China is at the expense of the environment, and the consumption of energy is large. However, with the introduction of the five-in-one national plan, China has embarked on a path of green, environmentally friendly, and energy-efficient development, instead of seeking economic growth at the expense of the environment. At the same time, regional population density and industrial "three wastes" are the pressure indicators affecting the green development of the Beijing-Tianjin-Hebei region. Through the analysis we can see that the Beijing-Tianjin-Hebei urban agglomeration of population density is larger, the industrial pollution is serious, leading to the ecological environment index peaked in 2014, as countries continue to strengthen the ecological environment regulation, ecological environmental index system of the late showed a trend of a sharp drop in industrial wastewater emissions, improving environmental governance effect.

State indicator layer (S): From 2010 to 2020, the closeness degree of state layer indicators in the Beijing-Tianjin-Hebei region showed a fluctuating downward trend, and the green development index of the state indicator layer showed a trend of first increasing and then decreasing, and then increasing and decreasing. The closeness degree index of state layer indicators showed a downward trend. The urbanization rate in the Beijing-Tianjin-Hebei region is increasing, the population is constantly flowing in, the per capita water cube resources and the per capita urban road area are relatively stable, and the forest coverage rate shows a small upward trend. Therefore, overall, the green development status of the Beijing-Tianjin-Hebei region is still under great pressure. Beijing-Tianjin-Hebei regional state-level indicators positively reflect the green development status.

Impact indicator level (I): From 2010 to 2020, the impact indicator level of green development in the Beijing-Tianjin-Hebei region showed an overall upward trend, which was mainly due to the great progress of ecological and environmental protection in the Beijing-Tianjin-Hebei region. With the high-quality development of the economy and people's pursuit of a better life, ecological environmental protection has attracted more and more attention from all walks of life, and the awareness of ecological environmental protection has been deeply rooted in people's hearts. Ambient air quality in the Beijing-Tianjin-Hebei region is improving, the area of nature reserves is increasing, and the proportion of the tertiary industry is also on the rise. Therefore, the closeness index of the influencing indicator layer also shows an upward trend, which plays a positive role in promoting the continuous improvement of the green development level of the Beijing-Tianjin-Hebei region.

Response indicator layer (R): From 2010 to 2020, the closeness index of response indicator layer showed a trend of first decreasing and then increasing. Because in recent years, ecological environment protection policy tilt, Beijing-Tianjin-Hebei region such as the discharge of industrial wastewater and solid waste treatment effect is obvious, at the same time, living garbage and sewage treatment is also rising, Beijing-Tianjin-Hebei regional energy consumption is in a stage of energy-intensive, must further strengthen building a conservation-minded society.

Beijing and Tianjin in the economic development, people's income, green infrastructure construction, the resource abundance compared with other cities in the Beijing-Tianjin-Hebei region has obvious advantages, the positive index of green development level of Beijing and Tianjin city value contribution is bigger, makes the two cities, especially Beijing always maintain high levels of green development; In addition, Beijing is positioned as a center of political, cultural, scientific and technological innovation and international communication, focusing on the development of culture, education, tourism, science, and technology and other industries. Tianjin focuses on the development of the port economy, logistics, and high-end manufacturing industries. Influenced by the different functional orientations of the two cities, Tianjin is slightly lower than Beijing in terms of urban green development level and is basically located at a higher level of green development level. Secondly, Zhangjiakou and Chengde in northern Hebei Province have made great efforts to build the ecological barrier between Beijing and Tianjin in recent years. The development intensity is low, and they have traditional advantages in resource abundance and green services, and the overall green level is relatively high

Combined with the above analysis, the overall closeness index of the Beijing-Tianjin-Hebei region shows an increasing trend year by year. Combined with the TOPSIS evaluation method, the closeness results of each index analyzed are also consistent with reality. Therefore, the evaluation results are stable and credible and lay a foundation for related research.

5.2 Evaluation results of green development of Beijing-Tianjin-Hebei sub-region

According to the data and model results, the TOPSIS model evaluation and calculation results of Beijing, Tianjin, and Hebei can be obtained, as shown in Table 7. Therefore, this section will analyze the evaluation results of the three regions respectively.

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Table 7 Results of TOPSIS model evaluation in Beijing-Tianjin-Hebei region

Region / Year	Beijing		Tianjin		Hebei	
	Composite score index	The sorting	Composite score index	The sorting	Composite score index	The sorting
2010	0.42521407	6	0.3739046	8	0.30543219	11
2011	0.36375265	9	0.45913102	7	0.30594287	10
2012	0.36920499	8	0.53854468	3	0.39197438	7
2013	0.31422035	11	0.36383269	10	0.39074935	8
2014	0.32838724	10	0.37168001	9	0.38403586	9
2015	0.37174986	7	0.3278555	11	0.4532835	6
2016	0.50266069	4	0.47158077	6	0.59012119	4
2017	0.46242917	5	0.47184561	5	0.53591403	5
2018	0.51055515	3	0.58403256	1	0.60991827	2
2019	0.53795865	2	0.48269813	4	0.59925405	3
2020	0.56516705	1	0.57470963	2	0.66141962	1

5.2.1 Evaluation results of Beijing's green development

From 2010 to 2020, the green development level of Beijing showed a downward trend and then an upward trend, as shown in the table. The comprehensive score index of green development in Beijing increased from 0.43 in 2010 to 0.51 in 2020. This shows that Beijing's green development presents a good trend. According to the changing trend, this process is divided into two stages, as shown in Figure 8:

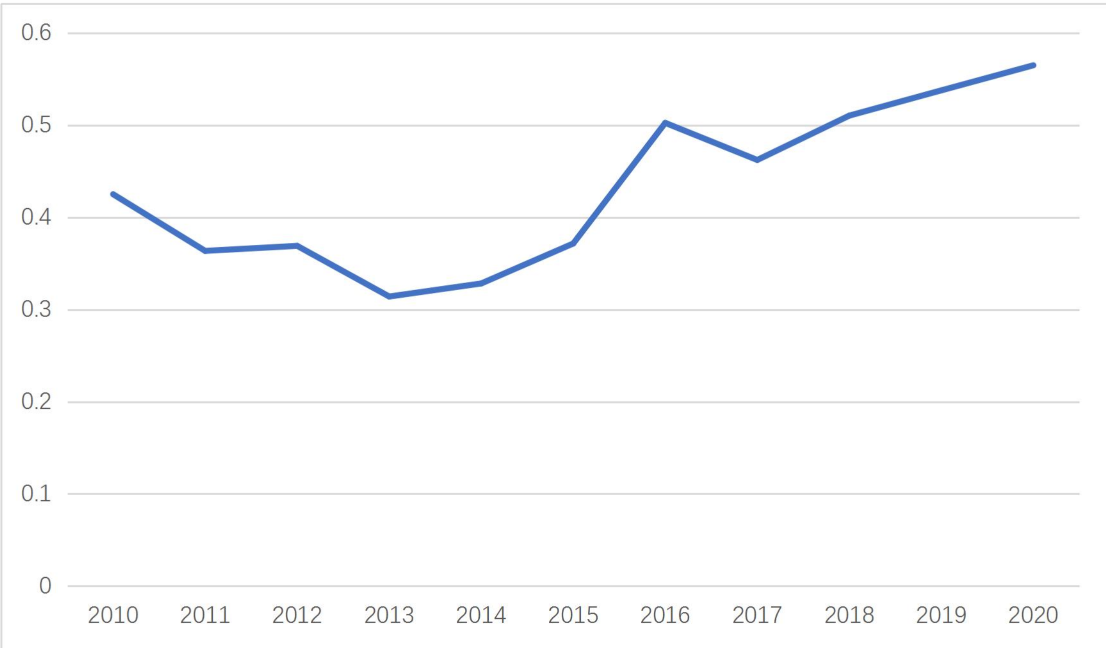

FIG. 8 Comprehensive Evaluation Index of green development in Beijing

The first phase (2010-2014): The level of green development decreased slightly. During this period, the comprehensive evaluation index of Beijing's green development level decreased from 0.43 in 2010 to 0.33 in 2014. From the perspective of the changes in the five index layers, in addition to the driving force index and state index rose, the pressure index, index, and response index have dropped or the same trend, among them, is the negative index of population density and industrial "three wastes" have risen from 2010 to 2014, rising the indicators of pressures to the development of green, the overall green development level of the city is not high.

The second stage (2015-2020): The level of green development increases rapidly. At this stage, the comprehensive evaluation index of Beijing's green development level increased from 0.37 in

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2015 to 0.57 in 2020. In this stage, the comprehensive utilization rate of industrial solid waste and the harmless treatment rate of household waste increased, the population density and the "three wastes" of the industry decreased, the efficiency of economic growth and the level of green development increased day by day, and the overall level of green development was significantly enhanced.

As the political, economic, and cultural center of China, Beijing has actively practiced its green development concept and committed itself to building the international first-class harmonious and livable capital, but in the process of its development, there are still outstanding problems such as economic total, population size, resource and environment contradiction, and there is still much room for improvement in green development. At the same time as the capital of Beijing represents the image of our country in the world, in the economic development should also be more environmental responsibility, economy, society, resource, environment, technology and policy elements such as core elements, to promote the development of green development is not isolated to each other, but at the same time have heterogeneity has the coupling and the internal phase connectivity. To comprehensively improve the green development level of Beijing, it is impossible to promote one or two factors alone. How to form an overall "joint force" to drive the green development of Beijing through the coordination of factors is the key to cultivating new development impetus.

5.2.2 Evaluation results of Tianjin's green development

From 2010 to 2020, the comprehensive evaluation index of Tianjin's green development is shown in Figure 9. The level of green development in Tianjin is on the rise. The comprehensive evaluation index rose from 0.37 in 2010 to 0.57 in 2020, indicating a relatively high level of green development.

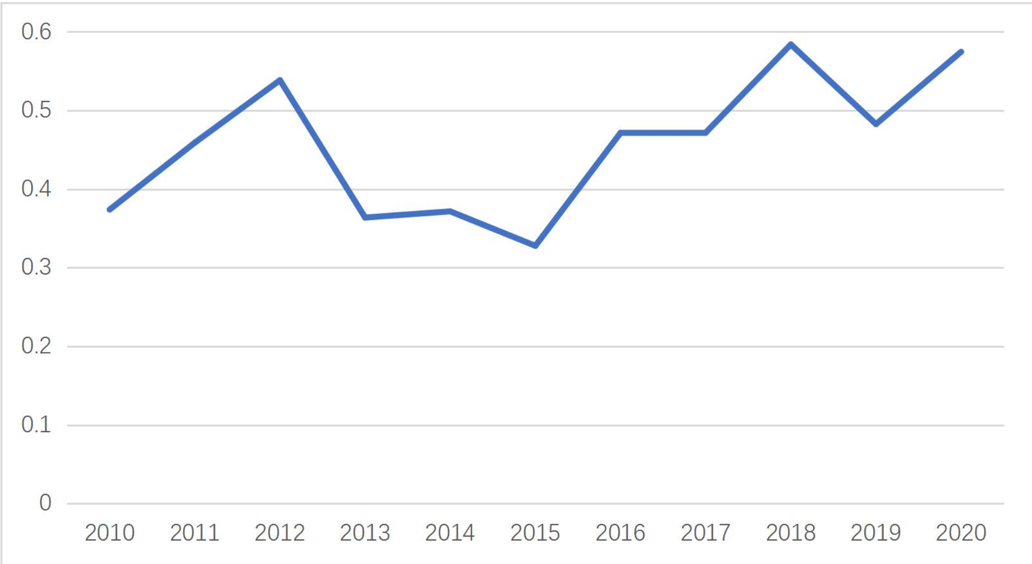

FIG. 9 Comprehensive Evaluation Index of Tianjin Green Development

The speeding up of industrialization is an important symbol of urban development, industrial development' s inevitable impact on urban ecology, environment, and various eyesores, restricting urban greening level, using industrial wastewater, industrial so2 emissions, and industrial soot emissions are three measures of Tianjin environment facing pressure force levels. By comparing the emissions of industrial "three wastes" in Tianjin in 2010 and 2020, the emissions of industrial wastewater, industrial carbon dioxide, and industrial soot have all decreased significantly in recent years, as shown in Table 10. The discharge of industrial wastewater decreased from 1960.8 million tons in 2010 to 173.0563 million tons in 2020, and the discharge of industrial sulfur dioxide decreased from 217,620 tons in 2010 to 9,756.36 tons in 2020. Industrial soot emissions dropped from 53,831 tons in 2010 to 15,044.48 tons in 2020. It shows that the treatment effect of industrial

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"three wastes" in Tianjin is good in recent years. The green development effect of Tianjin mainly benefits from the treatment of industrial "three wastes".

Table 10 Discharge of industrial "Three wastes" in Tianjin in 2010 and 2020

City	Industrial wastewater discharge (unit: ten thousand tons)		Industrial sulfur dioxide emissions (unit: ton)		Industrial soot emission (unit: ton)	
	2010	2020	2010	2020	2010	2020
Tianjin	19680	17305.63	217620	9756.36	53831	15044.48

As can be seen from the factor layer data, Tianjin all the data is in the direction of the green development progress, but slightly lower than that of Beijing, in recent years, Tianjin afforestation, wetland conservation and cracking of steel city, the implementation of the demolition and ecological restoration, ecological environment water treatment, high standard farmland construction, cultural tourism development such as "top ten key projects". Since the beginning of this year, Tianjin has unswervingly taken the new road of giving priority to ecology and green development. It has given priority to law-based, scientific, and precise pollution control, strengthened research on the causes and mechanisms of pollution and tackled key control technologies, and implemented precise policies and improved control effectiveness from five aspects: problem, time, location, target, and measure. Ecological and environmental authorities attach equal importance to supervision and service, improve the "two positive lists" of EIA approval and supervision and law enforcement, carry out the "hundred thousand" guidance and assistance action, and take the initiative to send "policies, technologies and plans" to enterprises, so as to jointly promote high-quality economic and social development and high-level protection of the ecological environment, and promote ecological civilization construction.

From 2010 to 2015, the green development level of Tianjin showed a slight downward trend. After 2015, the green development level gradually increased, and the comprehensive evaluation index increased from 0.33 in 2015 to 0.57 in 2020. In recent years, with the increasing progress of ecological civilization construction, Tianjin's industrial wastewater discharge, industrial sulfur dioxide discharge, and industrial soot discharge have been reduced year by year, which has greatly enhanced the level of green development in Tianjin.

5.2.3 Evaluation results of green development in Hebei Province

From 2010 to 2020, the comprehensive evaluation index of green development in Hebei Province increased year by year, from 0.31 in 2010 to 0.66 in 2020, as shown in Figure 11. It indicates that the overall green development level of Hebei Province is increasing year by year. The green development level of Zhangjiakou and Chengde in northern Hebei Province, Baoding, Shijiazhuang, Cangzhou, Langfang, Hengshui, and Tianjin in central Hebei Province is relatively high, but the green development level of Xingtai, Handan in southern Hebei Province and Qinhuangdao, Tangshan in eastern Hebei Province is slightly low in Beijing-Tianjin-Hebei region.

This is mainly because of the continuous enhancement of ecological civilization construction in cities such as Shijiazhuang, Baoding, Cangzhou, Langfang, Hengshui, Xingtai, and Handan in central Hebei Province. With the help of the regional advantages of piedmont plain, the green and low-carbon recycling industrial system has been actively constructed, and the level of urban green development has been continuously improved. In the industrial structure of Shijiazhuang, Hengshui, Xingtai, Handan, and other cities in the southern part of Hebei Province, the proportion of traditional intensive industries such as steel, coal, and chemical industry is slightly larger, and the pressure on resources and environment still exists in these cities. Tangshan in eastern Hebei Province is a traditional and new industrial base in the Beijing-Tianjin-Hebei region. In terms of pollutant emission, energy, and power consumption, Tangshan is at the forefront of the Beijing-Tianjin-Hebei region and has the lowest level of urban green development.

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2010-2020, Tangshan has been in the middle efficiency and high-efficiency range, while the city is an important industrial city of Beijing-Tianjin-Hebei, but emissions reduced year by year in recent years, resources, and constantly improve the city's economic development level, economic output capacity to a certain extent, to make up for a higher output of pollutants brought about by the ecological efficiency loss. Therefore, the efficiency of urban green development in Tangshan is high. 2010-2020, Baoding, Handan, and Shijiazhuang city green development efficiency of change between medium and invalid, the three cities in fixed asset investment, urban construction investment is more, resource utilization is low, at the same time because of iron and steel, coal chemical industry, building materials, petrochemical, and other energy-intensive industries in the industrial structure of heavy, highlights the environmental pressure, The level of urban green development and the speed of economic development are slightly lower, resulting in the scale diseconomy of urban green development.

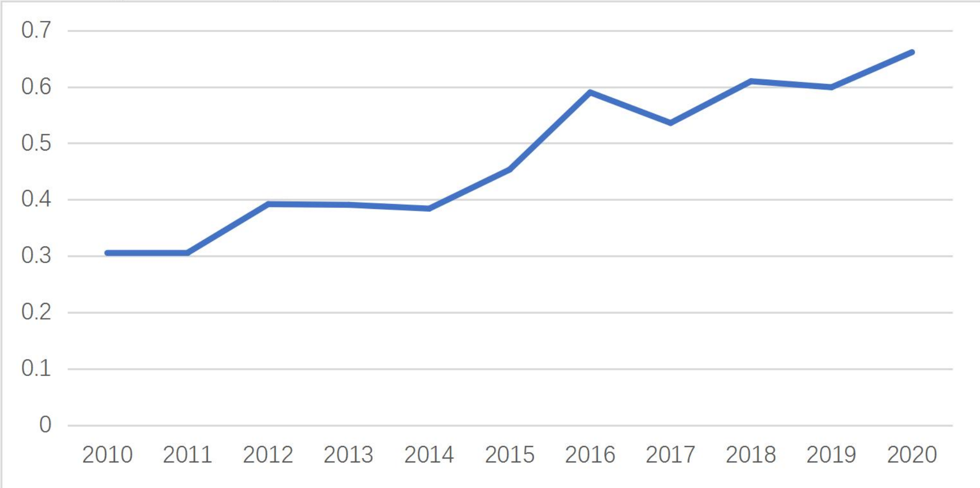

FIG. 11 Comprehensive evaluation index of green development in Hebei Province

6. Conclusions and suggestions

In this paper, the Beijing-Tianjin-Hebei region from 2010 to 2002 was taken as the research object, and an evaluation index system including 5 criterion level indexes and 17-factor level indexes was constructed. The entropy weight method was used to determine the index weights, and the TOPSIS model was used for comprehensive calculation and evaluation. The following conclusions and suggestions are drawn. The research method is reasonable, and the evaluation result is accurate, which has a certain reference value for guiding the green development of the Beijing-Tianjin-Hebei region.

2010-2020 based on the development of the Beijing-Tianjin-Hebei region green pressure layer and impact index is analyzed, the results show that Beijing-Tianjin-Hebei region population density dropped year by year, the industrial "three wastes" emissions reduced year by year, after the ecological environment of governance, ambient air quality was improved, the nature reserve area is growing steadily.

(2) Due to the existence of regional heterogeneity, the Beijing-Tianjin-Hebei region needs to form cohesion in green development governance. Driving force indicators show that in recent years, the green development and construction in the Beijing-Tianjin-Hebei region showed an overall trend of first rising and then declining. As the level of economic development and per capita income of each region is inconsistent, the green development of Tianjin and Hebei is also affected by per capita GDP, urbanization level, and population density under the radiation of Beijing, the capital city. Such heterogeneity of regional development leads to the unstable state of this index. Therefore, narrowing the gap between regions is still an important reference factor for future green development.

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(3) According to the analysis of this paper, it can be found that the economic growth rate of the Beijing-Tianjin-Hebei region is very fast, but in terms of green development, there is still an extensive development trend of high input and high consumption. For example, in the energy response index layer, the elasticity coefficient of energy consumption is still at a high value.

(4) In the context of supply-side structural reform, adhere to the concept of green, coordinated, and shared ecological development. To adapt to the new normal of economic development, we will continue to transform the economic development model, raise total factor productivity, reduce the energy consumption of enterprises, improve the efficiency of resource utilization, and reduce pressure on the ecological environment. We should also strengthen the legislation and law enforcement of the ecological environment to create a stable cultural environment for the development of a green ecological environment. We will continue to actively advocate the concept of "protecting the environment, everyone does their duty", strengthen the value guidance of citizens, mobilize the whole people to participate in environmental protection, and make joint efforts for the green development of the Beijing-Tianjin-Hebei region.

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