What is the Gap Between China's and Finland's Level of Sustainable Development? --Based on DPSIR-TOPSIS Modeling

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Abstract. This paper measures and comparatively analyzes the sustainable development levels of China's Beijing-Tianjin-Hebei urban agglomeration and Finland in 2013-2021 using DPSIR and the TOPSIS evaluation model (EWM-Topsis) modified based on the entropy weight method, and summarizes the gaps between China and Finland in each indicator level. The kernel density estimation method was used to analyze the dynamic evolution of the sustainable development levels of the Beijing-Tianjin-Hebei city cluster and Finland in ten years, and the Terrell index was used to analyze the differences in sustainable development between regions, and finally, the Tobit regression model was chosen to conduct an empirical study on the factors affecting sustainable development and put forward targeted countermeasures and suggestions.

Keywords: DPSIR model, EWM-Topsis, Kernel Density Estimation, Terre Index, Tobit regression model

1 Introduction

The concept of sustainable development was explicitly proposed in the IUCN's World Outline for the Conservation of Natural Resources in 1980, followed by the adoption of Building a Sustainable Society and Our Common Future in 1981 and 1987, respectively.In September 2015, the 193 member states of the United Nations formally adopted the 17 Sustainable Development Goals (SDGs) at the Summit on Sustainable Development (SDS), which aim to move from the 2015 to 2030 to completely solve the development problems in the three dimensions of society, economy and environment in an integrated way and shift to the path of sustainable development.

Most of the current research by domestic scholars focuses on the construction of the sustainable development indicator system and the assessment of domestic ecological sustainability and the value of ecosystem services, but there are fewer studies comparing with the international excellent cases, and there is a lack of empirical analysis. Yingting Xie and Hongmei Sun (2021) compared vertically and horizontally the level of sustainable development of natural ecosystems in Shanghai and Tokyo, and then put forward targeted suggestions for the sustainable development of Shanghai[1].Chunxu Hao and Chaofeng Shao use the SDGs indicator system to analyze the short board problems in China's ecological environment field and put forward targeted countermeasure suggestions such as promoting the localization of the SDGs indicator system and making up for the short boards of SDGs[2]. In terms of constructing the SDGs

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indicator system, Zhao Duo, Lu Jianbo, and Min Huai (2003) established an ecological environment sustainable development evaluation indicator system about Zhejiang Province, pointing out that it can be established with the assistance of principal component analysis and expert consultation method[3]. Wang Huijuan and Lan Zongmin (2022) assessed the sustainable development of Chinese cities by constructing, measuring and evaluating the index system of sustainable development, also through comprehensive scoring[4].

This paper takes ESI (level of sustainable development) as the measurement standard, and analyzes the differences between China's Beijing-Tianjin-Hebei region and Finland in each indicator layer and the dynamic evolution trend of changes during 2013-2021 by comparing the indicators of Beijing-Tianjin-Hebei urban agglomeration with Finland, which is the country with the optimal level of sustainable development in the international arena at the present time, and predicts the direction of the development in the future. Finally, the factors affecting the sustainable development of the Beijing-Tianjin-Hebei urban agglomeration are empirically analyzed, and countermeasures are proposed. Considering the inappropriate method of comparing countries and regions, all indicators in this paper are per capita indicators.

2 Measurement of the level of sustainable development in Beijing-Tianjin-Hebei and Finland

2.1Model Selection

In this paper, the DPSIR model is used to measure the sustainable development level of the Beijing-Tianjin-Hebei region and Finland, and the entropy weighting method is applied to determine the corresponding weights of each indicator from 2013 to 2021 and then weighted twice to obtain the corresponding comprehensive weights of each indicator. After standardizing the data and combining the weights, the comprehensive score of each region's sustainable development level was calculated. Finally, the TOPSIS model is used to analyze the gap between the Chinese regions represented by Beijing-Tianjin-Hebei and Finland, which has the highest ESI score, as well as the corresponding differences in each indicator.

The DPSIR model is modified by OECD based on the PSR model and DSR model, which is widely used in the analysis of resource-environmental and socio-economic issues in the international arena[5].The DPSIR model combines the characteristics of DSR ("Driver-State-Response") and PSR. The DPSIR model is a suitable method for evaluating the ecological security of watersheds because it can effectively reflect the causality of the system and integrate the elements of resources, development, environment and human health, etc[6]. The explanation of the DPSIR model is shown in Table 1. Explanation of the DPSIR model.

Table 1. Explanation of the DPSIR model

Concrete meaning	Indicator name	Meaning of the indicator
D(driving)	Driving force indicators	Potential impacts on socio-economic activities in the region, intrinsic causes of ecological changes and future development trends

P(pressure)	Pressure indicators	Normal production and living in the region requires access to resources from the surrounding area or direct impacts on the surrounding environment
S(state)	Status indicators	Various conditions presented by ecosystems that are influenced by drivers and pressures in the region
I(impact)	Impact indicators	The extent to which the various states of ecosystems in the region reflect and influence economic, social, resource and environmental conditions

2.2 Selection of indicators

Based on the relevant literature, by analyzing the actual development of the Beijing-Tianjin-Hebei city cluster and Finland, and taking into account the current situation of the ecological environment and the relevant policies implemented by the state in recent years, a total of 14 relevant indicators are selected in the five dimensions of the DPSIR model, and the model of sustainable development of the ecological environment of the Beijing-Tianjin-Hebei city cluster and Finland is constructed as shown in Table 2. Evaluation index system of ecological environment sustainable development.

Table 2. Evaluation index system of ecological environment sustainable development

Target level indicators	Normative level indicators	Factor-level indicators	Nature of rating indicator
Level of sustainable development	D	GDP per capita ($)	Positive indicators
		Per capita disposable income of residents (yuan)	Positive indicators
		Urbanization rate (%)	Positive indicators
	P	Natural population growth rate (%)	Positive indicators
		Population density (person/square kilometer)	Negative indicators
		Industrial sulfur dioxide emissions (tons/million people)	Negative indicators
	S	Forest Coverage Rate (%)	Positive indicators
		Land area per capita (km2/million people)	Positive indicators
		Water resources per capita (m^3)	Positive indicators

I	Share of tertiary industry in GDP (%)	Positive indicators
	Area of nature reserves per unit (units/million hectares)	Positive indicators
R	Urban greening coverage rate (%)	Positive indicators
	Industrial wastewater discharge compliance rate (%)	Positive indicators
	Sewage treatment rate (%)	Positive indicators

2.3 Data sources

According to the evaluation indexes of ecological sustainable development constructed in this paper, the ecological sustainable development capacity of Beijing-Tianjin-Hebei City Cluster and Finland in 2013-2021 is analyzed and ranked. The data in this paper are mainly from China Statistical Yearbook, Beijing Statistical Yearbook, Hebei Statistical Yearbook, Tianjin Statistical Yearbook and Finland Statistical Yearbook, and part of the data are from China Statistical Bulletin on National Economic and Social Development and China Environmental Situation Bulletin.

2.4 Measurement and analysis of the level of sustainable development

Entropy weighting (physics). In this paper, the Entropy Weight Method Modified Distance between Superior and Inferior Solutions (EWM-Topsis) is used to measure the level of sustainable development.[6] The basic idea of entropy weight method is to determine the target weights according to the variability of indicators. Using the entropy weight method to determine the weights of the indicators can ensure that the results are objective and accurate[7]. By establishing the entropy weight TOPSIS model for comprehensive evaluation of sustainable development, it avoids the interference of subjective factors in the traditional TOPSIS method of calculating the weights by subjective assignment method, and is able to reflect the dynamics of the sustainable development index and the trend of change in a more objective way.

Standardization of raw data. As the nature of evaluation indicators in sustainable development varies, usually in terms of dimension and order of magnitude, this paper adopts a standardized method to process the raw data as a way to eliminate the differences. Indicators showing positive and negative impacts on sustainable development are treated according to formulas (1) and (2), respectively

$$X_{ij}^{'} = \frac{X_{ij} - min\{X_i\}}{max\{X_i\} - min\{X_i\}} \tag{1}$$

$$X_{ij}^{'} = \frac{max\{X_i\} - X_{ij}}{max\{X_i\} - min\{X_i\}} \tag{2}$$

Where X'ij is the standardised value of the jth sample of indicators related to sustainable development in year i, and Xij is the jth original value in year i. Max{Xi} and Min{Xi} are the maximum and minimum values of the jth indicator.

Determination of indicator weights. The entropy weighting method determines the weights according to the amount of information conveyed to decision makers by individual indicators, which enhances the objectivity of indicator evaluation[8]. The calculation process is as follows:

Weighting of indicators：

$$Y_{ij} = \frac{X'_{ij}}{\sum_{i=1}^{m} X'_{ij}} \tag{3}$$

Indicator information entropy：

$$e_j = -k\sum_{i=1}^{m}(Y_{ij}\ln Y_{ij}), \quad k = \frac{1}{\ln m} \tag{4}$$

Information entropy redundancy：

$$d_j = 1 - e_j \tag{5}$$

Indicator weights：

$$w_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \tag{6}$$

In summary, the environmental sustainability indicators and weighting values are shown in Table 3. Environmental sustainability indicators and weightings.

Table 3. Environmental sustainability indicators and weightings

	2013	2014	2015	2016	2017	2018	2019	2020	2021
GDP per capita ($)	0.0782	0.0726	0.0578	0.0651	0.0635	0.0624	0.0551	0.0539	0.0653
Per capita disposable income of residents (yuan)	0.1659	0.1530	0.1403	0.1477	0.1360	0.1353	0.1268	0.1212	0.1155
Urbanization rate (%)	0.0060	0.0054	0.0047	0.0046	0.0040	0.0037	0.0032	0.0026	0.0400
Natural population growth rate (%)	0.0622	0.0703	0.1244	0.0807	0.0774	0.0924	0.0885	0.1415	0.0557
Population density (person/square kilometer)	0.0912	0.0899	0.0891	0.0978	0.0961	0.0971	0.0913	0.0893	0.0547
Industrial sulfur dioxide emissions (tons/million people)	0.0748	0.0731	0.0730	0.0833	0.0788	0.0806	0.0869	0.0799	0.0492
Forest Coverage Rate (%)	0.0533	0.0436	0.0431	0.0472	0.0465	0.0472	0.0443	0.0434	0.0600
Land area per capita (km2/million	0.2708	0.2652	0.2624	0.2876	0.2844	0.2887	0.2716	0.2665	0.1725

people)									
Water resources per capita (m^3)	0.1001	0.1318	0.1121	0.0851	0.1134	0.0923	0.1377	0.1095	0.1061
Share of tertiary industry in GDP (%)	0.0074	0.0069	0.0067	0.0062	0.0058	0.0052	0.0045	0.0040	0.0602
Area of nature reserves per unit (units/million hectares)	0.0799	0.0782	0.0773	0.0848	0.0838	0.0850	0.0800	0.0784	0.0437
Urban greening coverage rate (%)	0.0100	0.0097	0.0088	0.0098	0.0101	0.0099	0.0100	0.0096	0.0845
Industrial wastewater discharge compliance rate (%)	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0403
Sewage treatment rate (%)	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0522

Note: The larger the value of a positive indicator, the better the evaluation result; the smaller the value of a negative indicator, the better the evaluation result. (All indicators have been positively weighted)

Dynamic weighting method - quadratic weighting. Dynamic comprehensive evaluation is a development based on static evaluation after the introduction of the time factor, using time as a standard weighted average. The closer to the current time, the greater the weight of the data will be[9]. Drawing on the relevant studies of Tan Long and other scholars, this paper adopts the improved second weighting method.

The weights of 2013-2021 corresponding to t=1,2,3,4,5,6,7,8,9 corresponding to the year are denoted as Wt, and utilizing the monotonically increasing nature of the exponential function, we propose that

$$\mathrm{Wt} = \alpha e^{\beta t}, \alpha, \beta > 0 \tag{7}$$

where α is used as an adjustment factor to allow better normalization for a given β.

In this paper, $\alpha = 0.1$ and $\beta = 0.02078$ are taken.

TOPSIS model based on quadratic weighting. The TOPSIS model, first proposed by Yoon & Hwang[10], is suitable for comparison between multiple indicators and is a ranking method that best fits the ideal solution. After constructing the indicator system based on the DPSIR model, the TOPSIS model is used to rank the indicators. The process is shown below:

Determine the positive and negative ideal solutions from the weighted normalised matrix :

$$\text{positive ideal solution: } V^{+}=\{\max(V_{ij})|i=1, 2...,m\} \tag{8}$$

$$\text{negative ideal solution: } V^{-}=\{\min(V_{ij})|i=1, 2...,m\} \tag{9}$$

Calculate the distance from the ecological sustainability indicators of the Beijing-Tianjin-Hebei urban agglomeration to the positive and negative ideal solutions :

$$D_i^+ = \sqrt{\sum_{i=1}^{n}(vij - V^+)^2} \quad (10)$$

$$D_i^- = \sqrt{\sum_{i=1}^{n}(vij - V^-)^2} \quad (11)$$

Where: indicates the distance to the pove ideal solution, the smaller this value is, the closer the evaluation index is to the positive ideal solution; indicates the distance to the negative ideal solution, the smaller this value is, the closer the evaluation object is to the negative ideal solution.

Calculate the relative closeness C between each evaluation metric and the ideal solution with the following formula :

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (12)$$

Where ： Ci∈[0,1] The larger its value, the closer the evaluation object is to the ideal solution, and the larger the potential for ecological sustainable development.

2.5 Analysis of results

After using the entropy weighting method to determine the corresponding weights of each indicator in Beijing, Tianjin, Hebei and Finland from 2013 to 2021, the weights were weighted twice to obtain the comprehensive weights, and the raw scores were calculated as Table 4. Sustainable Development Score by Province.

Table 4. Sustainable Development Score by Province

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
province					Score				
Beijing	0.31	0.308	0.321	0.327	0.334	0.336	0.333	0.415	0.463
Tianjin	0.26	0.256	0.248	0.269	0.272	0.267	0.259	0.244	0.34
Hebei	0.306	0.308	0.36	0.328	0.32	0.338	0.32	0.268	0.329
Finland	0.692	0.687	0.643	0.668	0.668	0.652	0.665	0.622	0.637

The combined scores after normalizing the raw scores are shown in Table 5. Normalized Sustainable Development Level Score by Province (Country) and they are plotted as shown in Figure 1. Map of levels of sustainable development.

Table 5. Normalized Sustainable Development Level Score by Province (Country)

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Province					Score				
Beijing	0.197	0.198	0.204	0.205	0.21	0.211	0.211	0.268	0.262
Tianjin	0.166	0.164	0.158	0.169	0.17	0.167	0.164	0.157	0.192
Hebei	0.195	0.198	0.229	0.206	0.201	0.212	0.203	0.173	0.186
Finland	0.442	0.441	0.409	0.42	0.419	0.41	0.422	0.401	0.36

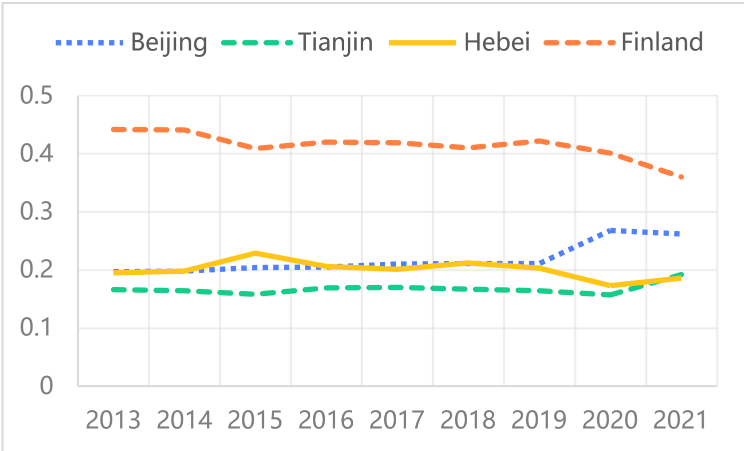

Figure 1. Map of levels of sustainable development

Descriptive statistics of the above data and synthesizing the results of growth rates over the years, it can be known that the overall level of sustainable development in the Beijing-Tianjin-Hebei region has increased slightly over the past nine years, and the overall level of sustainable development in the Finnish region has decreased slightly over the past nine years. The annual average of the measurement score of the Beijing-Tianjin-Hebei region increased from 0.292 in 2013 to 0.377 in 2021, with an average annual growth rate of 3.24%; it is worth noting that many regions showed negative growth in 2019 and 2020, and sustainable development slowed down in 2021, and the growth rate was rapid. Overall the annual positive growth is more than the number of negative growth, and the nine-year average growth level of sustainable development is also at a high level, indicating that the level of sustainable development in Beijing, Tianjin and Hebei, as well as in Finland, has continued to improve over the nine-year period.

3 Comparative analysis of the Beijing-Tianjin-Hebei and Finnish sustainable development indices

3.1 Measurement of the Thiel index

Model Introduction. The Theil index measures the overall disparity and the degree of inequality between groups and within groups, with the smaller the result of the index indicating less variability between regions. The Theil index facilitates the comparison of intra- and inter-group differences and their impact and contribution to the overall regional disparity . The formula is as follows:

$$T = T_b + T_w \tag{13}$$

$$T_b = \sum_{k=1}^{3} \left(\frac{S_k}{S_a} \right) \ln \left(\frac{S_k / S_a}{N_k / N} \right) \tag{14}$$

$$T_w = \sum_{k=1}^{3} \left(\frac{S_k}{S_a} \right) \left(\sum_{c \in g_k} \frac{S_c}{S_k} \ln \frac{S_k / S_a}{1 / N_k} \right) \tag{15}$$

Analysis of regional differences in the Beijing-Tianjin-Hebei region

Table 6. Results of the calculation of the Tyrell index

	2012	2013	2014	2015	2016	2017	2018	2019	2020
Overall gap	0.1382	0.1323	0.1158	0.121	0.1107	0.1089	0.1055	0.0977	0.0815
Gap between groups	0.0907	0.0916	0.0734	0.0667	0.0699	0.064	0.0747	0.0582	0.0512
Gaps within the group	0.0475	0.0408	0.0424	0.0544	0.0308	0.0449	0.0308	0.0395	0.0303

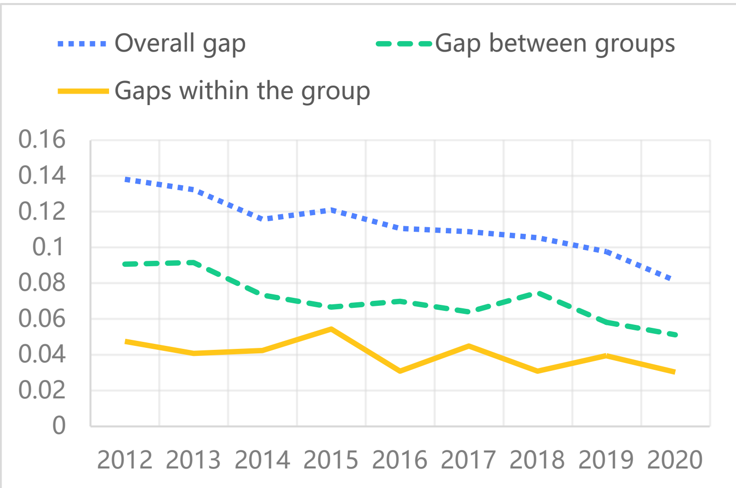

Figure 2. Gap Score Chart

The results of the analysis in Table 6. Results of the calculation of the Tyrell index and Figure 2. Gap Score Chart show that environmental sustainable development exhibits obvious regional differences, with the overall differences showing a decreasing trend, but the contribution of inter-regional differences to the total differences is increasing year by year. From 2012 to 2020, the overall disparity in the Beijing-Tianjin-Hebei region shows a decreasing trend, and the inter-group disparity and the intra-group disparity are also decreasing synchronously although there are some fluctuations in the process, which indicates that the environmental sustainable development in the Beijing-Tianjin-Hebei region shows a certain degree of convergence, and it is not difficult to infer that the effect of vigorously carrying out the strategy of sustainable development and other special promotional actions is gradually appearing, but the possible regional The implementation of differentiated policies also makes the impact of the differences in the sustainable development indexes of the three major regions of the East, the Middle East and the West on the overall differences is gradually expanding. A decomposition analysis of the overall differences in the SDI reveals that the overall differences mainly come from the internal differences within the three regions, while the intra-regional differences are mainly caused by the inter-provincial differences in Hebei Province.

3.2 Kernel density estimates for sustainable development at the aggregate level

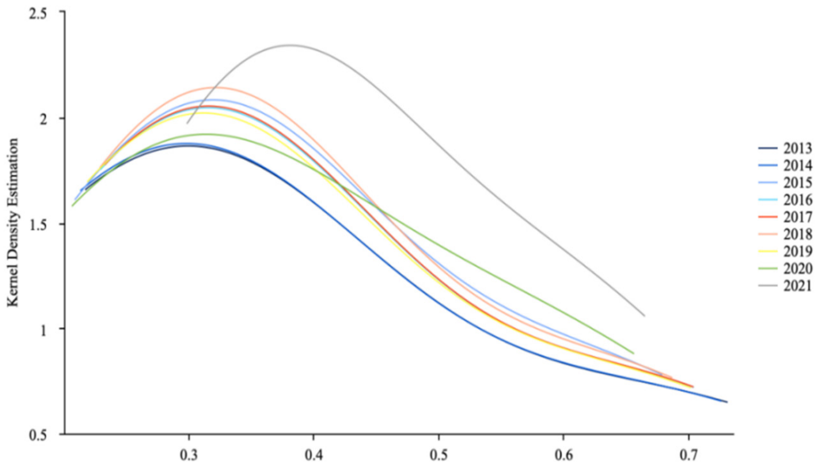

Figure 3. Kernel density estimates for sustainable development at the corporate level

As shown in the Figure 3. Kernel density estimates for sustainable development at the corporate level, the dynamic evolution of the kernel density of the overall sustainability level in Beijing-Tianjin-Hebei and Finland is shown in the figure. From the figure, it can be seen that from the distribution position, the sustainable development kernel density curve gradually shifts to the right, indicating that the overall sustainable development level is in an upward trend, which indicates that for the world, the sustainable development level presents a certain good momentum. However, it has been in a single-peak state, which shows that the possibility of multi-polarization is not high and still follows the overall upward trend.

Kernel density estimates of the level of sustainable development at the subregional level

Nuclear density estimates for the Beijing-Tianjin-Hebei region

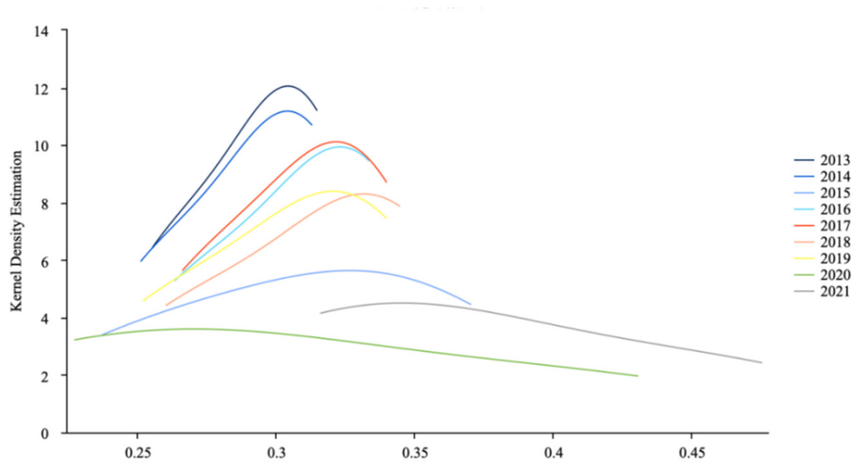

Figure 4. Estimated nuclear density in the Beijing-Tianjin-Hebei region

As shown in the Figure 4. Estimated nuclear density in the Beijing-Tianjin-Hebei region, the figure demonstrates the dynamic evolution of the kernel density of the level of sustainable development in the Beijing-Tianjin-Hebei region. From 2013 to 2015, the Kernel curve shifts to the lower right as a whole, and the width has a tendency to expand, indicating that the level of sustainable development continues to rise and there is a certain degree of variability in the Beijing-Tianjin-Hebei region during this period. However, from 2016 to 2020, the Kernel curve shifts left upward and continues to move downward on the original basis, indicating that the difference in the level of sustainable development in Beijing-Tianjin-Hebei decreases during this period of time, and the overall score tends to be consistent, and there is a dynamic convergence characteristic. In 2021, the Kernal curve shifts to the right and its width continues to expand, proving that the sustainable development of the Beijing-Tianjin-Hebei region has steadily improved in this year, and the differences have widened again.

The above figure accurately reflects the individual changes in the level of sustainable development in the Beijing-Tianjin-Hebei region and the overall variability of the level of sustainable development from 2013 to 2021. It can be concluded that the level of sustainable development of the three provinces is maintained at the higher level in the past years until 2021, and it can be judged by the trend that the differences in the level of sustainable development will be narrowed and continue to improve steadily after that.

Kernel density estimates for Finland

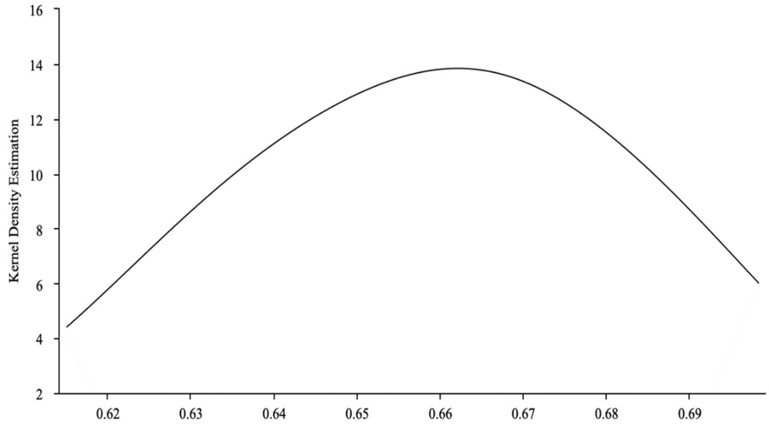

Figure 5. Kernel density estimates for Finland

As shown in the Figure 5. Kernel density estimates for Finland, the figure illustrates the dynamic evolution of kernel density for the level of sustainable development in Finland. As can be seen from the figure, the estimated effects of kernel density in Finland are almost identical from year to year, with an overall trend of widening width, indicating some variability.

The estimated kernel density effect of Finland, as the first country in the global ranking of sustainable development level, can reflect the stabilization of sustainable development level in recent years. To sum up, for the kernel density map, the development level of Beijing-Tianjin-Hebei region is still different from Finland to a certain extent, and we need to further stabilize the development in order to better achieve sustainable development and modernization of Chinese style.

4 Empirical study of factors affecting sustainable development

In the above study, the DPSIR-TOPSIS model was used to measure the level of regional sustainable development in the Beijing-Tianjin-Hebei region as well as in Finland from 2013 to 2021, and to analyze the spatial and temporal evolution patterns of the level of sustainable development in each city. In order to further explore the influencing factors of the sustainable development level of Beijing-Tianjin-Hebei, the Tobit regression model was used to analyze the degree of influence of each indicator on the regional sustainable development level based on the existing research results and available data.

4.1 Variable Selection

The selection of explanatory variables in Tobit regression needs to have a causal relationship with the explanatory variable regional sustainable development level, after reading a large amount of literature, the explanatory variables that have an obvious causal relationship with the level of regional sustainable development are selected as follows, and the variables of Tobit model are listed in Table 7. Tobit model variables:

Table 7. Tobit model variables

Factor	Explanatory variable	Variable symbol
Economic factor	GDP per capita ($)	Z1
	Per capita disposable income of residents (yuan)	Z2
Social factor	Urbanization rate (%)	Z3
	Natural population growth rate (%)	Z4
	Population density (person/square kilometer)	Z5
Resource environmental factors	Industrial sulfur dioxide emissions (tons/million people)	Z6
	Forest Coverage Rate (%)	Z7
	Per capita water resources (m^3)	Z8
	Share of tertiary industry in GDP (%)	Z9
	Urban greening coverage rate (%)	Z10
	Sewage treatment rate (%)	Z11

4.2 Data sources

The data used in the regression analysis are from China Statistical Yearbook, Beijing Statistical Yearbook, Hebei Statistical Yearbook, Tianjin Statistical Yearbook, Statistical Yearbook of Finland for the years 2013-2021, and some of the data are from China Statistical Bulletin of National Economic and Social Development, and China Bulletin of Environmental Conditions.

4.3 Tobit model and regression analysis results

Considering the explanatory variables and the Tobit model, the relationship between the level of sustainable development of the region and the influencing factors is as follows:

$$T_{i,t}=\beta_0+\beta_1 \ln z_1+\beta_2 \ln z_2+\beta_3 \ln z_3+\beta_4 \ln z_4+\beta_5 \ln z_5+\beta_6 \ln z_6+\beta_7 \ln z_7+\beta_8 \ln z_8+\beta_9 \ln z_9+\beta_{10} \ln z_{10}+\beta_{11} \ln z_{11}+\varepsilon_{i,t}$$

Where: Ti,t is the level of regional sustainable development in year t in region i; β_1, β_2, β_3.... .β_{11} are the regression coefficients of the influencing factors; β_0 is the intercept term of the regression equation; εi,t is the random error.The regression results of the Tobit model can be estimated by maximum likelihood estimation method using stata16 software, and the results are listed in the Table 8. Tobit model regression results.

Table 8. Tobit model regression results

Item	Ratio	Sandard error	T	P	Coefficient 95% confidence interval	
					Upper bound	Lower limit
Constant	-0.185	0.376	-0.492	0.623	0.552	-0.921
z1	-0.159	0.002	-2.219	0.027**	0	0
z2	0.343	0	2.768	0.006***	0	0
z3	0.0286	0	2.159	0.031**	0.002	0
z4	0.009	0.003	3.307	0.001***	0.015	0.004
z5	-0.145	0	0.463	0.644***	0	0
z6	-0.001	0	2.26	0.024**	0.001	0
z7	-0.002	0.002	-1.124	0.261	0.002	-0.006
z8	0.012	0.108	2.15	0.032**	0	0
z9	-0.005	0.002	-2.763	0.006***	-0.001	-0.009
z10	0.013	0.006	2.278	0.023**	0.025	0.002
z11	-0.001	0.003	-0.466	0.641	0.004	-0.006

Note: ***, **, * represent 1%, 5%, and 10% significance levels, respectively.

According to the regression results, it can be seen that the level of economic development, population growth rate and resource ownership in the Beijing-Tianjin-Hebei region have a significant impact on the level of regional sustainable development. Among them, per capita disposable income, urbanization rate, natural population growth rate, per capita water resources, and urban green coverage have a significant positive impact on the level of regional sustainable development, while population density, per capita sulfur dioxide emissions from industry, and the proportion of tertiary industry in GDP have a significant negative impact on the level of sustainable development.

5 Conclusions and recommendations

5.1 Reach a verdict

The level of sustainable development in the Beijing-Tianjin-Hebei region has been increasing since 2013, but regional disparities are also widening, which is expected to lead to a multipolar pattern in the future. This suggests that the concept of sustainable development has played an initiating role in laying a good foundation at the beginning of the study scope, and has been extended to the Jing-Jin-Ji regions at a faster pace and higher quality.

The Beijing-Tianjin-Hebei region has large gaps and imbalances compared to the Finnish region. The difference was large at the beginning of the 2013-2016 timeframe, but after 2017, as the concept of sustainable development continues to grow in China, the overall level of sustainable development in the Beijing-Tianjin-Hebei region continues to improve along with the implementation of sustainable development policies, and the impact is significant[11].

The level of economic development, population growth rate and resource ownership are important factors affecting the level of regional sustainable development, of which GDP per capita, per capita disposable income, natural population growth rate, per capita water resources, sewage treatment rate has a significant positive impact on the level of sustainable development of the Beijing-Tianjin-Hebei region, and the population density, per capita sulfur dioxide emissions from the industrial sector, and the share of the tertiary industry in GDP have a significant negative impact on the level of sustainable development. development level.

5.2 Suggestion

Based on the above conclusions, the following policy recommendations are proposed:

Adopt regional differentiated development strategies to narrow regional development gaps. Considering the diversity and imbalance in the level of sustainable development in each region as derived from the article, policy formulation should not only fully reflect local characteristics and differences, but also categorize and implement specific guidelines to coordinate development between and within regions. Strengthen synergistic cooperation in the Beijing-Tianjin-Hebei region and promote cross-regional cooperation and resource sharing[12]. Jointly solve regional environmental problems and social conflicts to achieve optimal allocation of resources and mutual benefit.

Carry out the construction of sustainable development from the aspects of economic structure, social development, resource control and environment. In terms of economic structure, promote industrial transformation, develop and improve the tertiary industry, get rid of the traditional high-energy-consuming industrial model, and change to a low-carbon industrial model; in terms of social development, adopt encouraging birth policies moderately, and increase the natural growth rate of the population; in terms of resource control, make efforts to increase the per capita amount of renewable energy, such as wind energy, water energy, tidal energy, etc., and replace the traditional high-energy-consuming coal, oil, natural gas, etc.;[13] in terms of environmental protection, increase the amount of renewable energy per person, Natural gas, etc.; in terms of environmental protection, increase the recycling of waste, control the emission of pollutants, through the promotion and application of relevant high-tech pollution treatment, reduce the emission of waste and environmental pollutants, and improve the utilization rate of resources.

Sustainable development should adhere to the principles of systematic promotion, key breakthroughs, social co-governance, incentives and constraints. Multi-directional promotion of the implementation of sustainable development measures, taking into account the smooth connection between consumption and production, circulation and recycling. It is necessary to give full play to the role of the market mechanism, give better play to the role of the economic system mechanism, and strive to mobilize the enthusiasm and creativity of all aspects of society[14]. Adhere to the goal of green and low-carbon, deepen and improve the system of relevant laws, standards, statistics and other systems in the field of consumption.

Multi-party coordination for sustainable development. The government should focus on solving the problem of imbalance in the level of sustainable development in different regions and increase the popularization rate of the concept of sustainable development[15]. Communities should take the initiative to guide residents and increase their awareness and acceptance of sustainable development. Strengthen public awareness of and participation in environmental protection and increase the popularity of environmental education. Encourage public participation in the decision-making process to increase transparency and fairness. Enterprises should strengthen the interactive R&D and application of products derived from sustainable development and Internet technologies, and accelerate the greening and digital transformation of their products. Promote industrial transformation and the transformation and upgrading of the industrial structure in the Beijing-Tianjin-Hebei region, and reduce reliance on traditional high-energy-consuming and high-polluting industries. Encourage the development of clean technologies and green industries, increase the proportion of environmentally friendly industries, and promote sustainable economic development.

References

[1] Xie Yingting,Sun Hongmei. Evaluation of the sustainable development level of urban natural ecosystems--comparison between Shanghai and Tokyo as an example[J]. Environment and Sustainable Development,2021,46(06):162-168.DOI:10.19758/j.cnki.issn1673-288x.202106162.

[2] ZHAO Duo,LU Jianbo,MIN Huai. Establishment of evaluation index system for sustainable development of ecological environment in Zhejiang Province[J]. Environmental Pollution and Prevention,2003(06):380-382.

[3] WANG Huijuan, LAN Zongmin. Construction, Measurement and Evaluation of Sustainable Development Indicator System for Chinese Cities[J]. Business and Economic Research,2022(07):184-188.

[4] Sharpley Richard. Tourism, sustainable development and the theoretical divide: 20 years on[J]. Journal of Sustainable Tourism,2020,28(11).

[5] Cheng Kaiming,Wu Ximeng,Zhuang Yanjie. New dynamics of new economy in China's provincial areas: statistical measurement, spatial pattern and association network[J]. Statistical Research,2023,40(03):18-31.DOI:10.19343/j.cnki.11-1302/c.2023.03.002.

[6] SUN Zexiao,ZHAO Banghong,QIN Anchen,ZHU Kexi. Measurement of sustainable development of rural tourism in ecologically fragile areas and analysis of influencing factors--Taking Dongchuan District of Kunming as an example[J]. Ecological Economy,2022,38(03):157-163+170.

[7] LI Hengji,QU Jiansheng,PANG Jiaxing,XU Li,HAN Jinyu. Spatial and temporal integrated measurement of population-economy-society-resource-environment system coupling coordination and sustainable development in Gansu Province[J]. Arid Zone Geography,2020,43(06):1622-1634.

[8] Zakari Abdulrasheed,Khan Irfan,Tan Duojiao,Alvarado Rafael,Dagar Vishal. energy efficiency and sustainable development goals (SDGs)[J]. Energy,2022,239(PE).

[9] Erling Holden,Kristin Linnerud,David Banister. The Imperatives of Sustainable Development[J]. Sustainable Development,2017,25(3).

[10] Deer Chenyu,Zhang Lin,Xue Bing,Zhang Zilong,Li Hengji,Lu Chengpeng. Research on spatio-temporal comprehensive measurement of regional sustainable development in Liaoning Province[J]. Economic Geography,2015,35(08):32-39.DOI:10.15957/j.cnki.jjdl.2015.08.005.

[11] YUAN Xiaoling,LIANG Peng,CAO Minjie. Measuring the quality of urbanization development in Shaanxi Province based on sustainable development[J]. Urban Development Research,2013,20(02):52-56+86.

[12] Li Ting. Policy evaluation of ecological environment sustainable development in Beijing-Tianjin-Hebei city cluster--Based on DPSIR-TOPSIS model[J]. Ecological Economy,2022,38(05):107-113.

[13] Edward R. Carr,Philip M. Wingard,Sara C. Yorty,Mary C. Thompson,Natalie K. Jensen,Justin Roberson.Applying DPSIR to sustainable development[J]. International Journal of Sustainable Development & World Ecology,2007,14(6).
[14] Agramont Afnan,van Cauwenbergh Nora,van Griesven Ann,Craps Marc. Integrating spatial and social characteristics in the DPSIR framework for the sustainable management of river basins: case study of the Katari River Basin, Bolivia[J]. Water International,2022,47(1).
[15] YANQI ZHANG, GUILI TANG, WENCHANG WANG, LING LIU, ZENGWEI ZHAO, BOTO GUO, YAZHOU WU, DONG YI. Application of Gini coefficient and Terrell index in the study of equity in health resource allocation[J]. China Health Statistics,2008(03):243-246.