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Evaluation Method and Empirical Study of Regional Collaborative Sustainable Development under Environmental Regulation

Mei Feng[1], Xinyi Li[1] and Wenbiao Fu[2]*

[1]Donlinks School of Economics and Management, University of Science and Technology Beijing ,No.30,Xueyuan Road, Haidian District, Beijing, 100083, PR China

[2]Development Research Center, State Administration for Market Regulation, No.9 Madian East Road, Haidian District, Beijing 100088, PR China

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According to the "pollution haven hypothesis", polluting industries may shift from developed areas to underdeveloped areas, which may lead to an unbalanced environmental regulation effect in a region consisting of several provinces. This means that the environmental regulation in various provinces will have on impact on regional collaborative sustainable development (RCSD). Therefore, this paper adds environmental regulation to the RCSD evaluation system, adopts a combination of TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) and grey relational analysis, establishes a distance collaborative model, and uses the empirical data of the Beijing–Tianjin–Hebei region (BTH region) from 2007 to 2016, evaluate the RCSD under environmental regulation. The evaluation results show that the development levels in Beijing, Tianjin, and Hebei are quite different and that there is a feature of unbalanced development; From 2007 to 2016, the level of comprehensive synergy development in the BTH region is at a steady rising stage, but the upward trend is not obvious and there is little change.

Keywords: Environmental regulation; Regional collaborative development; Sustainable development; Beijing-Tianjin-Hebei region

Introduction

Along with the continuous development of China's economy, the problem of excessive consumption of energy resources and destruction of the natural environment has become more prominent.[1,2] Environmental regulation is environmental laws, regulations and policies formulated by the government to protect the environment.[3] The means and intensity of environmental regulation vary according to local government, which may result in an unbalanced environmental regulation effect. Although the environmental regulation effect in some areas is good, it has caused environmental pollution in the surrounding areas. Therefore, environmental regulation plays an important role in the coordinated development of regions composed of several provinces. For China, the development of different provinces is quite different, and regional collaborative development is an important strategic goal for China's development. According to the "pollution haven hypothesis", polluting industries will shift to areas with low environmental regulation, which is not conducive to regional collaborative development. Therefore, it is necessary to evaluate the collaborative and sustainable development of a region from the perspective of environmental regulation. In this paper, TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) and grey relational analysis are combined to establish a distance collaborative model. Taking the Beijing–Tianjin–Hebei (BTH) region as an example, the regional sustainable development under environmental regulation can be evaluated.

System composition and evaluation model construction

The composition of the RCSD system under environmental regulation

Based on existing studies,[4,5,6] this paper analyzes and evaluate the regional collaborative sustainable development (RCSD) system under environmental regulation from two perspectives, which is shown in Fig. 1 On the one hand, this paper divides the sustainable development system under environmental regulation of a province into four subsystems:

Author for Correspondence:
Email: fuwb@samrdrc.org.cn

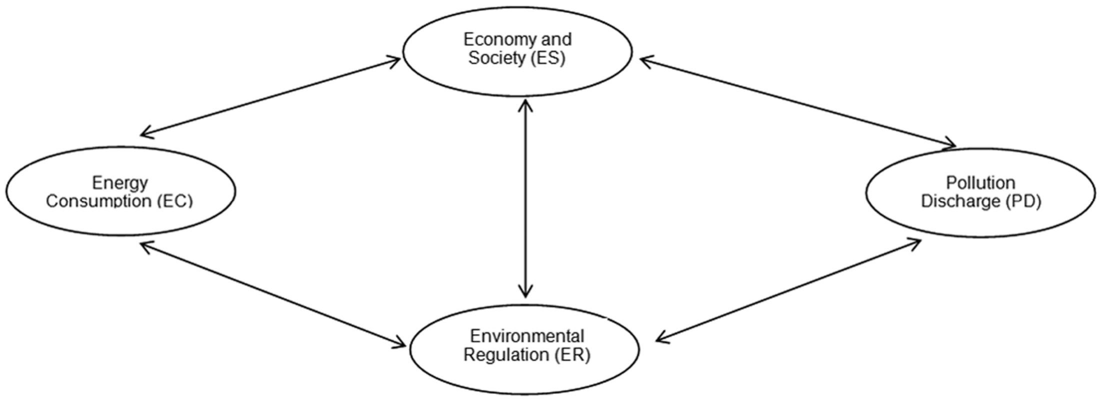

Fig. 1 — The composition of a regional collaborate sustainable development system under environmental regulation

Economy and Society (ES) subsystem, Environmental Regulation (ER) subsystem, Energy Consumption (EC) subsystem, and Pollution Discharge (PD) subsystem. These four subsystems impact each other. On the other hand, the various provinces are regarded as a subsystem for RCSD, and the comprehensive synergistic development of the entire region is further explored by combining economy and society, environmental regulation, energy consumption, and pollution discharge.

Evaluation model construction

The TOPSIS method is a multi-objective decision analysis method, which can measure the Euclidean distance between the actual state and the ideal state of the evaluation object and determine the relative development level. Grey relational analysis is a method that can find the relationship between subsystems in a system. This paper combines these two methods to establish a distance collaborative model to evaluate the collaborative sustainable development of the BTH region under environmental regulation.

(1) Standardization of evaluation indicators

First of all, it is necessary to standardize the data to eliminate the difference caused by different dimensions. This paper chooses range transformation method to standardize the data.

(2) Calculation of index weights

The entropy method is an objective weighting method for determining index weights through information entropy. In information theory, entropy is a measure of uncertainty. The greater the degree of variation in the indicator, the greater the impact of the indicator on the overall evaluation. In this study, the entropy method is used to determine the weight of each subsystem in the comprehensive evaluation. Drawing on Yang *et al*.[8], the weight of every subsystem can be obtained through entropy method.

Next, drawing on the study from Li and Liu[6],

(3) Determine the positive and negative ideal points of each subsystem and calculate the development degree d_{it}.

(4) Calculate the grey relational degree and determine the pull factors. In this paper, the weight of the absolute quantity and the rate of change are the same.

(5) Calculate the ideal development value and synergy degree of each subsystem.

(6) Calculate the comprehensive synergy development degree of the entire system.

Empirical Analysis

Evaluation Index System

According to the above, the evaluation index system can be divided into four parts. Based on the consistency and availability of data, this paper selects 16 indicators from ES, EG, EC, and PD and establishes an evaluation index system in Table 1.

Data processing and result analysis

This paper uses the related data from 2007 to 2016 in Beijing, Tianjin, and Hebei to analyze the collaborative sustainable development of the BTH region. The data come from the China Statistical Yearbook, the China Environmental Statistics Yearbook, the National Bureau of Statistics website, and the Wind database. All the data related to the value pattern in this paper are adjusted to the constant value based on the year 2000. All data were processed as described above in a standardized manner.

Table1 — Evaluation Index System for RCSD under Environmental Regulation

Primary indicators	Secondary indicators	Unit
1 Economy and Society	11 Regional GDP	Yuan
	12 Per capita GDP	Yuan
	13 The Proportion of the added value of the secondary industry to GDP	%
	14 Urbanization Rate	%
2 Environmental Regulation	21 The Proportion of the Environmental Pollution Control Investment to GDP	%
	22 Industrial Pollution Control Completed Investment	Yuan
	23 Completed Investment in the Treatment of Waste Gas Projects	Yuan
	24 Completed Investment in the Treatment of Wastewater Projects	Yuan
3 Energy Consumption	31 Electricity Consumption	kW·h
	32 Coal Consumption	ton
	33 Gasoline Consumption	ton
	34 Natural gas consumption	m^3
4 Pollution Discharge	41 Carbon Dioxide Emission	ton
	42 Sulfur Dioxide Emission	ton
	43 Wastewater Discharge	ton
	44 Total Smoke and Dust Emission	ton

Table 2 — CDs of four subsystems and CDD in Beijing, Tianjin, and Hebei

Year	Beijing					Tianjin					Hebei				
	Development Degree				CDD	Development Degree				CDD	Development Degree				CDD
	ES	ER	EC	PD		ES	ER	EC	PD		ES	ER	EC	PD	
2007	0.527	0.395	0.625	0.745	0.470	0.422	0.381	0.814	0.782	0.412	0.303	0.441	0.536	0.384	0.417
2008	0.537	0.342	0.605	0.739	0.430	0.432	0.374	0.807	0.783	0.414	0.321	0.478	0.540	0.388	0.429
2009	0.545	0.357	0.586	0.699	0.434	0.447	0.399	0.772	0.782	0.432	0.346	0.389	0.521	0.394	0.416
2010	0.553	0.348	0.577	0.705	0.427	0.463	0.389	0.731	0.777	0.435	0.367	0.393	0.497	0.392	0.414
2011	0.564	0.316	0.571	0.694	0.404	0.478	0.382	0.707	0.775	0.439	0.387	0.494	0.459	0.292	0.383
2012	0.575	0.373	0.547	0.701	0.435	0.494	0.324	0.675	0.760	0.421	0.407	0.446	0.444	0.302	0.379
2013	0.587	0.397	0.539	0.696	0.449	0.509	0.338	0.698	0.760	0.436	0.425	0.525	0.427	0.293	0.387
2014	0.601	0.438	0.525	0.689	0.472	0.524	0.398	0.678	0.751	0.471	0.440	0.607	0.434	0.254	0.389
2015	0.618	0.368	0.502	0.688	0.421	0.543	0.350	0.634	0.755	0.459	0.460	0.463	0.376	0.294	0.371
2016	0.635	0.425	0.492	0.673	0.456	0.571	0.214	0.617	0.777	0.413	0.479	0.381	0.377	0.380	0.396

Evaluation of sustainable development systems in three provinces

According to the entropy method described above, the weights of the subsystems in the three provinces can be calculated. The weights of subsystems of ES, ER, EC and PD in Beijing are 0.049, 0.655, 0.293 and 0.003. The weights of four subsystems in Tianjin are 0.533, 0.447, 0.018 and 0.002. Moreover, the weights of four subsystems in Hebei are 0.172, 0.167, 0.246 and 0.415.

According to the definition of the entropy method, the greater the information difference, the more information provided, and the larger the weight. The three provinces have great differences in all aspects. In Beijing, the environmental regulation subsystem has the largest weight. It can be seen that the investment in environmental regulation has changed greatly in recent years, and Beijing has paid more attention to the protection of the environment. Tianjin has experienced rapid economic development in recent years, and its emphasis on environmental protection has changed significantly. The weights of energy consumption and pollution discharge in Tianjin are small and the situation in Beijing is similar. Compared with Beijing and Tianjin, the proportion of the environmental regulation subsystem in Hebei is relatively small, reflecting the fact that the local attention paid to environmental protection is inadequate. According to step (3), combined with the weights of the three subsystems, the development degree (DD) and comprehensive development degree (CDD) of the sustainable development subsystems under the environmental regulations in Beijing, Tianjin and Hebei are shown in Table 2. It can be seen that the DD of each ES subsystem is increasing year by year, and the DD of the ER subsystem has certain fluctuations, which may be related to the cycle of the five-year planning. From the comprehensive comparison of the three places, the rankings are Beijing, Tianjin, and Hebei. This trend is in line with the general understanding of the development of the three provinces. As the capital, Beijing has the highest level of development, and its development in terms of combating environmental pollution is particularly prominent. This is because the proportion of secondary industry in Beijing is not high, and much emphasis is placed on protecting the environment.[7] Moreover, the implementation of environmental regulations is better. The development of environmental regulation and energy resources of the three provinces are not far behind, and the development degree of combating environmental pollution is quite different. Due to Hebei having the largest population and land resources of the three provinces, the implementation effect there is poor under the same resources input, resulting in a large gap in development of measures to combat environmental pollution. Hebei is also the province with the lowest environmental regulation intensity in these three provinces. From 2010 to 2015, its degree of development in terms of environmental protection dropped significantly. This may be due to the transfer of polluting industries from other regions, which also reflects the effect of “pollution haven”.

Evaluation of RCSD System under Environmental Regulation in BTH region

In this part, the three provinces of Beijing, Tianjin, and Hebei are regarded as three subsystems. Based on step (4) and (5), the grey comprehensive relational degree between each subsystem is calculated, and the pull factor between each subsystem is obtained. Thus, the DD and synergy degree (SD) of each subsystem, and the CDD, comprehensive SD (CSD), and comprehensive synergy development degree (CSDD) of the BTH region are calculated. The calculation results of several kinds of degrees are shown in Table 3.

The following conclusions can be drawn from the evaluation result:

(1) In the coordinated development of the BTH region, the pull factors of Beijing to Tianjin and Beijing to Hebei are 1.27 and 1.38, respectively. This shows that the development level of Beijing is above those of the other two provinces, which has a pulling effect on the development of Tianjin and Hebei. Therefore, the leading role of Beijing should be utilized fully to promote the coordinated development of the BTH region.

(2) The degrees of development of Beijing, Tianjin, and Hebei go from highest to lowest, in that order. From the perspective of synergy, the degree of synergy of Tianjin is the highest, indicating that sustainable development under environmental regulation in Tianjin is the best of the three. This may be due to the fact that, in terms of the development of Beijing, Tianjin, and Hebei, the industrial layout in Tianjin is relatively reasonable, and this province does not have too many polluting industries. At the same time, its own environmental regulation effect is good, which enables it to meet the level of development it merits in the BTH region (close to ideal development).

(3) From 2007 to 2016, the CDD, CSD, and CSDD, of the BTH region have not changed much. In 2008, there was relatively prominent growth. When the Beijing Olympic Games were held, the data of the region performed relatively well. In

Table 3 — Comprehensive Synergy Development Degree of Beijing, Tianjin and Hebei Regional Subsystem

	DD			CDD	SD			CSD	CSDD
	Beijing	Tianjin	Hebei		Beijing	Tianjin	Hebei		
2007	0.588	0.570	0.371	0.510	0.795	0.991	0.621	0.788	0.634
2008	0.572	0.573	0.399	0.514	0.812	0.988	0.663	0.810	0.646
2009	0.562	0.585	0.358	0.501	0.807	0.951	0.607	0.775	0.622
2010	0.560	0.581	0.347	0.496	0.803	0.949	0.595	0.768	0.614
2011	0.557	0.582	0.355	0.498	0.807	0.949	0.607	0.775	0.621
2012	0.563	0.564	0.326	0.484	0.790	0.959	0.571	0.757	0.605
2013	0.571	0.578	0.358	0.502	0.800	0.965	0.607	0.777	0.625
2014	0.578	0.602	0.415	0.532	0.823	0.969	0.667	0.810	0.656
2015	0.557	0.593	0.332	0.494	0.803	0.930	0.570	0.752	0.610
2016	0.566	0.568	0.330	0.488	0.791	0.960	0.575	0.759	0.609

2015, they declined. This may be due to the fact that, in 2014, China proposed to reduce Beijing's non-capital function. The development goal of the proposal is to build Beijing first, which may cause a decline in these degrees of development in a short period of time.

Conclusions

This paper adds environmental regulation factors into the evaluation of the sustainable development system, adopts the combination of TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) and grey relational analysis, establishes a distance collaborative model, and uses the empirical data of the Beijing–Tianjin–Hebei (BTH) region from 2007 to 2016 to evaluate the regional collaborative sustainable development (RCSD) under environmental regulation. The main conclusions are as follows:

(1) The respective development of Beijing, Tianjin, and Hebei shows great differences. For example, Beijing pays more attention to environmental protection, has stronger environmental regulations, and achieves better results. Tianjin is second. However, the economic development of Hebei Province is highly dependent on secondary industry, so the environmental regulation effect is poor.

(2) According to the empirical results, the volatility of the data shows a cyclical trend consistent with China's Five-Year Plan, indicating that the regional coordinated sustainable development is related closely to national policies and plans.

(3) From 2007 to 2016, the comprehensive synergy development of the BTH region has not changed much, indicating that the various policies and economic developments in recent years have not had a strong impact on the RCSD system under environmental regulation of BTH. The stimuli and impacts of the system's continued development have yet to be explored.

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Reference

1 Feng M, Yan Y & Li X, Measuring the Efficiency of Industrial Green Transformation in China. *J Sci Ind Res*,**7**(2019):495-498

2 Ma D, He F, Li G & Deng G, Evaluation of Chinese Environmental Efficiency based on CEPI. *J Sci Ind Res*,**3**(2019):139-143

3 Feng M, Li X, Technological Innovation Threshold Characteristic of the Impact of Environmental Regulation on Carbon Emission Based on Chinese Provincial Panel Data *J Sci Ind Res*,**5**(2019):274-277

4 Zheng D, Shi M, Multiple environmental policies and pollution haven hypothesis: Evidence from China's polluting industries. *J Clean Prod*, **141**(2017):295-304

5 Sun Y, Li G, Evaluation and upgrading of the Beijing-Tianjin-Hebei regional collaborative innovation capacity, *Prog in Geo*, **36**(2017) 78-86.

6 Li H, Wang S & Liu Y, Evaluation method and empirical research of regional synergetic development degree based on grey relational theory and distance collaborative model, *Sys Engi-Theo & Prac*, **07**(2014) 1749-1755.

7 Cheng, Y., Ren, J, Chen, Y & Xu C, Spatial evolution and driving mechanism of China's environmental regulation efficiency. Geogr Res-Aust, (2016):123-136. (in Chinese)

8 Solarin S A, Al-Mulali U & Musah I, Investigating the pollution haven hypothesis in Ghana: An empirical investigation. *Energy*, **124**(2017): 706-719.