Temporal and Spatial Changes of Ecological Environment Quality and Its Influencing Factors in Beijing-Tianjin-Hebei Region

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Abstract: Based on a theoretical explanation of the impact of the coordinated development of Beijing-Tianjin-Hebei on eco-environmental quality, this paper takes the first batch of pilot cities implemented in 2015 are regarded as a quasi-natural experiment. Based on the panel data of 61 prefecture-level cities from 2011 to 2021. This paper empirically testes the impact of the coordinated development of Beijing-Tianjin-Hebei on eco-environmental quality using a differences-in-differences model, and analyze the heterogeneity. The findings are as follows: the coordinated development of the Beijing-Tianjin-Hebei region improve the eco-environmental quality, and this result still holds after robustness tests such as the propensity score matching and changing time window; heterogeneity analysis shows that the larger the population size of a city, the greater the impact of coordinated development of Beijing-Tianjin-Hebei region on ecological environment quality . Therefore, government departments should perform their functions, give full play to the role of the coordinated development of Beijing-Tianjin-Hebei in improving the quality of the ecological environment, implement differentiated eco-environment coordinated governance plan based on local conditions, and provide Ecological environment of higher quality.

1. Introduction

A sound ecological environment is a boon to all. Despite long-term efforts, the Beijing-Tianjin-Hebei region has made great achievements in ecological and environmental governance. However, the contradiction between its economic and social development and sustainable development of environment and resources is still prominent. The regional development is unbalanced, and there is still room for improvement in environmental pollution, resource shortage, ecological overload and industrial transformation and upgrading.

The Beijing-Tianjin-Hebei region has become a "community of common destiny" because of its integrated ecological environment and continuous social and economic development. The governments of the Beijing-Tianjin-Hebei region are gradually attaching importance to ecological joint prevention and control and coordinated governance among regions. The Outline of the Plan for Coordinated Development of the Beijing-Tianjin-Hebei Region was officially released and implemented in April 2015. As one of its three major tasks, coordinated ecological and environmental governance took the lead in making breakthroughs. Beijing, Tianjin and Hebei responded quickly by developing a collaborative mechanism, unifying environmental governance standards, and launching a joint law enforcement mechanism. Optimize the energy structure, adjust the industrial structure, control motor vehicle pollution to improve the quality of ecological environment. In May 2020, the Regulations on the Prevention and Control of Pollution from Motor Vehicles and Non-Road Mobile Machinery were implemented simultaneously in the three regions of Beijing, Tianjin and Hebei, marking the first step towards coordinated legislation and law enforcement on ecological environment among the three regions.

At the same time, innovating the collaborative mode of regional development, creating a soft environment conducive to the nested innovation ecosystem of regional ecological collaborative development, reasonable division of labor, differential positioning, active integration, and establishing a regional interest balance mechanism will play a role in improving the performance of ecological collaborative governance in Beijing-Tianjin-Hebei region and supporting the regional green and high-quality development [1-3]. The coordinated development of the Beijing-Tianjin-Hebei region provides a new breakthrough for regional environmental governance. However, the profound impact of the coordinated development of Beijing, Tianjin and Hebei on the quality of the ecological environment needs to be tested and discussed in depth [4-6]. Accurately evaluate the implementation effect of the Beijing-Tianjin-Hebei coordinated development policy in the ecological environment field of the Beijing-Tianjin-Hebei region and the node regions around the Beijing-Tianjin-Hebei region, so as to provide theoretical and practical basis for relevant subjects to formulate the coordinated development policy and improve the ecological environment quality [7-9]. This paper takes the Beijing-Tianjin-Hebei coordinated development policy introduced and implemented in 2015 as the standard natural experiment, selects the data of 61 prefecture-level cities in Beijing-Tianjin-Hebei and surrounding Beijing-Tianjin-Hebei in the past 11 years, adopts the difference difference method to test the impact of Beijing-Tianjin-Hebei coordinated development on regional eco-environmental quality, and conducts an expanded analysis on its heterogeneity [10-13].

2. Theoretical Analysis and Research Hypothesis

According to the connotation of the coordinated development of Beijing, Tianjin and Hebei, promoting the improvement of ecological environment quality is an important content of the coordinated development of Beijing, Tianjin and Hebei. Providing good living environment to the public and improving residents' happiness is one of the goals of the coordinated development of Beijing, Tianjin and Hebei [14]. Based on Porter's hypothesis, industrial agglomeration can promote regional development. Industrial agglomeration generates technology spillover effect among various fields within the region, stimulates technological innovation in the region, reduces pollution emission through technological innovation, and improves the overall competitiveness of the region [15]. Specifically, the theoretical logic of the Beijing-Tianjin-Hebei coordinated development to improve the quality of the ecological environment can be verified respectively from the power source and demand side.

From the perspective of driving force, the Beijing-Tianjin-Hebei coordinated development has

transformed the Beijing-Tianjin-Hebei urban agglomeration into the most dynamic economic growth pole in northern China, a demonstration zone leading China's scientific and technological innovation and progress, and a core area for opening up to the outside world. It also provides new ideas for the coordinated ecological and environmental development of the Beijing-Tianjin-Hebei region. For example, in the construction of collaborative environmental protection mechanism, the establishment of strategic top-level design, air pollution joint prevention and control framework mechanism, the release of air pollution prevention and control action plans in Beijing, Tianjin and Hebei, and the continuous increase of ecological environmental prevention and control regulations [16]. In terms of the industrial access mechanism, Beijing formulated the industry prohibited catalogue and formulated the fiscal and tax policies of the industrial undertaking area [17]. In terms of legal and regulatory system establishment, financial support, resource tax, regional difference standard, ecological compensation mechanism, etc. [18]. In terms of the establishment of the supervision and assessment system, the CPPCC system platform should be fully utilized to play the role of democratic supervision and establish a trans-regional joint supervision mechanism [19].

From the demand side, the coordinated development of the Beijing-Tianjin-Hebei region will also help promote the optimal allocation of resources for coordinated ecological and environmental governance and effectively solve the problem of information asymmetry. At present, one of the most critical obstacles to the coordinated development of Beijing-Tianjin-Hebei region is that different subjects have different interest demands. The establishment of interest coordination mechanism enables all parties to safeguard their own interests and achieve win-win results through information sharing, ecological sharing and ecological co-governance [20]. Based on the above analysis, this paper proposes the hypothesis that the coordinated development of Beijing-Tianjin-Hebei will promote the improvement of ecological environment quality.

3. Research Design

1) Model setting

The factors affecting ecological environment quality must be considered comprehensively; otherwise, the results will have intrinsic deviation. In order to avoid the error caused by missing variables, the difference between two groups with the same trend can be made by the first-order difference within the group and the difference between the groups.

The Beijing-Tianjin-Hebei coordinated development was taken as a policy impact to conduct a quasi-experiment. The Beijing-Tianjin-Hebei and surrounding cities covered by the Beijing-Tianjin-Hebei coordinated development were taken as the treatment group, and the cities not covered were taken as the control group to compare the changes of eco-environmental quality in relevant regions before and after the implementation of the policy. To reflect the implementation effect of the Beijing-Tianjin-Hebei coordinated development policy in the field of ecological environment.

Since the release of the Beijing-Tianjin-Hebei Coordinated Development Plan in 2015, Beijing-Tianjin-Hebei and some cities around Beijing-Tianjin-Hebei have been implemented one after another. The cities in the treatment group are affected by different policies at different times. Therefore, the following multi-time point differential model is adopted in this paper to carry out empirical test.

$$E_{it} = \partial_0 + \partial_1 * did_{it} + \partial_2 * control_{it} + \mu_i + \lambda_i + \varepsilon_{it} \qquad (1)$$

$$did_{it} = post_i \times treat_t \qquad (2)$$

Where E is the explained variable, refers to the comprehensive evaluation index of

regional ecological environment quality, i represents the city, t represents the year, did_{it} is the core explanatory variable, dummy variable indicating whether each city covers the Beijing-Tianjin-Hebei coordinated development area, $control_{it}$ is other control variable, μ_i is the fixed effect of the city, λ_i is the fixed effect of time, ε_{it} is the random error term. The core coefficient that this paper is most concerned about is ∂_1 to measure the net impact of the coordinated development of the Beijing-Tianjin-Hebei region on the ecological environment quality of the region. If the coordinated development of the Beijing-Tianjin-Hebei region can promote the regional ecological environment, the coefficient ∂_1 is significantly positive.

2) Variable description

(1) Explained variables

In order to study the impact of the coordinated development of Beijing, Tianjin and Hebei on the ecological environment quality, the connotation and quantitative measurement of the ecological environment quality should be firstly defined. In the empirical study, there are great differences in the selection of indicators related to ecological environment quality. This paper adopts the comprehensive evaluation index of ecological environment quality in the Technical Specification for Evaluation of Ecological Environment Status (HJ192-2015) in combination with the connotation of ecological environment quality and the existing research results, as well as considering the systemicity of the rating system and the availability of data.

(2) Core explanatory variables

The Beijing-Tianjin-Hebei coordinated development covers regional interaction terms $did_{it} = post_i \times treat_t$. If a certain city i is included in the Beijing-Tianjin-Hebei coordinated development plan in year t, the value is 1; otherwise, the value is 0. Post is the year dummy variable, and the year before the outline of the Beijing-Tianjin-Hebei coordinated development plan is issued and implemented is 0, and the year after implementation is 1. Treat represents the policy dummy variable. Cities covered in the Beijing-Tianjin-Hebei coordinated development plan are set to 1 as the experimental group, and cities not covered are set to 0 as the control group.

(3) Control variables

Based on existing research results and actual research needs, this paper takes regional economic development level (Inpgdp), government financial scale (gov), fiscal autonomy (fd), public environmental awareness (Aware) and industrial transfer (indus) as control variables. Per capita GDP can partly reflect regional economic development. From the perspective of expected output, per capita GDP can be used to measure the efficiency of ecological environment governance [21]. The scale of government finance will affect the government's emphasis on ecological environmental protection and its investment in ecological environmental governance [22]. The revenue-expenditure ratio of the general public budget can be used to measure the financial autonomy of the government, which is inversely proportional to the dependence on transfer payments and proportional to the impact on the quality of the ecological environment [22]. The reality of residents' weak environmental awareness has become a key factor hindering the achievement of the development goal of "Beautiful China". The data analysis of CGSS2010 shows that the factors affecting the difference of residents' environmental awareness and behavior include economic, cultural, psychological and other factors. In this paper, the proportion of people with higher education reflects the level of ecological and environmental governance, as shown in Table 1. Finally, in order to reduce the influence of skewness and heteroscedasticity, logarithmic processing is carried out on some data of control variables.

Table 1. Description of variables

Variable type	Variable name	Variable description	unit
Explained variable	Ecological Environment Quality (Ei)	The comprehensive evaluation index was calculated in the Technical Specification for the Evaluation of Ecological and Environmental Conditions (HJ192-2015)	—
Core explanatory variable	Beijing-tianjin-hebei Coordinated Development (did)	Policy dummy variable * time dummy variable	—
Policy dummy variable	Policy dummy variable (treat)	If yes, the value is 1. No, the value is 0	—
Time dummy variable	Time dummy variable (post)	If yes, the value is 1. No, the value is 0	—
Control variable	Economic development level (lnpgdp)	Gross regional product per capital	Yuan/person
	Size of Government Finances (gov)	General budget expenditure /gdp	%
	Fiscal autonomy (fd)	General budget revenue/General budget expenditure	%
	Public Environmental Awareness(Aware)	Number of general undergraduate graduates/total population of the region	%
	Industrial Transfer (indus)	Proportion of tertiary industry	%

3) Data sources

The core explanatory variables of this paper are derived from the list of cities involved in various coordinated development policies since the promulgation and implementation of the Outline of the Plan for the Coordinated Development of Beijing-Tianjin-Hebei in 2015. The data of other variables are obtained from Statistical Yearbook, Ecological and Environmental Status Bulletin, government work report, government website, etc. The accurate data are supplemented by linear interpolation method. In order to make the comparison results more obvious and to comprehensively consider the availability of data, the study city scope was extended to a total of 61 cities in the Beijing-Tianjin-Hebei region and around the Beijing-Tianjin-Hebei region. Panel data of 61 cities from 2011 to 2021 were selected for a total of 11 years, and 1% of variable data was shrink-tailed to reduce the errors of individual discrete data on the results. Table 2 shows the descriptive statistical results of each variable.

Table 2. Descriptive statistical results of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
ei	671	38.029	25.393	0	82.7
did	671	.283	.451	0	1
gdp	671	3159.356	4082.71	373.36	40269
gov	671	.011	.011	0	.108
fd	671	.58	.447	.021	4.901
aware	671	.259	4.671	0	108.773
indus	671	42.622	37.08	2.2	948.8

4. Empirical Analysis

1) Baseline regression results

First, the bidirectional fixed model is used to test the net effect of Beijing-Tianjin-Hebei coordinated development on the improvement of ecological environment quality. The benchmark regression results are shown in Table 3. At the statistical level of 1%, when only the core explanatory variable (model 1) and five control variables (model 2) are considered, the estimated coefficients of the dummy variables of Beijing-Tianjin-Hebei coordinated development are all significantly positive, indicating that the improvement effect of Beijing-Tianjin-Hebei coordinated development on ecological environment quality is not affected by the missing variables after excluding the impact of the missing variables. Model 2 also shows that the three control variables of government financial scale, public environmental awareness and service industry development level are significantly positive at the statistical level of 1% or 5%, indicating that government financial scale, government financial freedom level, public environmental awareness and service industry development level have a positive impact on the improvement of ecological environment quality. Under the influence of multiple factors, the level of economic development and the level of government financial freedom is not significant, and the city may face other problems such as rising demand, thus limiting the positive impact of finance and economy on the improvement of ecological environment quality.

Table 3. Regression results of the benchmark model

Var	Model 1	Model 2
did	0.004***	0.001***
	6.331	3.614
gdp		0.883
		0
gov		0.044**
		73.059
fd		0.442
		-0.403
aware		0.004***
		0.021
indus		0***
		0.007
Constant	0***	0***
	36.237	36.849
Number of obs	671	671
R-squared	0.013	0.119

Note: *** p<0.01, ** p<0.05, * p<0.1

2) Parallel trend test

It is assumed that there is no time trend difference between all samples before project implementation. In this study, the following parallel trend test model will be used to ensure the applicability of the difference-difference model:

$$E_{it} = \partial_0 + \sum_{\tau=1}^{3} \sigma_{-\tau} * did_{i,\ t-\tau} + \sigma * did_{it} + \sum_{\tau=1}^{3} \sigma_{+\tau} * did_{i,\ t+\tau} + \partial_2 *$$

$$control_{it} + \mu_i + \lambda_i + \varepsilon_{it} \tag{3}$$

Where, $\sigma_{-\tau}$ represents the impact of the period τ before the implementation of the Beijing-Tianjin-Hebei coordinated development Policy on the ecological environment quality, $\sigma_{+\tau}$ represents the impact of the period τ after the implementation of the Beijing-Tianjin-Hebei coordinated development policy on the ecological environment status, σ represents the impact of the policy implementation on the ecological environment quality in the current period, and the meanings of other variables are the same as that of the benchmark regression model (1). The parallel trend chart is obtained by regression from formula (3), as shown in Figure 1.
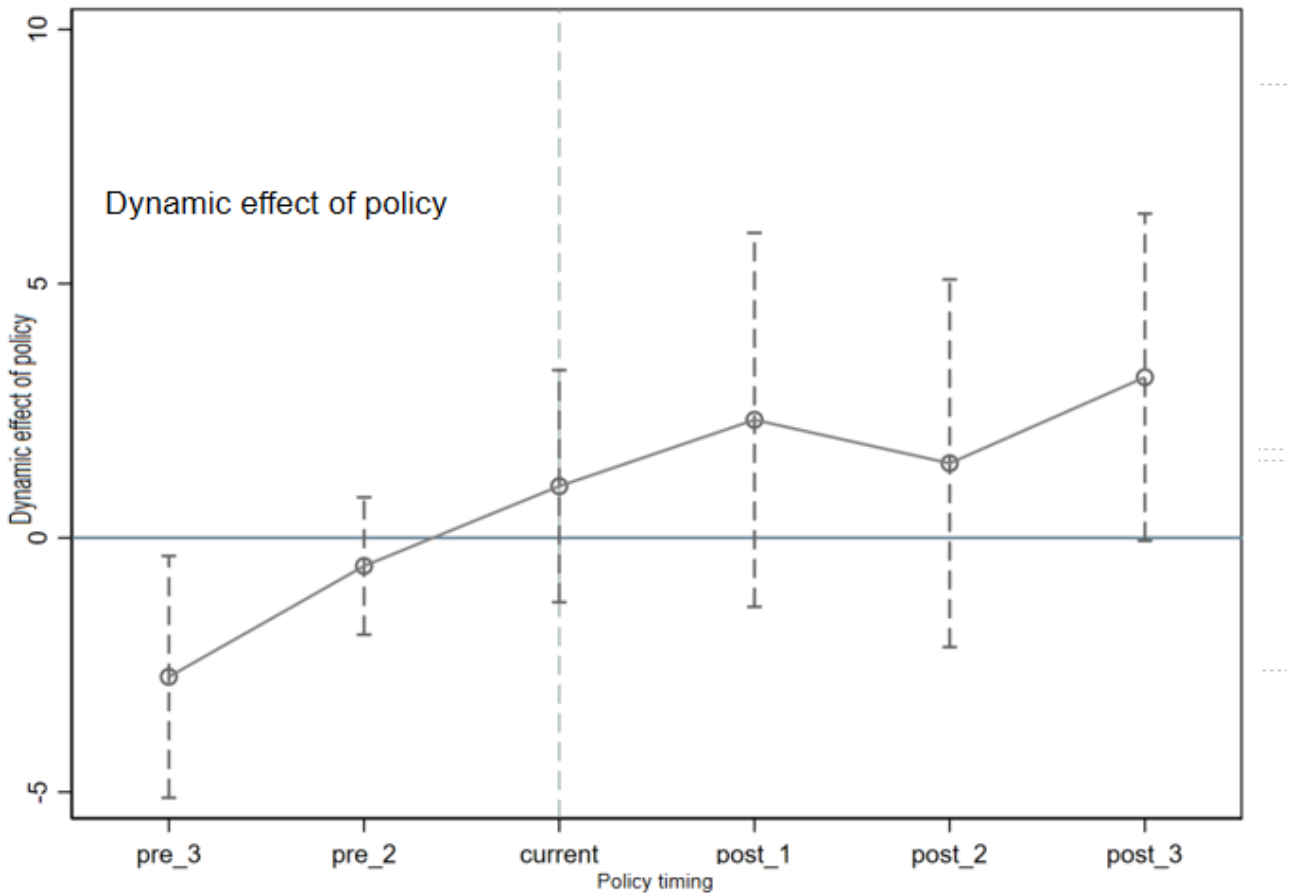

Figure 1. Parallel trend chart

The figure shows that the regression coefficients before the implementation of the policy are not significant, indicating that there is no significant difference in ecological environmental quality between the treatment group and the control group before the implementation of the policy in this experiment, and the hypothesis is valid. After the implementation of the policy, the regression coefficient was significantly positive and showed an upward trend, indicating that the ecological environment quality of the treatment group was significantly higher than that of the control group after the implementation of the Beijing-Tianjin-Hebei coordinated development policy, and the gap between the treatment group and the control group was gradually widening with the advancement of the policy.

3) PSM-DID test

The robustness test of score propensity matching (PSM-DID) can resolve the selectivity bias of the difference-difference method. In this paper, the sum density matching algorithm was used to

match the experimental group and the control group, and the results were shown in Figure 2. There was obvious overlap between the experimental group and the control group before and after matching, indicating that the nuclear density matching effect was good.
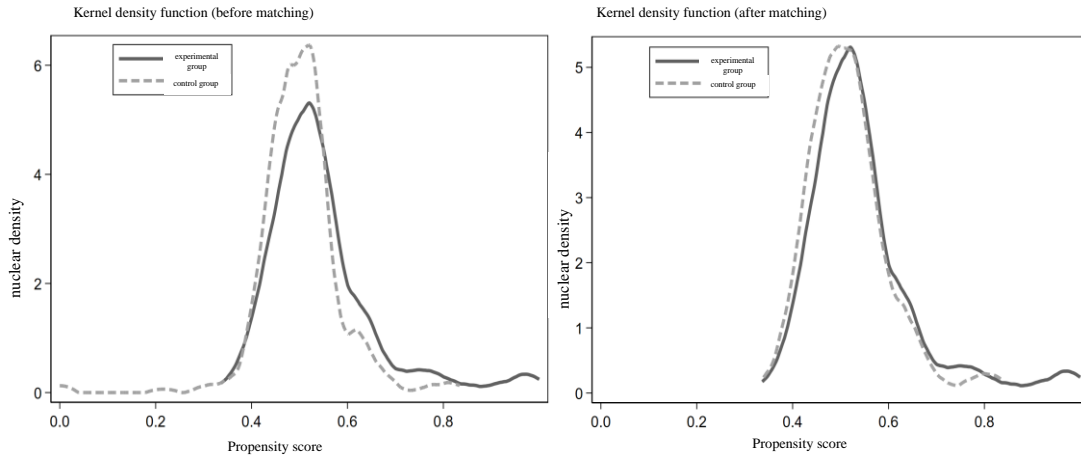

Figure 2. Kernel density function diagram

4) Other robustness tests

Three different time Windows show that the regression results of core explanatory variables are basically close to the baseline regression results, and are still positive and significant at the 1% statistical level. It shows that the change time window does not affect the baseline regression results of the Beijing-Tianjin-Hebei coordinated development on the ecological environment quality, which further tests the robust promoting effect of Beijing-Tianjin-Hebei coordinated development on the improvement of ecological environment quality.

Table 4. Change the time window

Var	2011-2018(1)	2011-2019(2)	2013-2021(3)
did	0.001***	0.001***	0.001***
	4.21	4.02	4.09
gdp	0.972	0.766	0.813
	0	0	0
gov	0.036**	0.088*	0.047**
	78.048	67.524	72.786
fd	0.7	0.519	0.609
	-0.703	-1.175	-0.939
aware	0.044**	0.021**	0.033**
	0.02	0.02	0.02
indus	0.002***	0.001***	0.001***
	0.004	0.005	0.005

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

5. Heterogeneity Analysis

The previous article tested the effect of the coordinated development of Beijing-Tianjin-Hebei on the improvement of ecological environment quality, but whether the city size will have a certain

impact on the effect of policy implementation remains to be verified. Based on the relevant research results of Chu Erming et al. (2022), this paper divides cities into three categories for grouping regression according to population size: large cities above 4 million, medium-sized cities between 2 million and 4 million, and small cities below 2 million. The empirical results are shown in Table 5.

Table 5. Analysis of urban size heterogeneity

	Large Cities (1)	Medium-sized Cities (2)	Small Cities (3)
did	0.082*	0***	0.121
	4.528	17.928	14.259
gdp	0.021**	0***	0***
	-0.001	-0.014	-0.022
gov	0***	0.013**	0.534
	834.782	919.32	547.263
fd	0.589	0.054*	0.761
	1.427	7.331	3.232
aware	0.861	0.541	0.483
	0.08	-0.107	19.152
indus	0.346	0.295	0.254
	0.025	-0.162	-0.372

The regression results show that at the statistical level of 1%, the core explanatory variables in model 1 and model 2 are positively significant, while those in model 3 are not, indicating that city size has a certain impact on the effect of policy implementation.

6. Conclusion

By summarizing the previous studies, this paper draws the following conclusions and enlightenments. The coordinated development of Beijing-Tianjin-Hebei can significantly improve the quality of ecological environment, and the regression results are still robust after the test of propensity score matching and replacement time window. The effect of the coordinated development of Beijing, Tianjin and Hebei on the improvement of ecological environment quality is different due to the different scale of the city.

Funding

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Zhao Linlin, Zhang Guixiang. Evaluation and welfare effect of eco-coordinated development in Beijing-Tianjin-Hebei . China Population. Resources and Environment. 2019,30(10):36-44.

[2] William J. Baumol and Wallace E. Oates. Yan Xuyang, trans. Environmental Economic Theory and Policy Design (2nd Edition). Beijing: Economic Science Press, 2003.

[3] Paul Cheshire and Edwin S. Mills. An Hussen, et al. Handbook of Regional and Urban Economics (Volume 3). Beijing: Economic Science Press, 2003.

[4] Arthur Lewis. Zhou Shiming, et al. Economic Growth Theory. Beijing: The Commercial Press, 2005.

[5]Makower H.. "A contribution towards a theory of Customs Union".Economic Journal, 1953, 363 (249):33-49

[6] Sun Hu, Qiao Biao. Problems and Suggestions on the coordinated development of Beijing-Tianjin-Hebei industry . China Soft Science. 2015(07):68-74.

[7] [Sun J W. Goals, tasks and implementation path of Beijing-Tianjin-Hebei Coordinated development. Comparison of Economic and Social Systems. 2016(03):5-9.]

[8] Wang Shuqiang, Xu Na. Environmental effects and influencing mechanisms of coordinated economic development in Beijing-Tianjin-Hebei Region . Enterprise Economics, 2019,38(02):65-72. (in Chinese)

[9] Zhao Tiantian, Wang Mingqi. Research on ecological environment Construction in Hebei under the background of Beijing-Tianjin-Hebei Coordinated Development . Hebei Enterprises. 2020(02):75-76.

[10] [Tang X Q, Zhang M H, et al. Research on the monitoring path of surface water environment in the context of Beijing-Tianjin-Hebei Coordinated development . China Environmental Monitoring, 2017,33(02):23-26.

[11] Yang Rongjin, Zhang Yi, et al. Innovating ecological compensation mechanism in Yongding River Basin to support the coordinated development of Beijing-Tianjin-Hebei region . Ecological Economy. 2019,35(12):134-138.

[12] [Xu N. Study on the impact of coordinated economic development in Beijing-Tianjin-Hebei region on environmental quality. Hebei University of Technology,2018.

[13] Zhao Linlin, Zhang Guixiang. Evaluation and welfare effect of ecological coordinated development in Beijing-Tianjin-Hebei region . China Population, Resources and Environment. 2020,30(10):36-44.

[14] Sun Jiuwen. The goal, task and implementation path of Beijing-Tianjin-Hebei Coordinated development . Comparison of Economic and Social Systems. 2016(03):5-9.

[15]Porter, M.E.. "America's Green Strategy".Scientific American, 1991, 264(4): 168-170.

[16] Li Huiru, Yang Lihui. Progress, effects and countermeasures of ecological and environmental collaborative protection in Beijing-Tianjin-Hebei . Journal of Hebei University (Philosophy and Social Sciences Edition). 2016,41(01):66-71.

[17] Tian Peifang, Tang Yandong et al. Effectiveness evaluation of coordinated environmental protection policies in Beijing-Tianjin-Hebei region based on Fuzzy-QFD model . Journal of Safety and Environment. 2019,23(02):547-555.

[18] Liu Xinsheng. On cross-provincial democratic supervision in the context of Beijing-Tianjin-Hebei Coordinated Development . Journal of Tianjin Institute of Socialism. 2015(01):4-7.

Mechanism and countermeasures of rural ecological environment collaborative governance in Beijing-Tianjin-Hebei under the concept of ecological sharing and co-governance . Agricultural Economics. 2019(12):9-11.

[20] Yang Hongyan. Evaluation and Influencing factors of ecological environment management efficiency in resource-based regions . Contemporary Chemical Industry Research, 2021(17):130-131. (in Chinese)

[21] Xu Changge, Jiang Shuoliang, Economic growth target constraint, inter-governmental competition and basic public service supply . Journal of Guangdong University of Finance and Economics. 2019,35(06):4-16.

[22] William Baumore, Wallace E. Oates, Trans. Yan Xuyang. Environmental Economic Theory and Policy Design (2nd edition). Beijing: Economic Science Press, 2003:77-83.