

Research on the Carbon Emission Reduction Cooperation Path of Beijing-Tianjin-Hebei Regional Cooperation

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Abstract—The Beijing-Tianjin-Hebei region is China's "capital economic circle". In the context of a low-carbon economy, the research on carbon emission reduction in the Beijing-Tianjin-Hebei regional cooperation has great significance for the coordinated development of the region. This paper uses panel data from nine provinces and cities in the Bohai Rim, Yangtze River Delta, and Pearl River Delta regions to construct an industrial structure advanced index to measure the spillover impact patterns of CO₂ emissions levels and structural effects. This study finds that industrial structure diversification and differentiation are important methods for achieving regional cooperation in reducing emissions. Under the background of the development of the integration of the Beijing-Tianjin-Hebei region, the industrial structure diversification, differentiation, and actively carry out regional cooperation mechanism to reduce emissions, construction of Beijing-Tianjin-Hebei regional carbon reduction cooperation path.

Keywords—Beijing-Tianjin-Hebei integration; carbon reduction cooperation; Entropy method

I. INTRODUCTION

Carbon emission has the same externality characteristics as the atmosphere, so its scope of existence is difficult to plan and no region can be carried out independently. Through regional cooperation on emission reduction, the effect of national emission reduction can be achieved by combining the point with the surface and the point with the surface. However, the cost of emission reduction varies from region to region, and mutual cooperation can combine technologies and resources with local advantages to reduce the cost of independent emission reduction. From the international perspective, the regional carbon emission reduction measures in the EU, the US and other places can provide a lot of experience for the components of China's regional cooperative emission reduction path.

The Beijing-Tianjin-Hebei region is the third largest economic growth pole in China after the Yangtze river delta and the pearl river delta. Due to its high degree of industrialization, the region's carbon emissions are at the forefront of the country, so it is imperative to reduce emissions. Moreover, the regional industrial structure of the Beijing-Tianjin-Hebei region is different, and the resource utilization efficiency, the level of clean technology and the development

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of the energy industry in the three regions are highly redeemable. Therefore, based on the analysis of the economic development level, industrial structure, resource endowment, clean technology, laws and regulations, culture, and government supervision of the three places, it is necessary to achieve common emission reduction goals and a consistent emission reduction path among heterogeneous economic communities.

Environmental problems such as smog and PM2.5 in the Beijing-Tianjin-Hebei region are increasingly intensified, and governments must be required to deepen cooperation in carbon emission reduction and coordinate environmental issues. Based on this, this paper focuses on the impact of structural effects on carbon emission reduction, constructs the Beijing-Tianjin-Hebei industrial structure optimization index and industrially advanced index, and uses the spatial lag model and spatial Durbin model to derive the impact of industrial structure optimization on carbon emission reduction. Impact, and then put forward the cooperation path of Beijing-Tianjin-Hebei carbon emission reduction.

II. THEORETICAL ANALYSIS AND ASSUMPTIONS

A. Theoretical Analysis

Based on the Kuznets Curve theory (EKC) given by Kuznet, a Nobel Prize winner in economics in the 1950s, and three hypotheses explaining the formation of its Kuznets curve, namely: the demand hypothesis, Ability hypothesis and related hypotheses [1]. For the principle of the formation of the EKC curve: In the process of economic development, the income difference initially increases with the growth of the economy. After reaching a certain extreme value, the income difference begins to narrow as the economy further grows [2]. Grossman (1990) proposed the environmental Kuznets curve based on the Kuznets principle [3]. That is, the relationship between environmental quality and economic growth has an inverted "U" curve. If the level of per capita income represents the level of economic development and the number of pollutants represents the level of environmental degradation, the amount of pollutants first increases with the increase of the level of per capita income [4]. When the income reaches a certain level, the amount of pollutants decreases with the further increase in the level of per capita income. For the three hypotheses that explain the EKC curve: the theory of capacity holds that both

pollution control and ecological protection require capital investment, which must be supported by economic strength. According to demand theory, the demand for a comfortable environment has income elasticity, that is, it is greatly affected by income [5]. The related theory holds that economic development will cause many related changes, such as changes in economic structure, urbanization, and technological progress. However, these three interpretations are complementary [6]. The theory of capabilities is based on development, the theory of needs is based on capabilities, and the related theory is an inevitable result of development. Therefore, when economic efficiency runs faster and energy efficiency is higher, energy consumption will also decrease. As the urbanization rate increases, the increase in the proportion of household consumption in per capita GDP will also reduce CO₂ emissions. In addition, the increase in the value-added of high-tech production capacity will also reduce the energy consumption per unit of GDP with the popularization of clean technologies, and strengthen carbon emissions reduction between regions[7].

B. Hypothetical Conditions

From this, we can construct the hypothetical conditions for the regional carbon reduction cooperation path in Beijing, Tianjin, and Hebei:

- Condition 1: Optimize from several indicators such as the proportion of household consumption in GDP, energy consumption per unit of GDP, urbanization rate, and the proportion of high-tech production value-added in total output value to promote emission reduction.
- Condition 2: Advanced industrial structure can strengthen regional carbon emission reduction in Beijing, Tianjin and Hebei.
- Condition 3: It has the opposite effect on CO₂ emissions and will cause an increase in carbon emissions. According to geographical things or attributes, the spatial distribution is related to each other, and there are clustering, random, and regularity distributions. The information in a spatial unit is similar to the information of its surrounding units, the connectivity between the spatial units, and the spatial non-uniformity or non-staticity of the moments of the attributes. Therefore, CO₂ will be transferred in the space of the area, thus Propose another plan.
- Condition 4: Carbon emissions are spatially transferable. In addition to the interaction between the three cities in the Beijing-Tianjin-Hebei region, there are also indirect effects between them.

III. MODEL DESIGN

This paper selects data from 9 provinces and cities in China from 2002 to 2018 in the Bohai Rim Economic Belt, the Yangtze River Delta, and the Pearl River Delta (Beijing, Tianjin, Hebei, Liaoning, Shandong, Jiangsu, Zhejiang, Guangdong, and Shanghai) Because these three economic zones have relatively developed economies, they have respectively the urbanization rate, the proportion of household consumption in GDP, the value of high-tech industries in the

total industrial output value, the value of the tertiary industry in GDP, and the energy consumption index (unit: ton standard Coal / 10,000 Yuan) analysis of 5 indicators.

A. Construction of Regional Industrial Structure Optimization Index

The first is the construction of the regional industrial structure optimization index. The article uses the entropy method to process the five indicators, assign a weight to each indicator, and finally obtain an index for each city each year. Finally, calculate a comprehensive score and compare each city horizontally. For example: Compare the comprehensive scores of the three cities' indicators in 9 cities in 2002, to obtain the optimization results and the regional industrial structure optimization index. The first is to standardize the data. The Positive indicator is

$$X_{ij}^+ = \frac{X_{ij} - \min\{X_j\}}{\max\{X_j\} - \min\{X_j\}} \quad (1)$$

The negative indicator is

$$X_{ij}^- = \frac{\max\{X_j\} - X_{ij}}{\max\{X_j\} - \min\{X_j\}} \quad (2)$$

Calculate the proportion of the i-th city and the j-th index value:

$$Y_{ij} = \frac{X_{ij}^-}{\sum_{i=1}^m X_{ij}^-} \quad (3)$$

Calculate index information entropy:

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

Calculate information entropy redundancy:

$$d_j = 1 - e_j \quad (5)$$

Calculate indicator weight:

$$W_i = d_j / \sum_{j=1}^n d_j \quad (6)$$

Calculate single index evaluation score:

$$S_{ij} = W_i \times X_{ij}^- \quad (7)$$

By comparing the data indicators of the Beijing-Tianjin-Hebei region with the three regional economic circles of the Pearl River Delta, the Yangtze River Delta, and the Bohai Rim Economic Belt, an industrial structure optimization index is derived, and an optimization path is proposed.

B. Construction of Regional Industry Advanced Index

The construction of the regional industry advanced index uses the method of three-dimensional space vector angle model. First, the GDP is divided into three parts according to the three industrial added values, and the proportion of each part in the total output value is taken as a component of the space vector, thereby constructing a three-dimensional vector:

$$X_0 = (x_{1,0}, x_{2,0}, x_{3,0}) \quad (8)$$

Then, calculate the industry vector meanings from low to high levels.

$$\theta_j = \arccos \left(\frac{\sum_{i=1}^3 (x_{i,j}, x_{i,0})}{\left(\sum_{i=1}^3 x_{i,j}^2 \right)^{1/2} \cdot \left(\sum_{i=1}^3 x_{i,0}^2 \right)^{1/2}} \right), j = 1, 2, 3 \quad (9)$$

Then the industrial advanced value W is obtained:

$$W = \sum_{k=1}^3 \sum_{j=1}^k \theta_j \quad (10)$$

In the above model, the larger the value of W, the higher the level of advanced industrial structure.

C. The Result

TABLE I. SPATIAL MEASUREMENT MODEL TEST RESULTS

	SLM-SF	SDM-SF		SLM-SF	SDM-SF	
	1	2	3	4	5	6
LOG(JULI)	-1.00		-1.04	-0.14		9.11
LOG(STR)	-0.40	-	-0.05	-0.57	-	
LOG(GDP)	0.29	0.30	-0.60	0.33	0.30	0.28
LOG(TL)	8.17	5.50	8.78	5.58	5.50	-3.17
R-squared	0.92	0.87	0.99	0.90	0.87	0.94
Adjusted R-squared	0.91	0.87	0.99	0.89	0.87	0.93
S.E. of regression	0.20	0.24	0.08	0.22	0.24	0.18
Sum squared reside	1.16	1.76	0.15	1.45	1.76	0.83
Log likelihood	8.38	1.54	42.08	4.73	1.54	14.02
Durbin-Watson stat	0.91	1.50	1.64	1.42	1.50	0.85

Comparing the Log L value, AIL value, and R2 value of each model form in the table, it is found that the SEM model cannot explain the research problem well, and the SDM model fits slightly better than the SI, M model. In the SDM model, the spatial lag terms of structural optimization and technical effects are not significant, so only the spatial lag terms of scale effects are considered. Finally, it is tested whether the SDM can be reduced to SI, M and SEM. The results show that under both spatial weight matrices, the null hypothesis is significantly negated, indicating that the SDM model is more suitable for the research problem in this paper. Therefore, we focus on the effect of a decomposition analysis of SDM models (3) and (5).

The results in Table I show that the coefficients under the two spatial weight matrices are significantly positive, and the provincial level of CO₂ emissions shows a significant spatial spillover effect, and the CO₂ emissions are affected by the neighboring provinces' emission levels. Under the economic space weight matrix, the spatial lag coefficient of CO₂ emissions is small. Model (5) shows that an increase of 1% in the CO₂ emissions in adjacent areas will cause an increase of CO₂ emissions in the area by 0.16%.

From the sign of the regression coefficient, the symbolic force of each model variable is consistent and meets the expected conditions. The symbol of structural optimization and

technical effect coefficient is negative, indicating that economic structure optimization and technological progress can significantly reduce CO₂ emissions; the sign of scale effect coefficient is positive, indicating that the expansion of regional economic scale at this stage will increase CO₂ emissions.

IV. CONCLUSION

Based on panel data of 9 provinces and cities in China from 2002 to 2018, this paper uses the entropy method to obtain a comprehensive structural optimization index, constructs a spatial dynamic panel data model, considers a variety of spatial correlation forms, and uses a partial regression force method of the spatial regression model. The effect on the level of CO₂ emissions is decomposed. It is concluded that under different spatial correlation models, there is a significant spatial dependence on the level of CO₂ emissions in China's provinces, and the degree of dependence has gradually increased. 2. The spatial accumulation of CO₂ emissions has a certain locked path, but there is a tendency to shift to low-carbon emissions accumulation. 3. The comprehensive structural effect of multiple indicators is an important influencing factor of CO₂ emission level, which has a significant direct impact, indirect impact, and total impact. The direct impact within the region of the structural effect is greater than the regional indirect impact. 4. Technical effects and scale effects have significant spatial spillover effects on the increase of CO₂ emissions. 5.CO: Emissions have significant time inertia and are greatly affected by the previous level of emissions.

Based on the above conclusions, some new ideas for reducing emissions are drawn:

- Due to the spatial agglomeration characteristics of CO₂ emission levels, there is a space transmission mechanism that affects the effects. It is necessary to promote Beijing-Tianjin-Hebei regional cooperation to control carbon emission levels as soon as possible, especially in neighboring regions.
- Structural optimization is a very effective way to achieve emission reduction. In addition to the traditional industrial structure adjustment and increasing the proportion of the tertiary industry, structural optimization also requires a multi-pronged approach to vigorously develop energy-saving and efficient high-tech product industries and rely on technology. The transformation of progressive leading industries, reducing the unit UDP energy consumption, changing the economic pulling model relying on investment, making household consumption an important way for economic growth, and guiding residents' low-carbon consumption patterns.

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