Cross-region Coordination in Local Government Regulation Aiming at Energy Saving and Emission Abatement and Optimization of Regional Division of Labor: Taking Manufacturing Industries in Five Provinces in North China as Examples

Kesen Zhang，Meiyan Wang，Anguo Liu

School of Economics and Management, Beijing University of Chemical Technology, Beijing, China

Kaizhong Yang

School of Government Management, Peking University, Beijing, China

Abstract: Two types of "government failure" emerge in the absence of interregional coordination in environmental, industrial, and spatial regulation: one is related to opportunistic behavior on the side of businesses in complying with regulatory requirements on energy saving and emission abatement, appearing in the form of "pollution haven" effect; the other is related to the convergence of industries targeted by local government in regulating businesses' behavior in energy saving and emission abatement through different incentives (and/or negative incentives), which induces excessive cross-region competition among businesses to the detriment of interregional division of labor based on specialization. Using data from manufacturing industries in five provinces in North China, we carry out an investigation of the difference in the efficiency with which businesses conduct energy saving and emission abatement. In conjunction with a study of the spatial distribution of manufacturing industries and characteristics of industrial specialization and division of labor in five provinces in North China, certain policy measures are derived for improving interregional coordination in environmental, industrial, and spatial regulation, aiming at energy saving, emission abatement, and optimization of regional division of labor.

Keywords: Energy saving, emission abatement, regional division of labor, governmental regulation, harmonized development.

Introduction

Recently, as environment and development increasingly have become the central issue in developing countries and areas. The actions concerning energy saving and emission reduction of industrial enterprises have become important to the whole society because understanding the trade-offs between the environment and development are necessary to achieve the win-win situation between environment and development. According to the classical Environmental Kruz Nez curve theory, the countries that step into the middle stage are generally going through a turning point in environmental and development issues. Before the turning point, economic growth will make the environmental pollution problems worse.

Once crossing the turning point, the ecological environment will vary with the further economic development. At present, China's economic development just entered a period of transition. The previous growth model, which was at the expense of the environment, characterized by "high input, high energy

consumption, high pollution and low efficiency," has been difficult to sustain. The commitments that the Chinese government made to the international community to reduce carbon dioxide emissions, as well as the strong voice with which domestic residents appealed to improve the environment, have forced various regions, industries, and the enterprises, which are the basic units of economic activities, to seek more environmentally-friendly development. Promotion of environmental standards and environmental regulation enforcement has brought a variety of transition pains to the development of different regions and different enterprises. Because of the economic development level differences between various regions and the variable background conditions of companies in their nature, geography, resources, environment, society, economy, and technology etc., there will be different degrees of variation for different governments' actual performance in environmental regulations and energy-saving action of the enterprises.

The performance of enterprises in energy saving and emission reduction has a direct impact on the sustainable development of society and the economy of countries and regions. Due to the publicity of environmental problems and the unevenness of regional development, enterprises and local government and its residents will expand extremely complex interactions focusing on the environment and development. The local enterprises, on the one hand, promote local employment and increase the income of the residents. On the other hand, they provide stable tax source for the local government. However, the ineffectiveness of enterprises' energy saving and emission reduction could lead to the destruction of local environment in different degrees. The trade-offs focus on the employment, income, and environment quality of local residents in different stages of development areas, thus affecting the local government's policies in economy, industry and environment.

Local government's policies and regulations, in turn, affect enterprise behaviors, including the performance in energy saving and emission reduction. This kind of interaction between enterprises, residents and governments will become more and more complicated in the case of multi-regional, regional, and sub-regional interaction. In particular, in the absence of district environment, industry, and space regulation coordination, it is easy to produce two types of "government failure." The failure is associated with the opportunistic behavior that enterprises base environmental regulation enforcement of interregional differences on energy saving and emission reduction. It represents the typical effect of "Pollution Haven Effect."

Another failure is associated with the incentive (and negative incentives) on the industrial point of convergence that different local government takes to promote energy saving and emission reduction. The incentive (and negative incentives) on industrial-oriented convergence is easy to induce interregional homogeneous competition, and it damages the specialization base of the regional division of labor. Doing research on the regional differences of enterprises' energy saving and emission reduction performance and exploring the possible policies and measures that help to put right the above two categories of "government failure" has an important practical significance in improving the interaction between local businesses, residents, and the government, as well as the interaction between local governments. It will also be practically significant to help to regulate the environmental behavior of corporations scientifically and reasonably, and to promote the regional division of labor improvement and the regional coordinated development.

The environmental problems affected by the energy-saving performance belong to typical

cross-regional public issues. In the three major economic zones in China, the Bohai Sea region, environmental issues are particularly representative. In recent years, smog, acid rain and industrial wastewater discharge have caused massive environmental pollution to the Bohai Sea region, and it has brought great challenges to sustainable development. It is particularly complex that five provinces and municipalities in North China located in the Bohai area (Beijing, Tianjin, Hebei, Shanxi, and Inner Mongolia) faced all kinds of public issues linked to environment and development. With the economically-developed Beijing and Tianjin steadily improving their environmental regulation efforts, low energy-efficiency pollution enterprises have moved to the surrounding areas to push the surrounding pollution.

The days on which the highly-developed Beijing and Tianjin region suffered from fog and haze not only haven't declined, but, rather, have increased. Thus, environmental regulations of cross-regional coordination are imperative. In addition, in the case of the intensified environmental regulations of Beijing and Tianjin, there are still some industries that neither have any advantages in scale nor have a good energy- saving performance.

The different treatment results in environmental regulation also bring some difficulties to the regional adjustment and optimization. It results in homogeneous competition between the five provinces that cannot be changed. In the background of nationwide transformation of the development mode and rapid development of environment-friendly new industry, five provinces in North China have developed their own new industry development plans and introduced appropriate policies and measures to encourage the development of environmental-friendly industries.

It is an important task for these five North China provinces and municipalities to carefully address the issue of how to prevent new environmental and industrial policy incentives from oversupply and to form a new homogeneous competition. Scientifically addressing and resolving these problems requires mutual cooperation between the region's own environmental policies and, also, requires mutual cooperation between the regional environmental policies and industrial policies. The cross-regional, integrated environment, industry, and space regulation is imperative.

To facilitate the discussion and analysis, we chose the five provinces in North China in Bohai Region, one of the three major economic zones, whose environmental issues is very prominent as the representative. Based on the main economic and energy consumption indicators of manufacturing enterprises in 2014, we analyzed the differences in industrial enterprises in five provinces in energy saving efficiency. Combined with the regional specialization of manufacturing industry and the characteristics of the division of labor, we aimed at promoting regional coordinated development of the five provinces of the city industrial and environmental policy regulation for regional coordination.

Our research will be organized as follows: the second part summarizes the domestic and foreign research progress on the differences of government regulations and pollution transformation. In the third part, we use the DEA method to analyze the efficiency and regional difference in the five provinces in North China in energy saving and emission reduction; in the fourth part, we use the location quotient analysis method to reveal the characteristics of the regional specialization and the division of labor in the five provinces in North China, and to analyze the comparative advantages of the provinces; the fifth part combines the analysis of the regional efficiency differences in the enterprise energy saving and emission reduction and the analysis results of industry comparative advantages to identify the key measures about

the regional coordination of industrial and environmental policy regulations in the five provinces and municipalities; some concluding remarks are given in the sixth part as the general conclusions of the study.

Research Progress of Regulatory Differences, Energy Efficiency and Pollution Abatement Transfer

Even if there is a unified central government policy regulation, depending on the differences in regional socio-economic development level, different regions will choose different local regulations according to their own choice of the manufacturing sector. Regional differences in environment, industry, and space regulation enforcement provide a space for manufacturing enterprises taking opportunistic behavior. The local government's behavior in the regulation of the "race to the bottom" will inevitably lead business and industry to transfer to regions with weak regulations. The industry and pollution transfer it caused not only makes the central government's total pollution control targets difficult to achieve, in extreme cases, the place which undertakes industrial transfer will get more harm than good due to deterioration of the ecological environment.

Copeland & Taylor (1994) put forward the hypothesis of pollution haven based on the study of the relationship between transfer of global trade and industrial activities and the environmental pollution: in an open economy, the developed countries implement more stringent environmental standards and environmental enforcement, which pushes up the environmental compliance costs of energy saving and emission reduction of inefficient and high-polluting industries. For high-pollution industries, countries or regions with lower environmental standards have a cost advantage. Free trade will force high-pollution industries that have lost their competitiveness to transfer from developed countries to developing countries. The differences in environmental standards or environmental law enforcement between countries and regions make developing countries or regions sanctuaries for low-energy-efficiency and high-pollution industries.

List & Co (2000) and Fredriksson et al. (2003) investigated the spatial distribution of FDI flowing into the United States along each state and found evidence that showed enterprise location decisions are influenced by environmental regulation enforcement. Wagner & Timmins (2003) found that the location choice of FDI outflowing from Germany was only affected by environmental considerations in the low efficiency of energy saving pollution-intensive industry situation. Xing & Kolstad (2002) used FDI data flowing out from the United States to study the issue and reached a similar conclusion.

Dean et al. (2004) used 626 Chinese manufacturing joint venture project data as the basis of research and found that the relationship between FDI and environmental regulation is different from those predicted by the pollution haven hypothesis: FDI from all the home countries flow to the provinces which have highly concentrated foreign investment and high per- capital income levels, a higher degree of foreign concentration, and those providing special tax incentives. However, less stringent environmental regulation is an important factor in determining the attractiveness of some of China's townships to their partners is from the joint venture of Hong Kong, Macao, and Taiwan regions and other Southeast Asian countries. Wu (2007) established the time series model based on panel data to make the empirical analysis for the correlation mechanism between foreign direct investment and environmental regulation in the various regions of China. Measurement results showed that environmental regulation has a certain impact

on the various regions of China to attract foreign investment; this effect appears as a negative effect when regulation differences drive the low efficiency of energy-saving companies to flow to underdeveloped areas as "pollution haven."

Gao Feng's (2015) study found that (1) the environmental situation in China exists in low efficiency of energy saving and emission reduction of enterprise and industry spatial agglomeration; (2) provincial environmental regulation intensity exists as a significant positive correlation in spatial distribution, and the spatial autocorrelation increased year by year; (3) the increase of provincial environmental regulation strength can obviously reduce the environmental pollution emission levels; (4) there are "race to the bottom" behaviors among the local government that   take environmental regulations as a means of race 8]. Zhao Yongliang, Shenze Wen, and Liaorui Bin (2015) based their findings on China's three economic zone data and expanded the study of "environmental regulation of inducible" agglomeration.

It shows "The stricter the environmental regulation is, the stronger the willingness of enterprises migrates to the agglomeration area. In addition, the social responsibility of enterprises has an inhibitory effect on migration intention." Huang Wanhua and Bai Yongliang (2011) researched the cross-regional water pollution control, which shows that the existence of environmental externalities makes the local governments pursue local economic development objectives and lessen environmental regulation. Vicious competition led to resource depletion war and severe environmental pollution. Cross-regional coordination between industry and environmental regulation is imperative.

A considerable amount of literature shows that in the case of efficiency differences of energy saving and emission reduction in enterprises, whether regional environment, industry, and space regulation are coordinated or not, will lead to quite different environment and development consequences. Uncoordinated environment, industry, and space regulation not only distorts competition incentives of enterprises, resulting in homogeneous competition and similar industrial structure that destroy the regional industrial division of labor based on specialization, but also enlarges the "pollution haven" effect, leading to high concentrations of industrial pollution in the local area.

Out of the observation of this problem, we are going to choose five provinces and municipalities in North China whose coordinated problems between environment and development issues is relatively prominent as a case to research. First of all, we compare and analyze the energy saving and emission reduction efficiency of the manufacturing enterprises in five provinces. Then, using location quotient to analyze the characteristics of the manufacturing industry of regional specialization and division of labor in five provinces and municipalities, and on this basis, we put forward regional regulation coordination suggestions to enhance the efficiency of enterprise energy saving and emission reduction and to promote the regional orderly competition and improve the specialization phase.

Regional Differences in Manufacturing Enterprise Energy Saving and Emission Reduction Efficiency in the 5 Provinces in North China

Description of the Model and Data Set
Energy saving efficiency is an important indicator to measure the performance of enterprise energy saving and emission reduction. Common efficiency measurement methods include the input and output method, DEA analysis method, regression analysis method, and so on. We follow the Liu Anguo et al. (2013) method, using a variable scale return BCC model of the DEA model to measure the energy saving and

emission reduction efficiency of manufacturing enterprises. The provisions of the BCC model are as follows:

$$\min_{\theta,\lambda} \theta$$

(1)
$$st.\begin{cases} -y_i + Y\lambda \geq 0 \\ \theta x_i - X\lambda \geq 0 \\ N1'\lambda \leq 1 \\ \lambda \geq 0 \end{cases}$$

i is the decision-making unit, θ is the efficiency value, λ is the weight vector for the input and output, X is input vector, Y is pollution emissions (or pollution output) vector, y_i is the output of the i-th decision-making unit, x_i is inputs, and $N1$ is an N × 1 vector that all elements are 1.

In order to ensure the relative accuracy of the calculation results, we take the input of production factor and pollution emission cross section data in China Provincial manufacturing as the model input to calculate the efficiency of energy saving and emission reduction, and then we take out the relevant parts of the five provinces in North China from the calculation results to compare and analyze. Due to the difficulty of obtaining industrial pollution emissions data of different industries (such as industrial wastewater discharge, carbon dioxide and sulfur dioxide emissions, industrial solid waste emissions)and the energy consumption of an industry or enterprise is generally positively related to the level of its pollution, we intend to use publicly available energy consumption data as a proxy variable for the level of pollution emissions in order to assess the efficiency of energy saving and emission reduction for different manufacturing enterprises.

In addition, because of a partial data loss of some provinces and municipalities, as well as part of the manufacturing sectors, the final energy consumption, capital, and labor input data in our study are from the 23 segments of the manufacturing industry in 23 provinces and autonomous regions. Energy consumption takes a million tons of standard coal as a unit; capital investment takes the manufacturing industry original value of fixed assets (unit: million yuan); and labor input takes employment number of the manufacturing industry (unit: million). Capital and labor input data were taken from the 2015 annual "China Statistical Yearbook of China industry." Energy consumption data were taken from 2015 provinces and cities statistical yearbook.

DEA Calculation Results Analysis

We use DEA Software 2 to calculate the pollution emission efficiency of different manufacturing enterprises in 23 different provinces. Table 1 shows the results of the calculation of the pollution discharge efficiency of five manufacturing industry segments in North China, including Beijing, Tianjin, Hebei, Shanxi and Inner Mongolia.

Table 1

The Results of the Calculation of the Pollution Discharge Efficiency

Industry	Beijing	Tianjin	Hebei	Shanxi	Inner Mongolia	Average values
Agricultural and sideline food processing	0.9957	0.8352	0.7636	0.9122	0.9912	0.8996
Food manufacturing	0.9902	0.8901	0.7995	0.991	0.9601	0.9262
Beverage manufacturing	0.9734	0.417	0.9876	0.9894	0.983	0.8701
Spin	0.7751	0.6741	0.6158	0.9771	0.8486	0.7781
Wood processing and Kitake to brown grass products	0.7758	0.0541	0.9968	0.1437	0.9735	0.5888
Furniture manufacturing	0.8666	0.1875	0.9103	0.0946	0.6345	0.5387
Paper and paper products	0.8788	0.825	0.8636	0.9369	0.9083	0.8825
Printing and recording media reproduction	0.9493	0.1343	0.9123	0.589	0.1269	0.5424
Stationery and sporting goods manufacturing	0.7453	0.6735	0.8997	0.5259	0.1687	0.6026
Petroleum processing, coking and nuclear fuel processing	0.9966	0.0751	0.998	0.9597	0.9979	0.8055
Chemical raw materials and chemical products manufacturing	0.9966	0.9853	0.8385	0.8832	0.8553	0.9118
Pharmaceutical manufacturing	0.9906	0.8398	0.8882	0.8845	0.9958	0.9198
Rubber and plastic products	0.9896	0.9035	0.8176	0.9332	0.7223	0.8733
Nonmetallic mineral products	0.7924	0.9661	0.874	0.8121	0.9954	0.888
Ferrous metal smelting and rolling processing	0.915	0.9718	0.1736	0.7692	0.9726	0.7604
Non-ferrous metal smelting and rolling processing	0.77	0.8953	0.9783	0.9992	0.9991	0.9284
Metalware	0.9954	0.9658	0.9877	0.7007	0.9249	0.9149
General equipment manufacturing	0.9841	0.4621	0.8264	0.9367	0.8154	0.8049
Special equipment manufacturing	0.9847	0.7944	0.8874	0.9959	0.6398	0.8604
Transportation equipment	0.9461	0.8155	0.805	0.9696	0.754	0.858

manufacturing						
Electrical machinery and equipment manufacturing	0.9799	0.6501	0.9511	0.8579	0.7929	0.8464
Computer, communications and other electronic equipment manufacturing	0.9935	0.2215	0.9397	0.8301	0.0989	0.6167
Comprehensive utilization of waste resources	0.1543	0.3114	0.891	0.078	0.5237	0.3917

As the energy consumption is used as a proxy variable of pollution emissions (or output), the higher the efficiency value of the pollution discharge is calculated, which indicates that the enterprise energy saving and emission reduction efficiency is lower in the industry. To compare the average value of pollution emission efficiency of the subdivision industry enterprises in Five provinces and municipalities with the pollution emission efficiency of the subdivision industry enterprises in all provinces, autonomous regions, and municipalities, we found that there are 17 industrial enterprises in Tianjin pollution emission efficiency value that is lower than the average value of 5 provinces and municipalities, and 10 industrial enterprises in Hebei province pollution discharge efficiency values are less than the 5 provinces' and municipalities' average. Each of the 8 industrial enterprises in Shanxi and Inner Mongolia pollution discharge efficiency value is lower than the average value of the 5 provinces and municipalities; only the 5 industrial enterprises in Beijing pollution discharge efficiency values are less than the 5 provinces' and municipalities' values. The relatively high efficiency of pollution emission corresponding to relatively low efficiency of energy saving and emission reduction, therefore, according to the number of enterprises with high energy saving and emission reduction efficiency of the 5 provinces in North China, are ranked as follows: in the first place is Tianjin; in second place is Hebei; Shanxi and Inner Mongolia tied for third place. Beijing ranks at the bottom.

Characteristics analysis of the Five provinces in North China, regional manufacturing specialization, and regional division of labor
Because the regulation of enterprise energy saving and emission reduction behavior should consider enterprise location choice of industrial transfer and the transfer of pollution effect and its influence on the regional division, we will use location quotient analysis to analyze manufacturing industry professional degree and the present situation of division in China's 23 provinces, autonomous regions, and municipalities. The location quotient calculation method is as follows:

$$
(2) \qquad LQ_{ij} = \frac{L_{ij} / \sum_{j} L_{ij}}{\sum_{i} L_{ij} / \sum_{i} \sum_{j} L_{ij}}
$$

In the (2) formula, i represents a region, j represents a certain industry, L_{ij} indicates the total output value of j industry in the i region, and LQ_{ij} represents the location quotient of j industry in the i region. The

total output value of the relevant manufacturing industry in the provinces and cities is taken from the 2015 annual "China Statistical Yearbook of industry." Table 2 gives the calculation results of the location quotient of the manufacturing industry segments in the 5 provinces in North China.

Table 2

The Location Quotient of Manufacturing Industries in 5 Municipalities/Provinces in North China

Location quotient value of 5 provinces in North China					
Industry	Beijing	Tianjin	Hebei	Shanxi	Inner Mongolia
Agricultural and sideline food processing	0.3667	0.4461	0.7063	0.5542	1.5876
Food manufacturing	0.8857	2.2595	0.9693	0.6856	2.1477
Beverage manufacturing	0.8467	0.4182	0.6989	0.8491	1.4505
Spin	0.0488	0.1207	1.2426	0.1526	1.0526
Wood processing and Kitake to brown grass products	0.0691	0.0468	0.429	0.0955	1.4424
Furniture manufacturing	0.7622	0.4678	0.7308	0.0917	0.2479
Paper and paper products	0.3314	0.6427	0.8585	0.1377	0.5575
Printing and recording media reproduction	1.2361	0.5039	1.0714	0.2694	0.2494
Stationery and sporting goods manufacturing	0.4081	1.0845	0.501	0.0747	0.2036
Petroleum processing, coking and nuclear fuel processing	1.3916	1.0312	1.0322	2.9366	1.5235
Chemical raw materials and chemical products manufacturing	0.3362	0.7577	0.8024	1.027	1.5565
Pharmaceutical manufacturing	1.9894	0.7847	0.7241	0.8345	0.9516
Rubber and plastic products	0.2636	0.6768	0.9585	0.316	0.3425
Nonmetallic mineral products	0.5436	0.22	0.7229	0.6802	0.9406
Ferrous metal smelting and rolling processing	0.1335	2.2883	3.7366	3.8375	1.6769
Non-ferrous metal smelting and rolling processing	0.0935	0.6673	0.2567	1.2665	2.3396
Metalware	0.6182	1.3342	1.8133	0.3847	1.1253
General equipment manufacturing	0.9472	1.0294	0.7971	0.55	0.423
Special equipment manufacturing	1.2139	1.1678	0.9505	1.1189	0.3936
Transportation equipment manufacturing	3.4501	1.3808	0.703	0.328	0.244
Electrical machinery and	0.9157	0.7645	0.8209	0.3566	0.3656

equipment manufacturing					
Computer, communications and other electronic equipment manufacturing	2.2481	1.4953	0.141	0.9144	0.0859
Comprehensive utilization of waste resources	0.1435	2.4804	0.513	0.0633	0.4337

In the 5 provinces in North China, Tianjin and Beijing, as the core of the social economy, are relatively developed regions; Hebei, Shanxi and Inner Mongolia are in the developing surrounding areas. Under the circumstances of the interaction and mutual influence between environment and development and the environmental policy and industrial development policy, we, first of all, ask how will the five provinces coordinate trade-offs between environment and development under "core-periphery" pattern, which is a matter of common concern for all provinces, autonomous regions, and municipalities. The "core-periphery" environment and economically coordinated development requires scientific coordination between the core areas and the surrounding areas about the space planning and regulation, industrial planning and regulation, and environmental planning and regulation.

Second, in the developing surrounding areas, like Hebei, Shanxi, and Inner Mongolia, there also exists the problem of dislocation development and coordinated development. Industrial development and regional development issues discussed here are interwoven together with the enterprise energy saving and emission reduction and performance of the government environmental regulation problems. They pose considerable challenges to the local industry regulation, space regulation, environmental regulation, and their interregional coordination. In order to facilitate the analysis, in the following discussion, we will analyze the local industrial regulation, spatial regulation, environmental regulation, and regional coordination in accordance with the respective characteristics and the different challenges of the core areas and the surrounding areas.

The Regional Regulation and Coordination Initiatives to Promote Enterprise Energy Saving and Emission Reduction Performance

Distinguishing regional regulation and coordination key areas to enhance the performance of enterprise energy saving and emission reduction

The interrelation and mutual influence between environmental policies, industrial policies, and regional policies require us to combine environmental problems and industrial problems with regional development issues and to study the inter-regional regulation coordination measures to improve the performance of enterprise energy saving and emission reduction in an integrated "environment - economy - society" framework. The policy suggestions on the development of the road to the coordinated development of the region cannot be derived from the research on the industry and regional development from the environmental problems or from the research on the environmental problems from the industrial and regional development. To this end, we combine the DEA analysis with the location quotient analysis results to research the coordination of regional regulation from the two dimensions of enterprise energy saving and emission reduction efficiency and regional specialization division of labor.

Taking the location quotient as a measure of the degree of regional specialization, the industries whose location quotients are greater than 1 indicate that they have formed the local advantages of division

of labor and stood in a dominant position in the regional division of labor; the industries whose location quotients are less than 1 don't have advantage in the division of labor and are in a subordinate status in the regional division of labor. Taking the average value of the energy saving and emission reduction efficiency of various industries in the local manufacturing industry in the 5 provinces as the basis of the comparison of the efficiency, we stipulate that an industry in one province whose efficiency value is higher than the average value is a high-efficiency industry; an industry whose efficiency value is lower than the average value is a low-efficiency industry. Accordingly , the comprehensive information matrix (Table 3) of energy saving and emission reduction efficiency and industrial division of labor in the 5 provinces in North China is obtained on the basis of which we can identify the key areas of regional regulation coordination to promote enterprise energy saving and emission reduction performances of the 5 provinces in North China.

The information matrix is divided into four regions: A region is an encouraged industrial development region covering high energy saving efficiency and advantaged division of labor (location quotient> 1) industries; B district is an environmental regulation intensive area, covering industries which have the advantages of division of labor (location quotient >1), but the energy saving and emission reduction efficiency needs to be improved; C area is the transfer industry candidate region, covering low energy saving and emission reduction efficiency and not having industry division of labor advantages (location quotient < 1). This kind of industry faces the dual pressure of increasing energy saving and emission reduction efficiency and cultivating the advantage of the division of labor. This kind of industry is at a disadvantage position in the regional competition and, besides, there are problem industries in the regional industrial structure adjustment, which easily evolve into the transfer candidate industries; D district is the key area of inter-regional coordination.

The industry in this region is highly efficient in energy saving and emission reduction, but it does not have the division of labor advantage (location quotient <1). Because the manufacturing enterprises in D region have good performance in energy saving and emission reduction, the 5 provinces and municipalities have enthusiasm for absorbing such kinds of enterprises in order to promote the development of related industries. In other words, the 5 provinces and municipalities will face competition in the development of related industries. To avoid the homogenization of industry competition in the D area and to achieve industrial dislocation development is the focus of the regional industrial policy coordination in the 5 provinces and municipalities.

Measures and recommendations to improve the inter regional coordination of environmental, industrial and spatial regulation in the 5 provinces in North China
Based on the integrated information matrix of energy saving, emission reduction efficiency, industrial division of labor, and division of manufacturing enterprises in 5 provinces in North China, we can get the following policy recommendations on environmental, industrial, and spatial regulation of regional coordination for the promotion of corporate environmental responsibility of the 5 provinces and municipalities in North China.

Encouraged industrial development region. Manufacturing enterprises in the encouraged industrial development region have good performance in energy saving and emission reduction, and the relevant industrial location is greater than 1. They are generally the local pillar industries. Provinces and cities should develop relevant encourage policies (such as tax cuts to provide environmental protection

technology research and development subsidies, etc.), for this type of environmentally-friendly enterprises and industries to promote their development in the local areas.

The environmental regulation intensive area. The energy saving and emission reduction performance of manufacturing enterprises is lower than the industry average in the environmental regulation intensive area, but the relative industry location quotient is more than 1, which is the local pillar industry with high energy consumption, high output, and high environmental impact. Upgrading the local environmental protection standards and environmental regulation can help promote enterprises to improve energy efficiency and emission reduction performance.

Table 3

The Comprehensive Information Matrix of Enterprise Energy Saving and Emission Reduction Efficiency and Industrial Division of Labor Advantage

		Energy saving and emission reduction efficiency > average value		**Energy saving and emission reduction efficiency <average value**	
Location quotient >1	A. Encourage the development of industrial areas	None	Beijing	Printing and recording medium reproduction, petroleum processing, coking and nuclear fuel processing, pharmaceutical manufacturing, special equipment manufacturing, transportation equipment manufacturing, computer, communications and other electronic equipment manufacturing	B. The areas for strengthening the environmental regulation
		Food manufacturing, general equipment manufacturing, special equipment manufacturing, transportation equipment manufacturing, computer, communications and other electronic equipment manufacturing, waste comprehensive utilization of resources, petroleum processing, coking and nuclear fuel processing	Tianjin	Stationery and sporting goods manufacturing, metal products, ferrous metal smelting and rolling processing	
		Textiles, ferrous metal smelting and rolling processing	Hebei	Printing and recording medium reproduction, metal products, petroleum processing, coking and nuclear fuel processing	

Location quotient <1	D. Key areas for Regional coordination	Chemical raw materials and chemical products manufacturing	Shanxi	Petroleum processing, coking and nuclear fuel processing, ferrous metal smelting and rolling processing, non-ferrous metal smelting and rolling processing, special equipment manufacturing	C. Candidates for the transfer of industry
		Chemical raw materials and chemical products manufacturing	Inner Mongolia	Agro food processing, food manufacturing, beverage manufacturing, textile, wood bamboo and rattan palm fiber and straw products, petroleum processing, coking and nuclear fuel processing, ferrous metal smelting and rolling processing, non-ferrous metal smelting and rolling processing, metal products	
		Textile, paper and paper products, non-metallic mineral products, non-ferrous metal smelting and rolling processing, waste comprehensive utilization of resources		Beverage manufacturing, furniture manufacturing, general equipment manufacturing, electrical machinery and equipment manufacturing, Agro food processing, food manufacturing, brown grass of bamboo and rattan wood products, cultural and sports goods manufacturing, chemical raw materials and chemical products manufacturing, rubber and plastic products, ferrous metal smelting and pressure extension processing, metal products	
		Paper and paper products, electrical machinery and equipment manufacturing, agricultural and sideline products processing industry, beverage manufacturing, textile, brown grass of bamboo and rattan wood products, furniture manufacturing, printing and record medium reproduction, pharmaceutical manufacturing, and so on.	Tianjin	Rubber and plastic products, chemical raw materials and chemical products manufacturing, non-metallic mineral products	

		Agricultural and sideline products processing, paper and paper products, rubber and plastic products, non-metallic mineral products, food manufacturing, chemical raw materials and chemical products manufacturing, pharmaceutical manufacturing, transportation equipment manufacturing	Hebei	Bamboo, cane, palm, and straw products, furniture manufacturing, electrical machinery and equipment manufacturing, beverage manufacturing, cultural and sports activities manufacturing, non-ferrous metal smelting and rolling processing, general equipment manufacturing, special equipment manufacturing, computer, communications and other electronic equipment manufacturing, comprehensive utilization of waste resources	
		Nonmetallic mineral products, brown grass of bamboo and rattan wood products, furniture manufacturing, cultural and sports activities manufacturing, metal products, pharmaceutical manufacturing, comprehensive utilization of waste resources	Shanxi	Beverage manufacturing, computer, communications and other electronic equipment manufacturing, Agro food processing, food manufacturing, textile, paper and paper products, printing and record medium reproduction, rubber and plastic products, general equipment manufacturing, transportation equipment manufacturing, electrical machinery, and equipment manufacturing and made	
		Printing and record medium reproduction, cultural, educational and sporting goods manufacturing, rubber and plastic products, special equipment manufacturing, transportation equipment manufacturing, electrical machinery and equipment manufacturing, computer, communications, and other electronic equipment manufacturing	Inner Mongolia	Pharmaceutical manufacturing, nonmetal mineral products, furniture manufacturing, paper and paper products, general equipment manufacturing, comprehensive utilization of waste resources	

The candidate region for industry transfer. The energy saving and emission reduction performance of manufacturing enterprises lying in this region is lower than the industry average level, and

the industry location is less than 1 without the advantage of the division of labor. These types of enterprises form a strong negative environmental externality in the production process, and the contribution they make to the local economic development is relatively low. For the industries in this region, industrial policies and environmental policies must work together. First, out of overall consideration about the industrial transfer costs, the advantages and disadvantages of the industrial division of labor and the strength of the external environment, it is suggested   that such enterprises be sorted according to the location quotient index , and the industries ranked in the post three should be included in the local priority industrial transfer candidate list.   Individual serious pollution enterprises and industries of local environment can be incorporated into local a priority transfer industry candidate directory. Besides, for the manufacturing enterprises that   have not been listed in the industrial scope to be a priority transfer or priority to eliminate, the more stringent local environmental protection standards, which environmental regulation and strengthen area enterprises use, should be applied to them as well and increase the intensity of environmental regulation.

Key areas for regional coordination. As mentioned earlier, the manufacturing industries lying in the D area are the growing industries impacted relatively less by the environment. Because the 5 provinces, autonomous regions and municipalities support these industries positively, they will face competition when developing industries in D area. The interaction between industrial policy and regional development policy for the development of industries and enterprises in D area is the key point of regional coordination. In order to achieve dislocation development and to avoid the homogenization competition, different provinces, autonomous regions and municipalities must determine their choices of industries according to their specific industry comparative advantages, and they must construct a new regional specialized division of labor for industries in D region so that they can enlarge their respective advantages through the development coordination. There are differences in development level and function positions between the core areas of Beijing and Tianjin and the surrounding areas of Hebei province, Shanxi province and Inner Mongolia. First, a core area whose location quotient does not have obvious advantages and whose environmental impact of the relative industry is higher should not form direct competition with the surrounding area. That is, the core area 's choice for the industries in D region must be in harmony with its status and function. Second even if the core areas cede part of development opportunities of the industries in D region to the surrounding areas, neighboring provinces and autonomous regions need to take the path of differentiation in cultivating industries and undertaking the industry transfer of the core areas. For this consideration, we will be aimed at industries in D area for specific analysis based on the different characteristics in the core and the surrounding areas.

(1) Policy coordination between the core and the surrounding area

The industries in Beijing lying in D area include textile, paper and paper products, non-metallic mineral products, non-ferrous metal smelting and rolling processing, and waste resources comprehensive utilization industry. Except for the metallic mineral products industry, whose location quotient is 0.54, the rest of the industry location quotients are below 0.33. Beijing's position as a political, cultural, and international communication center determines that it is the first option for Beijing to develop its capital services. It is recommended that Beijing choose to transfer the above industries to the outside of the region step by step.

The pharmaceutical manufacturing, mechanical and electrical equipment manufacturing, and

non-ferrous metal smelting and rolling processing industry in Tianjin, located in the D District, whose location quotients are, respectively, 0.7847, 0.7645, and 0.6673. The required additional investment to nurture the three industries into pillar industries is lower than the cost of transferring them outside of the district. The location quotient of paper and paper products is 0.6427, making it a high-pollution industry. The location quotients of the rest of the industries in Tianjin located in D region are below 0.5. Tianjin is the economic center in the north, and to develop the service function of a producer service industry, which has the characteristic of being environmentally friendly, is a necessary step to get out of the way of the development of Tianjin and the adjustment of industrial structure. It is recommended that Tianjin should keep the development of pharmaceutical manufacturing, electrical machinery and equipment manufacturing, and non-ferrous metal smelting and rolling processing industry, and Tianjin should choose to transfer the rest of industries in D area to outside the region in a step-by-step manner.

(2) The policy coordination between the provinces and cities in the surrounding areas
Among the surrounding provinces, autonomous regions and municipalities, the manufacturing industry in Hebei Province is relatively developed. There are 20 segments of the manufacturing industries whose location quotients are above 0.5; there are only 12 in Shanxi Province and 13 in Inner Mongolia whose location quotients of segments of the manufacturing industries are above 0.5. Therefore, the focus of policy coordination between the surrounding areas of provinces, autonomous regions and municipalities should encourage industries and enterprises in Shanxi Province and Inner Mongolia located in D area to actively participate in the regional competition; industries and enterprises in Hebei Province in D area should optionally participate in the regional competition.

The success of policy coordination between provinces in the surrounding area is largely determined by the choice of industry in D area in Hebei Province. The agricultural and sideline products processing, rubber and plastic products, and non-metallic mineral products industry in Hebei Province, located in the D District have location quotients that are, respectively, 0.7063, 0.9585, and 0.7229. They rank No. 2, 1, and 2, respectively, in the same industry among the 5 provinces and municipalities. The location quotients of pharmaceutical manufacturing and transportation design manufacturing industry are 0.7241 and 0.7030, and the location quotients both rank as No. 3. However, the products of pharmaceutical manufacturing and transportation equipment manufacturing industry are typically differentiated products. They do not generate homogenization competition with the same industry whose location quotient ranks higher in other provinces and municipalities.

Therefore, it is suggested that Hebei Province should maintain development medicine manufacturing, agricultural and sideline products processing, rubber and plastic products, non-metallic mineral products, and the transportation equipment manufacturing industry, and choose to transfer the rest of its industries in D area to the outside of the region in a step-by-step manner.

The location quotient (0.8585) of the paper and paper products industry in Hebei province is less than 1. Although ranking in the first place in the 5 provinces, autonomous regions, and municipalities, it does not have the advantage of the division of labor that other domestic provinces and municipalities do. Considering the severity of their environmental impact, it is suggested that Hebei Province should transfer the industry to the outside of the region.

Conclusion

Using the BBCA model of variable scale returns in the DEA model, we measure and analyze the regional differences in energy saving and emission reduction performance of manufacturing enterprises in 5 provinces in North China. According the number of enterprises with high energy saving and emission reduction efficiency sorted in the 5 provinces in North China, Tianjin ranks first, Hebei ranks second, and Shanxi and Inner Mongolia are tied for the third. Beijing ranks at the bottom.

Because of the mutual connection and mutual influence between enterprise energy saving and emission reduction and development of enterprises and industries, regional economic development, and local government's regulation, we further combine the analysis of the distribution of manufacturing industry and the characteristics of specialization in the 5 provinces in North China to try exporting initiatives and make recommendations to promote the performance of enterprise energy saving and emission reduction and to promote regional coordinated development of regional regulation. We put the DEA analysis and location quotient analysis as the basis for the development of enterprises in energy saving and emission reduction efficiency; the industrial division comprehensive information matrix helps us identify the key areas of inter-regional regulation coordination to promote enterprise energy saving and emission reduction performance in the 5 provinces in North China.

According to the two dimensions of energy saving and emission reduction efficiency and regional division of labor advantage, we classify the manufacturing industries in the 5 provinces in North China into four types: the encouraged industrial development area, the environmental regulation intensive area, the transfer candidate industry, and the regional coordination key area. We provide the policy advice to improve the performance of enterprise energy saving and emission reduction and to promote the regional coordinated development, aiming at different industrial regions. Our research, based on industrial energy consumption data, is just a preliminary attempt. With the improvement of future, related pollution emission data availability (industrial wastewater discharge, carbon dioxide and sulfur dioxide emissions and solid waste emissions), our research conclusions and the practicality of the relevant policy recommendations are expected to be further enhanced.

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