Estimation and Analysis of Water-Coal Trade Flows in North China: Based on Input-Output Tables and Location Quotient Method

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Keywords: North China; Flow estimation; Input-output; Location quotient method

Abstract: North China is the most water-starved region in China with rich coal resources. However, it is also short of water resources, which limits its development in the long run. The work firstly analyzed and compared the input-output tables of China by province in 2012 and 2017, then calculated the inter-provincial water and coal trade volume in North China through the location quotient method, subsequently, this work utilized the supply coefficient in the column coefficient model to clarify the inter-provincial water-coal development trend in North China, and finally provided some suggestions on strengthening the internal trade of the water-coal industry in North China.

1. Introduction

North China in physical geography generally refers to the vast area north of the Qinling-Huaihe River line and south of the Great Wall. It is the most economically active region in northern China with abundant coal resources. However, as the most water-starved region in China, facing serious ecological problems, its per capita water resources, soil and water resources allocation ratio are significantly lower than the national average. Regional trade can alleviate the problem of water shortage through domestic regional trade and even inter-regional trade in North China, and plays an irreplaceable role in taking advantage of the market scale, promoting sustainable economic development and enhancing national competitiveness [1]. There are quite a lot domestic studies on inter-regional trade, for example, *Measured the level of trade facilitation in the western region of China based on provincial panel data from 2003 to 2016* by Shi Weiwen, and then used panel cointegration regression technique to empirically investigate the effect of trade facilitation on economic growth [2]. Zheng Lei and others used trade integration index, dominant comparative advantage and export similarity index to portray the foreign trade pattern of western region and its inter-provincial differences in terms of spatial structure and product structure [4]. Based on the input-output tables of Chin a by provinces in 2012 and 2017, this work applied the location quotient method to estimate the water and coal trade flow matrices in North China, and analyzed the water and coal trade volumes of each province and their development trends in 2012 and 2017. Specific data were drawn for the development of coordinated and holistic water and coal resources in North China.

2. Model building

2.1 Method selection

Through the literature review, the common methods for calculating the trade flow between regions are divided into two categories: survey methods and non-survey methods. The two most widely used methods in the non-survey method are the gravity model and the location quotient method. For the survey method, namely, it adopts a similar way to the preparation of input-output table, investigating the production input structure and product flow structure of major, medium and small enterprises to obtain the regional flow of products from different sectors in different regions. Specifically, it is the most accurate method, but the demand for data is too large, so it is difficult to have enough human, material and financial resources to conduct a detailed investigation. For the second type of non-survey method, only the regional flow can be estimated. For the gravity model, the focus is on the calculation of the friction coefficient. The common method is the single point estimation method and the transport distribution coefficient to approximate the friction coefficient in the gravity model. The single point estimation method requires relatively complete base-year statistics, including both regional output and input and inter-regional traffic, but in practice, many inter-regional traffic statistics of goods and services are not available. For the approximate determination of friction coefficients in the gravity model using the distribution coefficients of transport volumes, the sectoral inter-provincial freight volumes have not been disclosed in China, and only total trade data can be estimated by this method. At the same time, the method has a strong reliance on transport data, which leads to a low accuracy of value volume estimation [5], so the method of calculating trade coefficients in the gravity model is discarded. There are relatively few cases calculated using the location business method. Therefore, this work made use of the location commercial method to calculate and determine the intermediate flow of each region. As shown in Figure 1.

$$LQ^r_i=(X^r_i/X^r)/(X^N_i/X^N) \quad (1)$$

X^r_i represents the output of Division I in regional R, and X^r is the total output of regional R; X^N_i is the output of national Division I; X^N is the total output of nation. Location merchants represent the trade model of a region. If the location quotient of an industry in a region is greater than 1, then the production of the industry in the region not only fully meets the full demand of the industry products in the region, but also meets part of the demand of the industry products in other regions. If the location of an industry in a region is less than 1, then the region needs the products of other regions as a supplement.

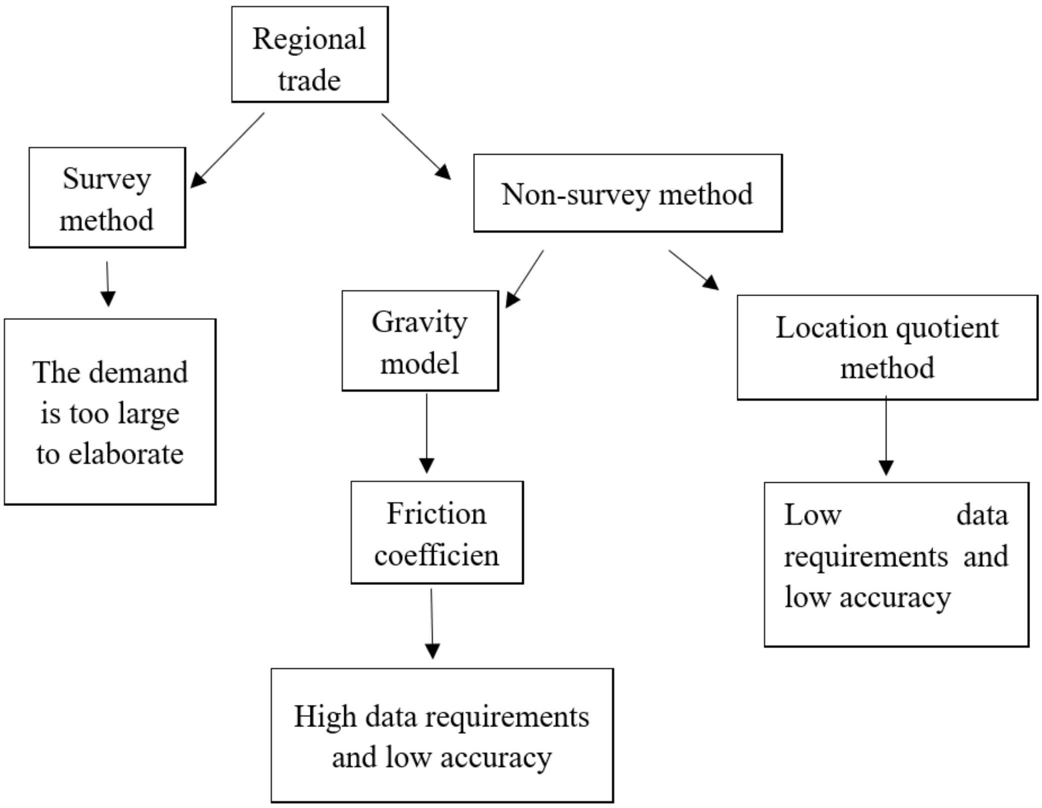

Figure 1: To calculate and determine the intermediate flow rate of each region based on the location quotient method

2.2 Calculation steps

We assume that the country consists of two regions, r and s.

First, calculate the location quotient of each department of region r and region s.

Second, estimate regional internal input coefficient.

$$a_{ij}^{r} = \begin{cases} LQ_i^r a_{ij}^N, LQ_i^r < 1 \\ a_{ij}^N, LQ_i^r > 1 \end{cases} \tag{2}$$

Third, the input coefficient between regions is estimated.

$$a^{rr}_{ij}=t^{r}_{i}a^{N}_{ij} \tag{3}$$

$$a^{ss}_{ij}=t^{s}_{i}a^{N}_{ij} \tag{4}$$

$$t_l^k = \begin{cases} LQ_i^k, LQ_i^r < 1 \\ 1, LQ_i^r > 1 \end{cases} k = (r, s) \tag{5}$$

In the two-region model, if the production of region r cannot meet the input needs of region r, then r needs to be imported from region s, so that the input to region s product inflow into region r can be separated.

$$a^{sr}_{ij}=(1-t^{r}_{i})\ a^{N}_{ij} \tag{6}$$

$$a^{rs}_{ij}=(1-t^{s}_{i})\ a^{N}_{ij} \tag{7}$$

Fourth, the input coefficient matrix is multiplied by the total output of each region and each department to obtain the intermediate flow matrix of each region.

Fifth, the intermediate flow matrix was balanced by the RAS method. (Error is less than 1)

2.3 Index system construction

The inter-regional intermediate input matrix is set to a smaller scale of region 5. The regional classification is Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia and other regions, including the other provinces except the five provinces in North China. The department is water production and supply and coal mining and selection products (all the data in the table are net flow, which are not split the foreign department, assuming that there is no import and export of water and coal). Taking the intermediate flow matrix of water resources in 2012 as an example, the column on the left side of the table indicates the outflow area, and the upper side line indicates the inflow area. The basic form is shown in Table 1.

Table 1: The basic form of the index system construction

Water Resources in 2012	Beijing	Tianjin	Hebei	Inner Mongolia	Shanxi	Others
Beijing	/	/	/	/	/	/
Tianjin	/	/	/	/	/	/
Hebei	/	/	/	/	/	/
Inner Mongolia	/	/	/	/	/	/
Shanxi	/	/	/	/	/	/
Others	/	/	/	/	/	/

3. Calculation result

3.1 Location quotient

Table 2: Location quotient results: water production and supply

Water production and supply	Provincial location quotient in 2012	Provincial location quotient in 2017
Beijing	0.966171159	1.128848882
Tianjin	0.827610266	1.367960972
Hebei	0.495604877	0.507973699
Inner Mongolia	1.021565312	1.082528257
Shanxi	0.530832932	0.637784836
North China	0.744469918	0.914639397
Nationwide	1	1

Table 3: Location quotient calculation results: total output of coal mining and selection products

Total output of coal mining and selection products	Provincial location quotient in 2012	Provincial location quotient in 2017
Shanxi	10.85372812	17.06127333
Inner Mongolia	6.02578771	8.050086822
Hebei	1.51798085	0.593005722
Tianjin	1.479226878	0.013216428
Beijing	0.991748626	0.03196795
North China	3.313965994	3.145333744
Nationwide	1	1

3.2 Inter-regional trade flow

3.2.1. Inter-regional trade flow

Table 4: Inter-regional trade flow: water resources trade (2012)

In 2012	Beijing	Tianjin	Shanxi	Hebei	Inner Mongolia	Others
Beijing	572384	0	0	0	0	0
Tianjin	0	376432	0	0	0	0
Shanxi	0	0	182114	0	0	0
Hebei	0	0	0	435317	0	0
Inner Mongolia	272.5	1006.2	2188.6	6024.2	442907.6	0
Others	19768.6	77344.9	158769.6	437013.8	0	165712233.2

Table 5: Inter-regional trade flow: water resources trade (2017)

In 2017	Beijing	Tianjin	Shanxi	Hebei	Inner Mongolia	Others
Beijing	0	0	29103.9	103894.1	0	0
Tianjin	0	0	58097.4	207394.0	0	0
Shanxi	0	0	0	0	0	0
Hebei	0	0	0	0	0	0
Inner Mongolia	0	0	7894.2	28180.5	0	0
Others	0	0	72226	257829.9	0	0

3.2.2. Coal Resources trade

Table 6: Inter-regional trade flow: coal resources trade (2012)

In 2012	Beijing	Tianjin	Shanxi	Hebei	Inner Mongolia	Others
Beijing	9718938	0	0	0		0
Tianjin	2806.9	7523925	0	0		3602860.2
Shanxi	435312	0	5675044.4	0		55876812.6
Hebei	5858.8	0	0	14529606.2		7520199
Inner Mongolia	28664.2	0	0	0	7326505.5	36792797.3
Others	0	0	0	0		170326001

Table 7: Inter-regional trade flow: coal resources trade (2017)

In 2017	Beijing	Tianjin	Shanxi	Hebei	Inner Mongolia	Others
Beijing	246359	0	0	0	0	0
Tianjin	0	71198	0	0	0	
Shanxi	5271056	3756037	3448912.6	2606410	0	43760426
Hebei	0	0	0	5374761	0	0
Inner Mongolia	2189023	1559849	0	1082419	3263025	18173317.6
Others	0	0	0	0	0	134524974

4. Data analysis

4.1 Analysis method

Data analysis method adopts the supply coefficient calculation method proposed in the column coefficient model (MRIO):

$$C^{rs}_i = z^{rs}_i / (z^{1s}_i + z^{1s}_i + z^{2s}_i \ldots z^{rs}_i + \ldots + z^{ns}_i) \text{ (Suppose for n areas)} \tag{8}$$

The z^{rs}_i provides product outflow to region s by region r in sector i, and the denominator section indicates product inflow from all regions received by region s in sector i. Namely, the product outflow of region r to region s in sector i accounts for the proportion of the product outflow of all region to region s.

Beijing, Tianjin, Shanxi, Hebei, Inner Mongolia and others are expressed in 1, 2, 3, 4, 5 and 6, respectively, while water production and supply and coal mining and selection products are expressed in a and b, respectively.

4.2 Internal water trade analysis in North China

4.2.1. Water Resources trade analysis in 2012

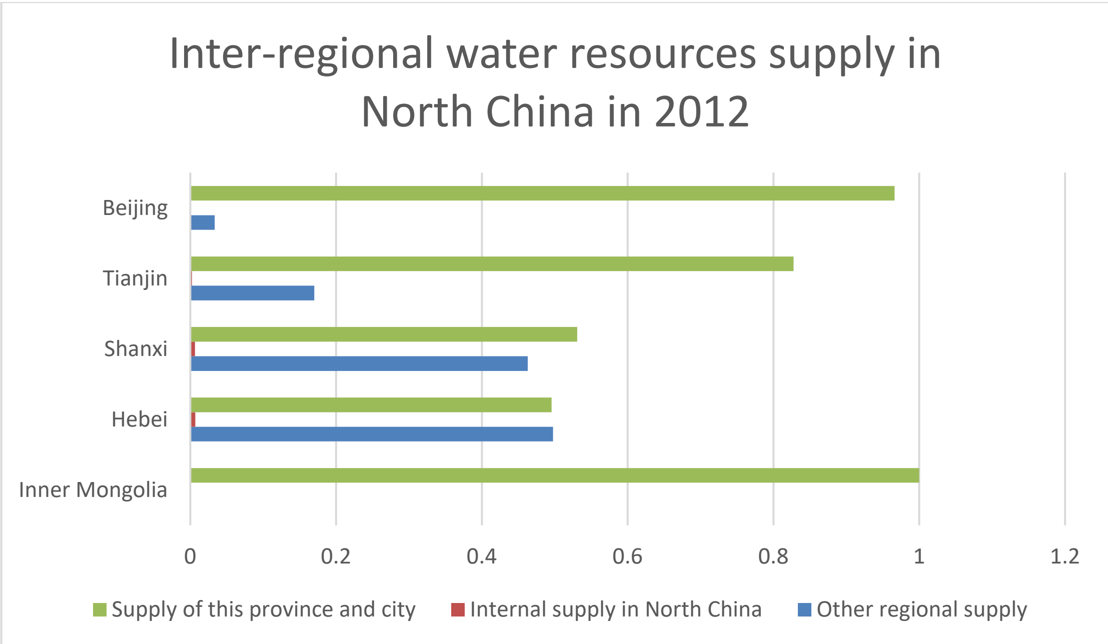

Figure 2: Water resources supply distribution in North China in 2012

In 2012, only Inner Mongolia was fully self-sufficient in water resources, with other provinces and cities coming from external supply. For Beijing and Tianjin, water is basically supplied by the region, and a small part is supplied by other regions outside North China, which shows that Beijing and Tianjin are lower than the national average, but they can be basically self-sufficient. Shanxi and Hebei supply nearly 47% and 50% from outside, causing serious water shortage. As a whole, there is no internal water transfer, and the water supply comes from outside North China. If the water resources cannot be self-sufficient in North China, the transportation from outside North China will inevitably face high transportation costs.

4.2.2. Water resources trade analysis in 2017

In 2017, Beijing and Tianjin achieved a great improvement in the self-supply of water resources, and even realized the supply of water resources in Shanxi and Hebei provinces, which are very short of water. The internal trade of water resources in North China has changed from scratch, which is bound to reduce the cost of water transportation from other regions for the water-poor Shanxi and Hebei provinces. This is a successful transition from Beijing and Tianjin, which needs local water supply from other regions, and can be supplied to other provinces in North China.

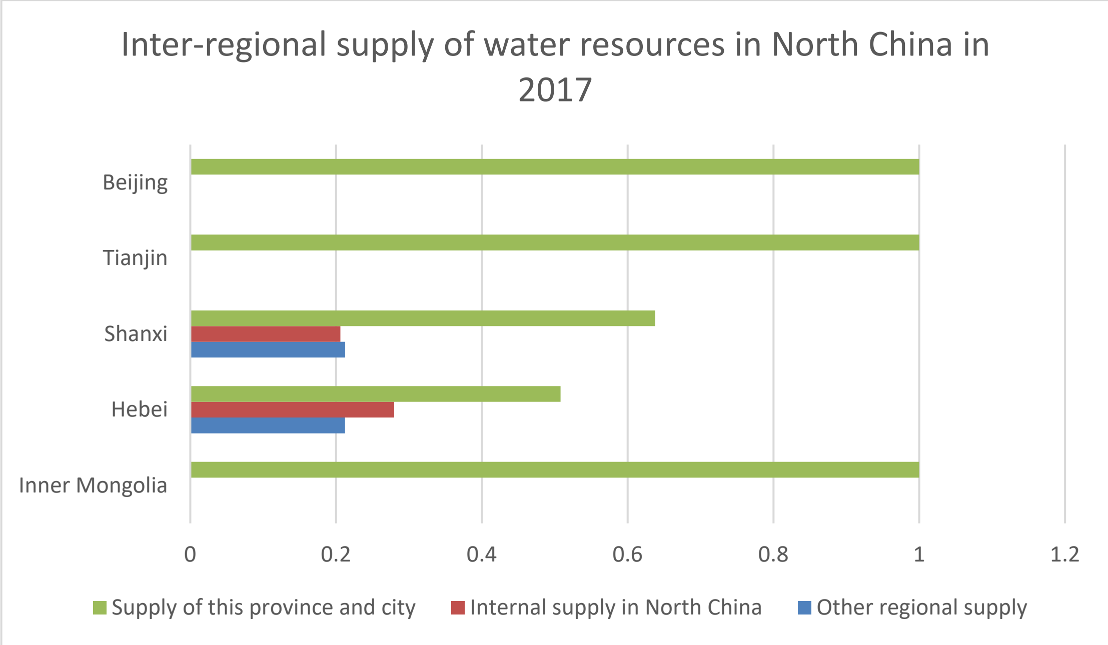

Figure 3: Water resources supply distribution in North China in 2017

4.3 Coal trade analysis in North China

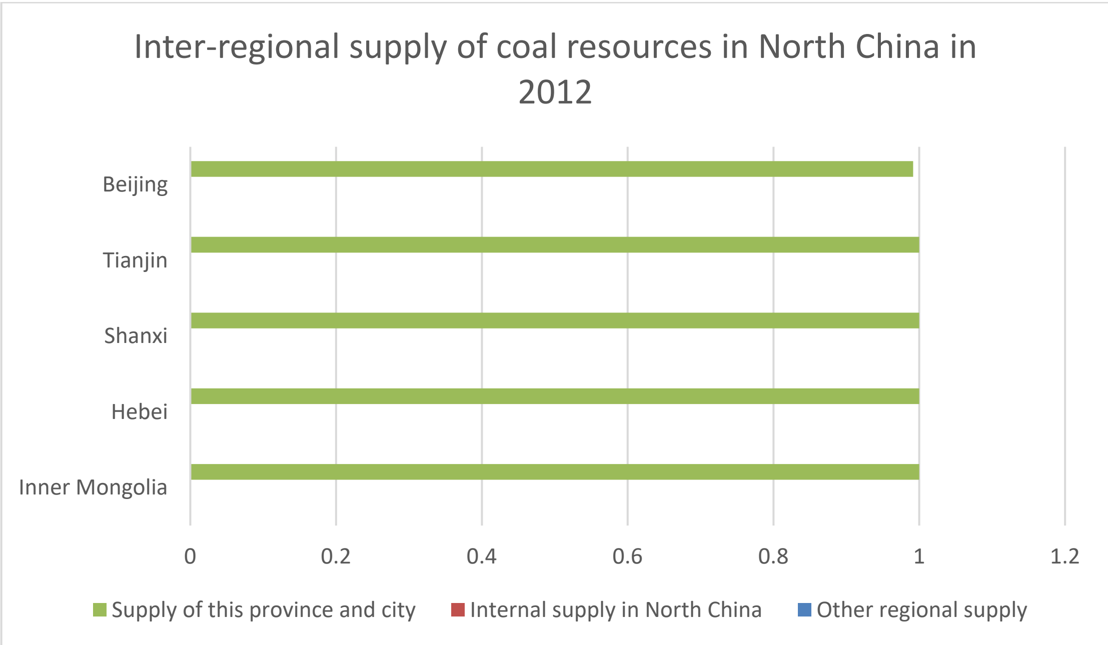

Figure 4: Regional supply distribution of coal resources in North China in 2012

In 2012, the five coal provinces and cities in North China can basically realize the self-supply of each region. Except for Beijing, the other four provinces and cities do not need the net inflow of other provinces and cities, and most of the coal in Beijing is also supplied by the city. Among other provinces and cities except North China, Shanxi accounted for the largest proportion, with 20.384169%.

In 2017, the sharp decline in coal production in Beijing and Tianjin is bound to increase the internal coal trade in North China. Coal trade has become frequent, among which only Shanxi and Inner Mongolia have realized the self-supply of coal, and Shanxi has the most supply to the other four provinces and cities. For other regions except North China, the supply in North China accounts for 31.525% of the total, among which Shanxi reaches 22.2746%.

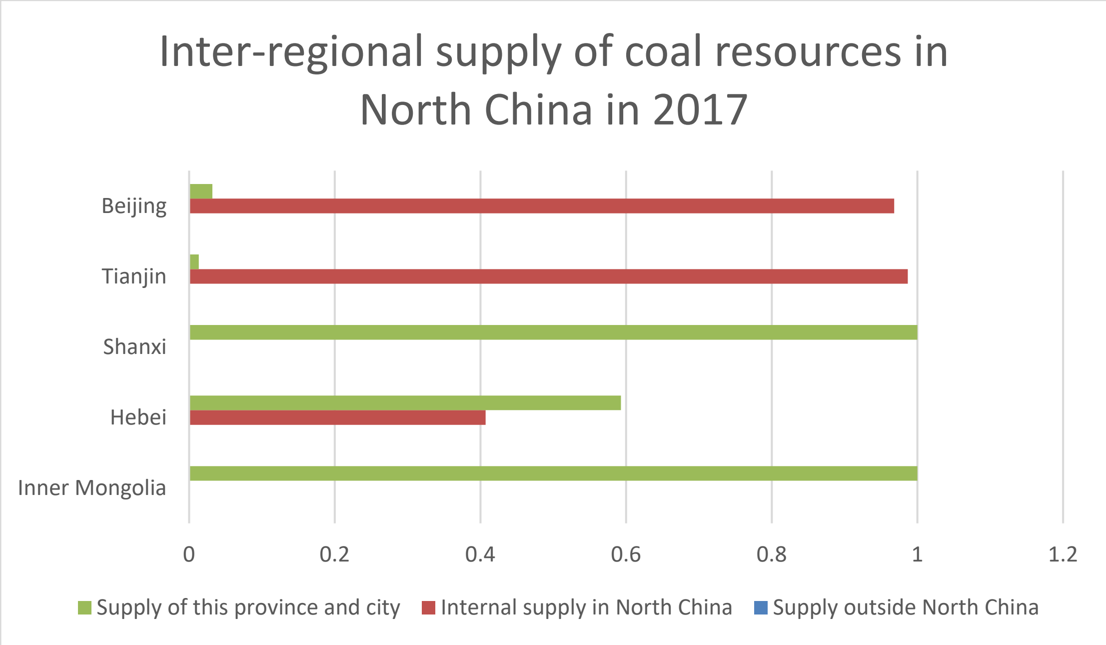

Figure 5: Regional supply distribution of coal resources in North China in 2017

5. Summary

From 2012 to 2017, the inter-regional trade in water and coal resources in North China became frequent, and the economic ties became closer. For water trade, the overall water environment in North China has been improved, with the overall location quotient rising from 0.7444 to 0.9146. The supply of water resources from outside the province and cities from other areas outside North China to inside north China can realize regional circulation to a certain extent. This change is mainly due to the transformation of the water sector in Beijing and Tianjin from inferior departments to superior departments. For water-starved Shanxi and Hebei, the change is bound to reduce the cost of transportation from other areas outside north China and improve transportation efficiency. Because of the dense population and natural geographical environment constraints, although the water production and supply in Shanxi and Hebei increased in 2017 compared with 2012, it is very difficult to achieve self-sufficiency in water resources output in Shanxi and Hebei in a very short time. Therefore, how to strengthen the water resources advantages of Beijing and Tianjin, produce scale effect, and fully realize the self-circulation of water resources in North China is the goal that needs to be completed at present.

For coal trade, North China has great advantages, inter-regional trade has become frequent, this is because Beijing and Tianjin have changed in coal production, the regional coal mining and selection products have declined. Although it is still a dominant industry in North China, the main responsibility for coal supply within and even outside North China falls on Shanxi province and Inner Mongolia. This also strengthens the regional trade of coal in North China, and the production of coal mining and selection products will bring some environmental problems such as greenhouse gas emissions and air pollution. From the transformation from 2012 to 2017, it can be seen that Hebei, Tianjin and Beijing have implemented the transformation strategy in the production of coal mining and selection products. How to reduce environmental pollution in Shanxi and Inner Mongolia is a problem that the local governments need to consider today and even in the future.

References

[1] Tian Xu, Geng Yong, Wu Rui, Xu Yue. Space and temporal evolution path of regional water footprint and virtual water trade in China [J]. Environmental and Economic Research, 2021, 6 (04): 85-11.

[2] Li Zili, Xia Xiaohua, Huang Guitian. Study on the reestimation of interprovincial trade flow and

trade development characteristics in China [J]. Statistical Research, 2020, 37 (08): 35-49.

[3] Zheng Lei, Song Zhou Ying, Liu Weidong, Liu Yi. Analysis of trade pattern and trade structure in western China [J]. Geographic Research, 2015, 34 (10): 1933-1942.

[4] Zhang Min, Fan Jin, Zhou Yingheng. Preparation and update of the input-output table in multiple regions within the province: Jiangsu case [J]. Statistical Study, 2008 (07): 74-81.

[5] Liu Qiang, Shobingoshi Okamoto. Preparation and problems of inter-regional input-output model in China [J]. Statistical Study, 2002 (09): 58-64.