Research on the Efficiency of Beijing Tianjin Hebei Logistics Industry Based on Three Stage DEA Model

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Abstract. In order to explore the impact of external environmental factors on the efficiency of logistics industry in Beijing Tianjin Hebei region, this paper uses Three-stage DEA method to study the efficiency of logistics industry in Beijing Tianjin Hebei region from 2013 to 2017. The results show that the overall logistics efficiency of Beijing Tianjin Hebei region is in a good state, but it does not reach the optimal state. After the adjustment, the pure technical efficiency and scale efficiency have obvious changes, which indicates that the external environmental factors such as the consumption level of residents, the total amount of telecommunications business and the total retail sales of regional social consumer goods have a significant impact on the efficiency of the logistics industry. Relevant departments can put resources in a targeted way to promote the efficiency of Beijing Tianjin Hebei logistics industry.

1. Introduction
Accelerating the development of modern logistics industry is not only related to the effective adjustment of China's industrial structure and the effective transformation of development mode, but also an important support and guarantee for improving the competitiveness of national economy and building ecological civilization in the future. Scholars at home and abroad have launched a wealth of exploration on the issues related to the efficiency of the logistics industry. Markovits Somogyi et al. combined DEA with AHP to measure the logistics efficiency of 29 European countries[1]; Huaqing Wu et al. analyzed the operation efficiency of Chinese logistics enterprises [2]; Zhang Jingyi et al. analyzed the efficiency of logistics industry in 31 provinces and cities from 2010 to 2014[3]. Zhang Liguo et al. Measured the dynamic changes of total factor energy efficiency of China's logistics industry, and analyzed the differences between regions[4]; Wang Dongfang et al. used Three-stage DEA and bootstrap DEA methods to calculate the technical efficiency of logistics industry in 31 provinces and cities of China in 2016, and analyzed the spatial differences and drivers[5].

2. Research methods
2.1 phase I BBC model
In the first stage, only the input and output index values are considered. Because the logistics industry has variable returns to scale, the BCC input oriented model in data envelopment analysis is used to calculate the input target value and slack variable value. Because the application of this model method has been mature, this paper will not elaborate.
2.2 second stage SFA model
The second stage of SFA model is based on the slack variables obtained from the first stage DEA. The input slack variables are taken as the explained variables, while the external environment and random error factors are taken as the explanatory variables. The following similar SFA regression function model is constructed:

$$s_k = f'(z_k; B') + v_k + u_k$$ (1)

2.3 DEA model adjusted in the third stage
In the third stage, the adjusted DEA model replaces the original input data with the adjusted input data. Combined with the original output data, the BCC model is used to calculate the efficiency of the decision-making unit again. In the third stage, the efficiency of decision-making units calculated by the adjusted DEA model is the result of excluding the external environment and random error factors, which can reflect the actual situation of the efficiency level of each decision-making unit.

3. Empirical analysis

3.1 empirical results of the first stage
Deap 2.1 software is used to analyze the logistics efficiency level of Beijing Tianjin Hebei from 2013 to 2017. The calculation results, as shown in Table 1. From the perspective of comprehensive efficiency, from 2013 to 2017, Beijing, Tianjin and Hebei were all around 0.9, with high efficiency and good development. In the pure technical efficiency and scale efficiency of the logistics industry, we can find that in the five years from 2013 to 2017, the scale efficiency is generally greater than the value of pure technical efficiency.

| region  | years | crste | vrste | scale | Returns to scale |
|---------|-------|-------|-------|-------|-----------------|
| Beijing | 2013  | 0.922 | 0.944 | 0.977 | dres            |
|         | 2014  | 0.898 | 0.9   | 0.998 | ires            |
|         | 2015  | 0.955 | 0.977 | 0.977 | dres            |
|         | 2016  | 1     | 1     | 1     | -               |
|         | 2017  | 1     | 1     | 1     | -               |
|         | 2013  | 1     | 1     | 1     | -               |
|         | 2014  | 1     | 1     | 1     | -               |
| Tianjin | 2015  | 0.951 | 0.969 | 0.982 | ires            |
|         | 2016  | 0.968 | 0.979 | 0.989 | ires            |
|         | 2017  | 1     | 1     | 1     | -               |
|         | 2013  | 0.945 | 0.977 | 0.967 | dres            |
|         | 2014  | 1     | 1     | 1     | -               |
| Hebei   | 2015  | 0.962 | 0.973 | 0.989 | dres            |
|         | 2016  | 0.954 | 0.959 | 0.995 | dres            |
|         | 2017  | 1     | 1     | 1     | -               |
| mean    |       | 0.969 | 0.979 | 0.992 |                 |

3.2 Second stage SFA regression results
With the help of Frontier 4.1 software, the data of Beijing Tianjin Hebei region from 2013 to 2017 are analyzed by SFA, and the results are listed in Table 2. From the results of regression analysis, the three environmental variables of highway mileage, total retail sales of social consumption and consumption
level of residents have a significant impact on the relaxation variables of the two input indicators, and all pass the 1% significance level test. Among them, the regression coefficients of the total retail sales of social consumer goods and the consumption level of residents to the two input slack variables are positive, the regression coefficients of telecom business volume to the three input slack variables are all negative.

Table 2 SFA regression results of the second stage

| Variable name                  | Consumption level of residents | Telecom business volume | Telecom business volume | $\sigma^2$   | $\gamma$  |
|--------------------------------|--------------------------------|-------------------------|-------------------------|--------------|-----------|
| the number of employees        | 0.393E+05                      | -0.201E+03              | 0.147E+01               | 0.296E+10    | 0.999E+00 |
| Investment in fixed assets     | -0.121E+02                     | 0.555E-04               | -0.386E-01              | 0.386E-03    | 0.532E+04 | 0.999E+00 |
| Logistics mileage              | -0.172E+04                     | 0.807E-02               | -0.567E+01              | 0.572E-01    | 0.332E+08 | 0.999E+00 |

3.3 Empirical results of DEA after adjustment in the third stage

In the second stage, SFA model is used to adjust the input variables of logistics industry efficiency in Beijing Tianjin Hebei region from 2013 to 2017. Combined with the data of origin and export, Deap 2.1 software is used to calculate the logistics industry efficiency again, and the TE, PTE and Se values excluding the influence of external environment variables and random errors are obtained. The efficiency of logistics industry in Beijing Tianjin Hebei region after adjustment is shown in Table 3.

Table 3 efficiency of Beijing Tianjin Hebei logistics industry after adjustment

| Region  | years | crste | vrste | scale | Returns to scale |
|---------|-------|-------|-------|-------|------------------|
| Beijing | 2013  | 0.943 | 0.965 | 0.978 | irs              |
|         | 2014  | 0.935 | 0.958 | 0.976 | irs              |
|         | 2015  | 0.935 | 0.988 | 0.946 | irs              |
|         | 2016  | 0.969 | 1     | 0.969 | irs              |
|         | 2017  | 1     | 1     | 1     | -                |
|         | 2013  | 1     | 1     | 1     | -                |
|         | 2014  | 1     | 1     | 1     | -                |
| Tianjin | 2015  | 0.942 | 0.995 | 0.946 | irs              |
|         | 2016  | 0.959 | 0.998 | 0.961 | irs              |
|         | 2017  | 1     | 1     | 1     | -                |
|         | 2013  | 0.979 | 0.986 | 0.994 | irs              |
|         | 2014  | 1     | 1     | 1     | -                |
| Hebei   | 2015  | 0.936 | 0.94  | 0.995 | irs              |
|         | 2016  | 0.948 | 0.951 | 0.997 | irs              |
|         | 2017  | 1     | 1     | 1     | -                |
| mean    | 0.971 | 0.985 | 0.984 |       |
Comparing the results of BCC model in the first stage and DEA model after adjustment in the third stage, we can see that after excluding the influence of external environmental factors on the efficiency of logistics industry in Beijing Tianjin Hebei region, the DEA analysis after adjustment in the third stage of Beijing Tianjin Hebei region has changes with the results in the first stage. From the overall situation, the comprehensive efficiency and pure technical efficiency of the adjusted regional logistics efficiency are improved, while the scale efficiency is reduced. In general, the logistics efficiency of Beijing Tianjin Hebei region needs to be improved, especially in terms of pure technical efficiency. In addition, the scale factor restricts the development of logistics industry in the three regions.

4. Conclusions and suggestions

4.1 Conclusions

Based on the above research, the following conclusions are drawn:

First, comparing the results of the first stage BCC model and the third stage adjusted DEA model, it is found that the scale efficiency of the third stage adjusted DEA model is generally lower than that of the first stage BCC model, and the pure technical efficiency of the third stage adjusted DEA model is higher than that of the first stage BCC model, The state of scale efficiency has also changed.

Second, the results of logistics efficiency calculated by Three-stage DEA model show that the pure technical efficiency of Beijing Tianjin Hebei region needs to be further improved. The scale factor also restricts the development of logistics industry in Beijing Tianjin Hebei region, so it is necessary to appropriately expand the scale of logistics industry and pay attention to the improvement of logistics technology.

4.2 Suggestions

According to the above research conclusions, this paper puts forward the following suggestions:

First, accelerate the optimization and integration of logistics resources in Beijing Tianjin Hebei region. The analysis shows that the distribution of logistics resources in Beijing Tianjin Hebei region is obviously unbalanced. For example, high-end logistics talents are mostly concentrated in Beijing and Tianjin, and Hebei and Tianjin have obvious advantages in port infrastructure. In view of the unreasonable distribution of logistics resources in Beijing Tianjin Hebei region, the poor integration and optimization of logistics resources and the low utilization rate of logistics resources, government departments should strengthen macro-control, optimize the allocation of logistics resources in Beijing Tianjin Hebei region and improve the utilization rate of logistics resources by improving logistics technology, logistics management mode and the smoothness of logistics network.

Second, actively promote the informatization construction in Beijing Tianjin Hebei region. Logistics informatization is an important condition to improve the quality of regional logistics service and the efficiency of regional logistics operation. In order to promote the development of Beijing Tianjin Hebei regional logistics and enhance the efficiency of Beijing Tianjin Hebei regional logistics, it is necessary to apply modern information technology to the process of regional logistics operation. In order to realize the innovation of regional logistics informatization and improve the informatization level of Beijing Tianjin Hebei logistics industry, we should establish and improve the logistics information network and regional logistics information management system of Beijing Tianjin Hebei by establishing standardized public service information sharing and interconnection mechanism, and building provincial and municipal logistics information platform.

Acknowledgments

This work was financially supported by Tianjin Research Innovation Project for Postgraduate Students fund. (No. 2020YJSS030)

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