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Convergence Analysis of Regional Logistics Efficiency in China

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ABSTRACT

This paper uses the data envelopment analysis (DEA) method to measure the logistics efficiency of China's different regions from 2011 to 2018, and on this basis, tests the σ convergence and β convergence. The results show that: there is no absolute convergence trend in the whole country and the eastern region, but there is absolute convergence in the central and western regions. After adding human capital, government intervention, opening up, industrial structure as the control variables, there are obvious signs of conditional convergence in the country's overall logistics efficiency. The improvement of human capital and the reduction of government intervention play the most significant role in promoting the convergence of logistics efficiency. This shows that if appropriate policies are adopted the Central and Western regions can narrow the logistics efficiency gap with the Eastern regions.

KEYWORDS: *logistics industry; efficiency difference; absolute convergence; condition convergence*

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1. INTRODUCTION

As the "accelerator" of economic growth, the development of the logistics industry has increasingly attracted the attention of governments throughout China, which has also directly contributed to the strong support and investment in the logistics industry in various regions. China is a resource-poor country. In the process of vigorously developing the logistics industry to serve the regional economy, it is necessary not only to pay attention to the total input of logistics resources, but also to its efficiency. Therefore, for China, it is more practical significance to get higher output under the same input conditions by improving logistics efficiency. Most of the existing researches on logistics efficiency are the measurement of port logistics efficiency (Chen et al., 2016; Yu et al., 2018; Chen, 2019; Yi, 2019; Cao, 2020; Wang et al., 2020; Liu, 2020), or the measurement of logistics industry efficiency in a Certain region (Cao, 2018; Yang et al., 2019; Zhou et al., 2019; Zhang & Cui,), and the efficiency analysis of Listed Logistics Companies (Wu, et al., 2012).

It is generally believed that there are differences in the efficiency of logistics in China, but whether this difference will continue to exist, previous studies have not yet concluded (Zhang, et al., 2017; Liu, et al., 2018; Lan, et al., 2020; Liu & Xu, 2020). At present, few people systematically analyze the convergence of logistics efficiency. In this paper, the data envelopment analysis (DEA) method is used to measure each province's logistics efficiency. On this basis, the convergence theory is applied to test the convergence of logistics efficiency.

2. Research methods

2.1. Introduction of DEA method

DEA is one of the most commonly used methods to measure the relative efficiency of the same type of decision-making unit (DMU). It was first proposed by the famous operational research scientist Charnes et al. (Charnes et al., 1978), and has been widely used in the efficiency evaluation of banks, universities, hospitals, insurance companies and manufacturing industries. The DEA method uses pure mathematical linear programming technology to determine the production frontier. It is a data-driven nonparametric method. It does not need to set specific function forms and specific behavior assumptions, and effectively avoids the problems caused by the wrong production functions and inefficiency item distribution form. In this paper, the CCR model (Charnes, Cooper, Rhodes) of DEA method is used to measure the logistics efficiency of provinces and regions in China.

2.2. Convergence measure method

There are several methods for testing convergence. Two of the more common types of convergence measured are sigma (σ)-convergence and beta (β)-convergence. Therefore, this study applied the σ and β convergence methods to test the convergence of China's regional logistics efficiency.

Convergence refers to the degree of dispersion (generally measured by the logarithmic standard deviation) of the per-capita income level (or growth rate level) as each economy shrinks over time. β convergence refers to the negative correlation between the per capita output growth rate of different economic systems and the initial per capita output level, which reflects the catching-up process of backward economies to advanced economies. However, β convergence can be divided into absolute β convergence and conditional β convergence. Where, the former means that there is no need to control any specific factors. Under the premise of different initial levels, the backwards economies' growth rate is faster than that of the developed economies. Eventually, they all reach the same steady growth rate and level. The latter also, refers to the need to control certain factors, such as human capital and policy variables, so that different economies can achieve the same steady-state (Sala-i-Martin, 1996).

The test equation for absolute β convergence is (Barro et al., 2004).

$$\log(y_{i,t+T}/y_{i,t})/T = \alpha - \beta \log y_{i,t} + \varepsilon_{it} \quad (1)$$

The expression $(y_{i,t+T}/y_{i,t})/T$ refers to the average annual growth rate of per capita real GDP of the economy from t to $t+T$. $\log y_{i,t}$ is the logarithm of per capita real GDP of economy i at time t. α is the intercept term, β is called the convergence coefficient, and ε_{it} is a series of uncorrelated random error terms. A significant positive β means that regions with low initial per capita income grow faster than regions with high initial per capita income, which confirms the absolute convergence hypothesis. The larger β is, the stronger the convergence trend is.

The most important feature of conditional β convergence test is that it controls the differences among individuals. Moreover, it can reduce the degree of collinearity among independent variables and has more degrees of freedom. Due to the spatial correlation of China's regional economic growth, the panel data model is reasonable for studying regional growth and its convergence.

The following equation can express the conditional β convergence test:

$$\log(y_{i,t+T}/y_{i,t})/T = \alpha - \beta \log y_{i,t} + BX + \varepsilon_{it} \quad (2)$$

where X is the control variable, and B is the coefficient of the control variable.

In recent years, some scholars have proposed "club convergence" to deepen the understanding of convergence. Galor (1996) thinks that the concept of "club convergence" is different from conditional convergence. It means that various economic systems within economic groups with similar initial economic development level tend to converge under the premise of similar structural characteristics, but there is no sign of convergence between groups.

3. Data and variables

The sample used in this paper is the input and output data of the logistics industry in 29 Chinese mainland provinces in 2011~2018 years. The data mainly come from China Statistical Yearbook and China Statistical Yearbook of Tertiary Industry.

Input variables generally use capital input and labor input. In terms of capital input, we use the internationally popular "perpetual inventory method" to estimate each period's capital stock in each region based on the 1990 constant price, and then analyze the impact of capital input on output. For labor input, limited to statistical data availability, the average number of employees in the logistics industry over the years is used as the labor input index. This paper uses the turnover of goods as the output variable of the logistics industry.

4. Analysis of empirical results

4.1. σ convergence test

First, we use the σ convergence method to measure the convergence of logistics efficiency in different regions of China. σ convergence belongs to absolute convergence. In this paper, σ is the standard deviation of the logarithm of logistics efficiency. If the standard deviation gradually decreases with time, it means that the technical efficiency between regions is getting closer and closer, and there is σ convergence. The calculation formula of σ is shown in equation (3).

$$\sigma = \sqrt{\left[\sum_{i=1}^{n}(\ln TE_i - \overline{\ln TE})^2\right]/n} \quad (3)$$

Among them, ln TE_i is the natural logarithm of technical efficiency of each province, and is the average of natural logarithm of technical efficiency.

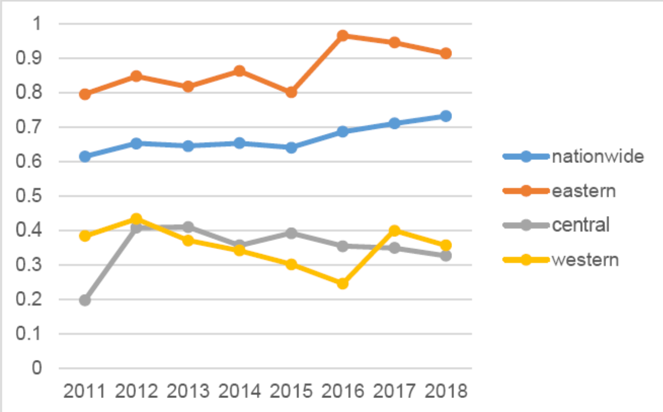

Figure 1 The σ value of logistics industry efficiency across nationwide, eastern, central and western

Figure 1 shows the change of standard deviation of the logarithm of logistics efficiency overtime in China as a whole and three major regions. As for the whole country and the eastern region, the standard deviation of logistics efficiency logarithm shows an upward trend from 2011 to 2018. It does not show σ convergence during the whole investigation period. Although there are some ups and downs in the central and western regions, there is a trend of σ convergence during the investigation period. From Figure 1, we can also find that the standard deviation of logistics efficiency in the eastern region is significantly higher than that in the central and western regions, which indicates that the internal gap in the eastern region is larger than that in the central and western regions, and the trend of σ divergence in the eastern region after 2015 indicates that the internal gap is gradually expanding, which is worthy of attention.

4.2. β convergence test

A. Absolute β convergence test

In order to better investigate the changes in logistics efficiency differences in various regions of China in different periods, we improve the traditional β convergence model (1). To simplify the analysis, we use natural logarithm and take the sign before β as a positive sign to obtain the absolute β convergence model

$$\ln(TE_{i,t+1}/TE_{i,t}) = \alpha + \beta \ln TE_{i,t} + \varepsilon_{i,t} \quad (4)$$

Among them, $TE_{i,t}$ is the base year logistics efficiency of the region and $TE_{i,t+1}$ is the end year logistics efficiency of the region. A negative β would mean that the logistics efficiency between regions tends to converge; rather than it diverging. Panel data has constant parameters (mixed regression), variable intercept, and variable coefficient model. After the covariance test and Hausman test, we determine that the variable intercept fixed effect model is the specific form of model estimation. To illustrate the problem more clearly, we use a variety of methods to estimate and compare the estimated results.

The left half of Table 1 shows the econometric analysis results on the convergence of logistics efficiency of 29 provinces and regions in China using different estimation methods. Model 1 is based on the result of constant parameter model; model 2 is based on the result of random effect model; model 3 is based on the result of fixed effect model; model 4 is the regression result obtained by using fixed-effect model, generalized least squares (GLS) estimation and cross-section weights, to reduce the heteroscedasticity caused by cross-section data.

Table 1 absolute β convergence test of logistics efficiency

	whole country		East		Central		West
	Model 1	Model 2	Model 3	Model 4			
β	0.012 (0.512)	0.032 (0.985)	0.014* (1.770)	0.013** (2.248)	0.031* (1.986)	-0.026*** (-4.434)	-0.028*** (-7.282)
Intercept term	0.137*** (5.359)	0.201*** (3.313)	0.150*** (6.630)	0.168*** (7.167)	-0.119*** (-3.115)	-0.729*** (-8.591)	-0.280*** (-7.133)
Adjusted R2	0.009	0.041	0.564	0.730	0.473	0.705	0.506
F	5.349	21.031	38.459	79.387	13.525	14.224	17.314

Note: the values in brackets are the test values,*, **, *** respectively indicate that they are significant at 10%, 5% and 1% levels.

It can be seen from Table 1 that the fitting effect of models 1 and 2 is very poor, and the regression results cannot be used. The fitting effect of model 3 is better than that of model 1 and model 2, and model 4 adopts GLS and takes cross-sectional weighting, so the overall fit is further improved. Compared with the four models, model 4 has the highest fitting, and the regression coefficient of initial efficiency is positive, which indicates that the gap of logistics efficiency among provinces in China is widening from 2011 to 2018, and does not reflect the catch-up effect of backward regions to advanced regions. In the right half of Table 1, model 4 is used to test the convergence of logistics efficiency in the East, the Middle, and the West regions. The results show that the Eastern region shows significant divergence signs, while the Central and Western regions

show convergence. Combined with the previous σ convergence analysis, we can say that there is neither absolute convergence nor "club convergence" in the nationwide logistics efficiency.

It is worth noting that there is a significant difference in logistics efficiency in the eastern region. This may be due to the acceleration of marketization, which has weakened various social and economic conditions that promote the convergence of logistics efficiency in the process of marketization.

B. Conditional β convergence test

In the above analysis, both σ convergence and β convergence test results show that there is no absolute convergence in the whole country and the eastern region. Therefore, we test the conditional β convergence.

By adding several control variables to the absolute convergence equation (4), the conditional β convergence model is obtained as:

$$[\ln(TEi\,,t+1\,/\,TEi\,,t\,)]\,/\,T=\alpha+\beta\ln TEi\,,t+BX+\varepsilon i\,,t \quad (5)$$

In the equation, X represents the control variables, B is the coefficient of control variables, and the other variables are defined in the same equation (4). For the control variables, according to the existing literature, we may consider the following factors: Human Capital (HC), Degree Openness (FT), Industrial Structure (IS) and Government Intervention (GOV).

HC is the intangible capital formed by people's investment in education and health. The research shows that the difference of human capital is an important factor affecting the difference of regional economic development, but the cost of learning technological knowledge in backward areas is much lower than that in developed areas, which may lead to convergence (CAI, & Du, 2004). In this paper, the average education level of residents is used to measure the level of regional human capital.

GOV variable is used to reflect the government's size and its degree of intervention in the market. Since the reform and opening up, the Chinese government has played an important role in the process of economic development, but the excessive scale and excessive intervention have distorted the market mechanism to a certain extent and slowed down the process of marketization. Relevant studies also show that excessive government intervention is an important factor causing regional economic differences in China (CAI, & Du, 2004). Referring to the previous literature, In the equation, X represents the control variables, B is the coefficient of control variables, and the other variables are defined in the same equation (4). For the control variables, according to the existing literature, we may consider the following factors: Human Capital (HC), Degree Openness (FT), Industrial Structure (IS) and Government Intervention (GOV).

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FT reflects the degree of openness of each province. The more open the district is, the more reasonable the flow of factors can be promoted, and at the same time, the spillover and diffusion of technology between regions will be promoted, which may have the effect of narrowing the technological gap between regions. The technology diffusion model developed by Sala-i-Martin & Barro (1995) especially points out that the openness of economic system, including the introduction of foreign direct investment (FDI), is the key factor in promoting technology diffusion thus determine the convergence speed. In this paper, the ratio of the actual turnover of FDI to (GDP) is used to measure the degree of openness of each province.

Research shows that the promotion of industrial structure (IS) has an important impact on regional disparity convergence (Shen & MA, 2002). The upgrading of industrial structure is conducive to improving labor productivity. Generally speaking, the adjustment potential and intensity of backward areas are often greater than those of developed areas. Therefore, industrial structure's upgrading plays a vital role in regional convergence (Zhang, 2007). As China's industrial logistics accounts for more than 85% of the total social logistics (Ding, 2018). Therefore, we use the proportion of the added value of the secondary industry in GDP to express its industrial structure characteristics.

In terms of model selection, Hausman test found that the fixed effect regression effect is better than the random effect regression result, so this paper only reports the fixed effect model regression results (Table 2).

Table 2 conditional β convergence test of logistics efficiency

	Model 5
β	-0.060***(-9.826)
Intercept term	-0.24***(-6.688)
HC	0.02***(8.545)
GOV	-0.022***(-3.428)
FT	0.009**(2.328)
IS	0.012*(1.896)
Adjusted R2	0.744
F	80.109

Note: Human Capital (HC), Government Intervention (GOV), Degree of Openness (FT); The brackets' values are the test values, *, **, *** respectively indicate that they are significant at 10%, 5% and 1% levels.

It can be seen from Table 2 that there is a significant negative correlation between the initial logistics efficiency and the growth rate of logistics efficiency in model 5, which indicates that there is conditional β convergence of logistics efficiency among regions in China during the study period. F test shows that the model is significant on the whole, and the coefficients of the four control variables are significant at 1%, 5% or 10% level. Among them, the promotion of human capital and the reduction of government intervention have the most significant effect on the convergence of logistics efficiency.

Specifically, the coefficient of HC is positive at the 1% significance level, which indicates that human capital has a positive effect on the convergence of logistics efficiency. This is consistent with the convergence test results of China's economic growth by Tian & Zhang (2019), long et al. (2020). The coefficient of (GOV) is negative at the 1% significance level, which indicates that reducing the proportion of government intervention can promote the exertion of market mechanism and the convergence of logistics efficiency. The coefficients of openness (FT) are all positive at the significance level of 5%, which indicates that the increase in the degree of openness will help promote the convergence of regional logistics efficiency. The coefficient of industrial structure (IS) is positive at the 10% significance level, which indicates that the optimization and upgrading of industrial structure help the convergence of regional logistics efficiency. This result also confirms the research of Long et al. (2020).

5. Conclusion

This paper measures the logistics efficiency of different regions in China from 2011 to 2018, and tests the convergence of efficiency on this basis. The results show that there is no absolute convergence in the whole country and the eastern region, while there is absolute convergence in the central and western regions. After adding HC, GOV, IS as the control variables, there are obvious signs of conditional convergence in the overall logistics efficiency of the country. The increase of human capital and the decrease of government invention have a significant impact on the convergence of logistics efficiency. This shows that if appropriate policies are adopted, the central and western regions can narrow the logistics efficiency gap with the eastern regions.

Our conclusion has substantial policy implications: As far as the whole country is concerned, the government should focus on the reform at the management level to save investment and improve technical efficiency; at the same time, the government should promote learning, imitation and technology flows between regions while encouraging innovation, and increase policy support for logistics development in the central and western regions to give full play to their "late-mover advantage."

As far as the central and western regions are concerned, the following aspects should be paid attention to in the process of promoting logistics: First, local governments should increase investment in education, strengthen the construction of talents, and promote the accumulation of human capital, so as to create conditions for the convergence of regional logistics efficiency. Second, the local governments should speed up reform, strive to change government functions, vigorously create a soft environment for logistics development, and expand the role and scope of market mechanism in allocating resources, thereby accelerating the development of logistics. Third, it is needed to expand the opening up and establish an open factor allocation mechanism and operation mechanism that is conducive to the rapid growth of modern logistics. Fourth, it is also needed to take advantages of labor cost and resource supply to cultivate an effective transfer mechanism to undertake the gradient transfer of manufacturing industry from the Eastern region to the Central and Western regions, and gradually change the export of primary products and raw materials; at the same time, the local governments should grasp the logistics demand released by the upgrading of industrial structure to further improve the degree of logistics socialization.

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