Organisational Studies and Innovation Review

Vol. 1, no.1, summer, 2015

Research of the Efficiency of Logistics Industry in China —Based on Malmquist Index Method

Deng Lei**, Xu Xinwen *, and Tang Shasha *

*College of Mechanical Engineering, Chongqing University**

*Chongqing Key Laboratory of Logistics, Chongqing University***

Abstract: In order to research the dynamic changes of the production efficiency of Chinese logistics industry, the dynamic variation of total factor productivity (TFP) of logistics industry in China was analyzed in this paper by taking the amount of employees in logistics industry, length of logistic network and fixed investments as the input indexes, and taking the freight traffic volume and tonnage mileage as output indexes with the panel data of 31 provinces from 2007 to 2013 based on Malmquist-DEA approach. Besides, four main economic districts are divided from 31 provinces and cities in accordance with related polices promulgated by National Bureau of Statistics. Then the current situation and changes of TFP and its decomposition efficiency of all districts were further analyzed in this paper. According to the research results, the TFP of Chinese logistics industry maintains a high growth rate, and the development in technology has an obvious facilitation in TFP growth. But the poor pure technical efficiency has become the bottleneck of the development of TFP. Seen from the perspective of regional development, the development of TFP of the logistics industry in western economic zone is most obvious, which is mostly benefited by fixed assessment investment. But varying degrees of input redundancy can be found in each economic district, and among the four districts, the eastern and middle districts are blamed for high redundant construction degree and serious resources waste.

Key Words: Logistics Industry; Total Factor Productivity; Zone Development; DEA-Malmquist

Introduction

In recent years, the logistics industry has developed rapidly, according to the data published in 2014 by National Development and Reform Commission, National Bureau of Statistics and China Federation of Logistics & Purchasing , the total volume of social logistics in 2013 is 197.8 trillion, having risen by 164% compared with that of 2007,

growing much faster than GDP in the same period, which shows that the logistics industry has become “propeller” and “accelerator” of national economic development. But there are still some prominent problems in the development of logistics industry, and one of those is the low operation efficiency of social logistics, which has always been the bottleneck of the development of logistic industry, hindering the development of highly efficient, green and intensive logistic industry .

At present, scholars quantitatively study the efficiency of logistics operation with Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). Honkey made a benchmarking analysis to the relation between the width and strength of logistics service and the production efficiency using DEA method. Deng Xueping and Wang Xu analyzed the TFP of 8 logistics enterprises between 2001 and 2006. They found that the efficiency of logistics enterprise developed well but the growth rate is low and the technological efficiency and technology fell down, scale efficiency grows a little during the period. Gao Mujin studied the efficiency of 10 cities in Shan Xi province and made comparison with the whole western area, found that the low whole technological efficiency was caused by lower scale efficiency and advice was put forward to logistics development of Shan Xi province.

This paper delivered the research from the aspect of increase of logistics and the variation of the increase of different provinces and regions, to put forward some advices to improve our logistics industry and analyzed the dynamic change of logistics, which may help provinces and regions to make the development policy.

Model and Index Selection, Data resource

Introduction to the model

Data Envelopment Analysis (DEA) was developed by A. Charnes, W.W.Cooper, E. Rhodes based on relative efficiency in 1978. DEA method is applied to evaluate the multi-input, multi-output, same-type DMUs. This paper chooses the C2R combing BC2 model to analyze the TFP index condition of 31 provinces in 2013.

Output-oriented C2R model including The Archimedes dimensionless Ɛ is as form (1) shows:

$$
\begin{aligned}
&D(\varepsilon)=\min\left[\theta-\varepsilon\left(e^{-}S^{-}+e^{+}S^{+}\right)\right]\\
&s.t.\begin{cases}\sum_{j=1}^{n}X_j\lambda_j+S^{-}=\theta X_0\\ \sum_{j=1}^{n}Y_j\lambda_j-S^{+}=Y_0\\ \lambda_j\geq 0,\ j=1,2,\cdots,n\\ S^{+}=\left(s_1^{+},s_2^{+},\cdots,s_s^{+}\right)^{T}\geq 0, S^{-}=\left(s_1^{-},s_2^{-},\cdots,s_m^{-}\right)^{T}\geq 0\end{cases}
\end{aligned}
\tag{1}
$$

$\theta,\lambda_j(j=1,2,\cdots n)$ Stand for dual variable, $e^{-}=(1,1,\cdots,1)\in E_m$ $e^{+}=(1,1,\cdots,1)\in E_s$ S+ and S- are slack variable. If we put constraint condition $\sum_{j=1}^{n}\lambda_j=1$ then we can get the variable

scale reward BC2 model .

When we make comparison to the logistics between different periods, we need the Malmquist method. According to Fare, output-oriented Malmquist model based on technology time S and T is as follows formula (2):

$$M_{S.T} = \left[\frac{D_0^s(x_t, y_t)}{D_0^s(x_s, y_s)} \times \frac{D_0^t(x_t, y_t)}{D_0^t(x_s, y_s)}\right]^{1/2}$$

$$= \frac{D_0^t(x_t, y_t)}{D_0^s(x_s, y_s)} \times \left[\frac{D_0^s(x_t, y_t)}{D_0^t(x_t, y_t)} \times \frac{D_0^s(x_t, y_t)}{D_0^t(x_s, y_s)}\right]^{1/2} \quad (2)$$

$$= TEc \times Tc$$

Among these coefficients, TEc stands for the technology efficiency change from S to T, which means the degree of technology improvement; Tc stands for the technology change from S to T, which is the degree of the application of new technology or the innovation.

Source of data and selection of input-output index system

Considering the complexity and availability of the data, all the data in the paper are from the law of the People's Republic of China Statistical Yearbook (2007-2013), the statistical yearbook of each province and the database of information network. Since our country has not explicitly defined the logistics industry in the national industries classification, transportation, warehousing and postal service added value accounted for more than 80% of the added value of the logistics industry from the aspect of historical data, so this paper define the logistics industry in China as transportation, warehousing and postal service.

(1) Input index mainly consider three aspects: manpower, material and financial resources.

(2) Output index mainly include the freight volume of each transportation mode (mainly roads, railways, inland waterway transport in this paper) and the goods turnover volume that has a direct positive relationship with efficiency.

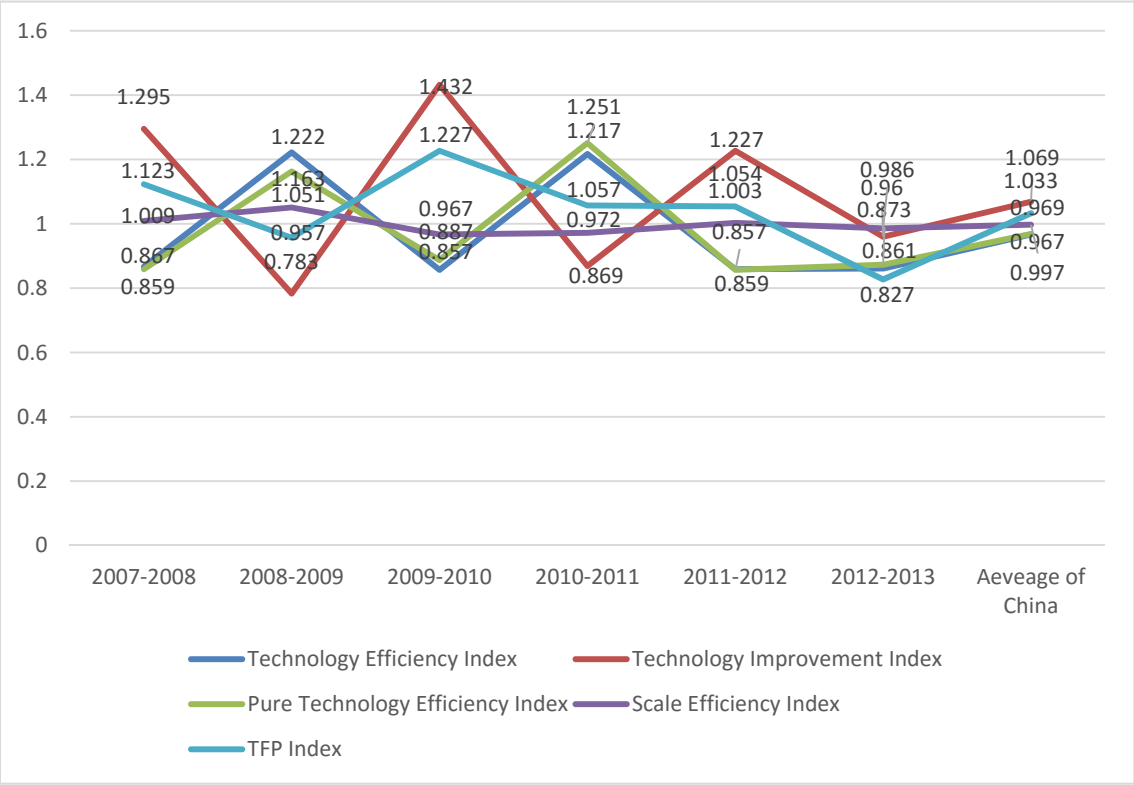
Empirical results and analysis

Analysis of the TFP variation of logistics industry in China

Overall analysis of TFP and decomposition efficiency variation

With DEAP Version 2.1 based on the output-oriented Malmquist production model and input-output data of logistics industry, we get the empirical results as Figure 1 and Table 1 shows.

Figure 1： Broken line graph of TFP and decomposition efficiency of logistics industry



Data source: Data are all calculated by DEAP 2.1

By the analysis of the data and development trend we can get:

(1) Analysis of TFP index variation. The TFP index increased by a high growth rate of 3.3% in 2007-2013 in logistics industry. The technical progress index increased 6.9% averagely, but the technology efficiency decreased by 3.3%, and the scale efficiency index didn't change much. The faster technology increase covered the decrease of technology efficiency, which on the one hand promoted the TFP of logistics industry to increase continuously, On the other hand shows the strong promotion of logistics technology to the increase of efficiency.

(2) From the view of variation of pure technology efficiency and scale efficiency, the average of pure technology efficiency decreased by 3.1%. From the figure we can get that the pure technology indexes of 2007, 2009 and 2012 are less than 1, which in other words shows that without considering the effects of scale factor, the pure technology efficiency of the 4 years are invalid. That reflects that the level of enterprise management and technology is low, but this part of resource is controllable factors, combining the input factors of this article, we can improve the enterprise management level by improving the quality of logistics talents, the facility of logistics and optimize the trend of investment and so on.

Analysis of TFP of regional logistics industry

In order to reflect the social development condition in each region, this article divides China into 4 regions according to 'The several opinions to promote the rise of the central region by the party central committee and state council', 'several policies and advices promulgated by the state council on the implementation of western development '.

The results of the analysis of TFP of 4 economic zones are as follows in Table 1.

Table 1: Regional TFP and decomposed efficiency during 2007-2013

EI / Region	TEc	Tc	PTc	SEc	TFP
EC	0.972	1.031	0.989	0.983	1.002
MC	0.984	1.077	1.002	0.983	1.060
WC	0.963	1.107	0.946	1.018	1.067
NEC	0.958	1.048	0.949	1.010	1.003
AVE	0.969	1.066	0.972	0.999	1.033

Data source: Data are all calculated by DEAP 2.1

After the analysis of data and its variety of regional logistics in China, we can draw these conclusions:

(1) The TFP growth rate of logistics industry in western economic zone ranks number 1. By analyzing the reasons we found that after the development of the western region strategy, investment of logistics industry becomes more and more, the logistics infrastructures are more and more completed and what's more a large number of logistics specializers swarm into western region. During 2007-2013, the average annual growth rate of logistics workers is 7.3%. The annual logistics networks miles is up to 5.90 million kilometers after conversion, and the average annual growth rate is 2.8%. The annual growth rate of fixed asset investment is 30.5%. From the proportion of input accounting in the total, growth rate, combining with the TFP growth, the social fixed asset investment has the greatest contribution to the growth of logistics industry.

(2) From the view of the index variation of pure technology efficiency and scale efficiency, only the pure technology efficiency in the middle economic zone is great than 1, namely, the level of logistics management and labor quality as well as logistics technology application efficiency are much higher than other economic zones. The pure technology efficiency of the rest of three economic zones are smaller than 1.

Analysis of the improvement of technology efficiency

In order to further analyze the development condition and improvement of technology efficiency of logistics industry, this paper took the input-output data of the nearest year 2013 as the example to analyze with DEAP 2.1, and the results are as follows in Table 2.

Table 2 :Analysis and improvement of technology efficiency of 31 provinces in 2013

EI / DMU	TE	PTE	SE	SEc	LI/%	NRI/%	FAI/%
SD	0.455	0.666	0.683	drs	56.5	29.2	59.6
JS	0.502	0.746	0.674	drs	27.1	44.8	60.4
ZJ	0.683	0.687	0.994	drs	-	1.73	50.8
FJ	0.401	0.403	0.995	irs	-	-	55.0
SH	1.000	1.000	1.000	-	-	-	-
GD	0.653	0.881	0.741	drs	73.6	16.3	66.0
HN1	0.296	1.000	0.296	irs	-	-	-
BJ	0.233	0.262	0.891	drs	19.0	-	21.7

TJ	0.913	1.000	0.913	irs	-	-	-
HB1	0.844	0.916	0.921	drs	-	17.9	64.1
AVEE	0.598	0.756	0.811		17.62	11.0	37.8
AH	1.000	1.000	1.000	-	-	-	-
HB2	0.274	0.376	0.728	drs	21.2	34.2	52.3
HN2	0.418	0.466	0.898	drs	10.2	27.1	33.6
HN3	0.361	0.568	0.636	drs	35.4	43.4	37.2
JX	0.579	0.623	0.929	irs	39.1	34.3	-
SX1	0.490	0.491	0.998	irs	-	-	19.8
AVEM	0.520	0.587	0.865		21.2	27.8	28.6
GX	0.562	0.565	0.995	irs	-	-	34.1
IM	0.421	0.421	1.000	-	-	-	35.6
NX	0.626	1.000	0.626	irs	-	-	-
XJ	0.254	0.268	0.949	irs	16.7	31.5	-
QH	0.168	0.219	0.768	irs	-	-	12.6
SX2	0.378	0.379	0.997	drs	4.10	-	10.5
GS	0.354	0.401	0.881	irs	-	34.3	-
SC	0.244	0.423	0.577	drs	44.2	42.1	61.1
YN	0.345	0.348	0.991	irs	-	32.1	41.2
GZ	0.357	0.367	0.973	irs	-	28.9	51.4
TIB	0.256	1.000	0.256	irs	-	-	-
CQ	0.300	0.301	0.998	irs	-	-	27.2
AVEW	0.355	0.474	0.834		5.42	14.1	22.8
LN	0.825	0.894	0.923	drs	3.5	19.0	58.6
JL	0.205	0.219	0.935	irs	-	-	13.6
HLJ	0.236	0.251	0.940	irs	45.7	32.2	-
AVENE	0.422	0.455	0.933		16.4	17.1	24.1
AVE	0.472	0.585	0.842		15.2	17.5	28.3

Data source: Data are all calculated by DEAP 2.1

As we can get from table 2, the average scale efficiency of logistics industry in 2013 is 0.842, so there is certain room to improve, but the pure technical efficiency equals only 0.585, leading to the low comprehensive technical efficiency, which is only 0.472, reflecting that the logistics industry development in our country urgently needs to enhance the level of technology and management. From the point of regional development, the northeast economic region has the highest scale efficiency of 0.933, which is 12.2% higher than the least efficient in eastern economic zone. Combining the TFP growth and the scale efficiency change, the major investment in fixed assets has become an inhibiting factor for the improvement of the efficiency of logistics industry in eastern region, continuous input of fixed assets will cause the waste of resources, in the contrary, we can turn the development direction to improve the level of management, science and the improvement of the utilization efficiency of resources .

Maintaining the output level of 2013, we can get the degree of saving inputs of the logistics industry. In 2013, the average improvement level of investment in fixed assets

of DEA technique invalid provinces is 28.3%, the workforce of logistics industry is 15.2% and the logistics network mileage is 17.5%, which shows that there is a large room for improvement in the aspect of saving resource.

Conclusion and Advice

This paper analyzed the dynamic variation of multi-period TFP of logistics industry of 31 provinces in China during 2007-2013, then further divided China into 4 main economic zones and analyzed the development of regional efficiency. Finally, the article thoroughly analyzed the efficiency of logistics in 2013 and gave some advice for improving.

(1) During the period of 2007-2013, TFP average growth rate of China's logistics industry has remained at a relatively high level of 3.3%, and to some extent, 6.9% annual technical progress overshadowed the impact of decreasing technical efficiency, showing the important role of technological advances in the TFP growth of logistics industry. To further enhance the logistics technology innovation and diffusion capacity, modern logistics industry needs to deeply integrate advanced technology represented by cloud computing, internet of things, mobile computing, and big data, to improve the influence of technical progress on the logistics industry, and to promote automation and intelligence of modern logistics industry.

(2) By the analysis of the variation of regional logistics efficiency, we get that, with the inburst of a large number of logistics talents and logistics technology after the west development strategy, the operation efficiency of logistics continue to increase, and the index of TFP is 1.067, which is higher than other 3 regions, the investment of social fixed assets give a major push to increase the efficiency. The middle economic zone has a higher pure technology efficiency, which means the level of logistics management and the quality of the labor force are better, so other economic regions such as the northeast zone need to enhance the allocation efficiency of resources when they increase the capital investment and scales.

(3) From the analysis of logistics static efficiency and improvement in 2013, the average of scale efficiency index equals 0.842, but the comprehensive technology efficiency is pretty low only 0.472 due to lower pure technology efficiency. Scale efficiency of 16 provinces continue to increase such as Fujian, so they can continue to complete the logistics enterprise development structure, take the intensification and high-efficiency as the development mode, but they need also to avoid redundant construction. DEA invalid provinces have a larger improvement room, the average of the fixed assets improvement is 28.3%, workforce investment is 15.2%, network mileage is 17.5%, and among them the east economic region should turn their development direction to the increase of technological management level and shoot the arrow at the target.

Acknowledgements

This research is supported by the Fundamental Research Funds for the Central Universities Project (Nos: CDJZR12110008); Chongqing Application and Development Project (2014yykfA40006); the Social Science Research Project for Education Ministry

(Nos: 10YJC630039), China; Chongqing Science and Technology Research Projects (Nos: cstc2012ggC00001); National Science and Technology Support Project (2015BAH46F01).

Bibliography

Wang Weiguo, Ma Yueyue, (2012). Logistics Regional Efficiency Study-Based On 3 Stage DEA model Malmquist-luenberger Index Method. *System Engineering,* 30(3*),* pp.14-16.

Maersk,(2014). *Report of The Influence on China Maersk ,* The new Chu business.

Hokey Min, Seong Jong Joo,(2006). Benchmarking the operational efficiency of third party logistics providers using data envelopment analysis. Supply Chain Management: An International Journal, 11(3), pp..35-37.

Deng Xueping, Wang Xu, A da Suk Fung Ng, Lin Yun,(2008). The Analysis of TFP Logistics Enterprises in China. System Engineering, 26(6), pp.46-48.

Gao Mujin,(2012). Research of Logistics Efficiency of Shanxi2 Province Based on DEA . Northwest Agriculture & Forestry University. 26(5), pp.17-19.

Wei Quanling,(1988). New Zone of the Evaluation of relative effectiveness DEA Method, Renmin University of China press.

Liu Binglian, Lin Tan, Liu Yuhai,(2010).Dynamic Efficiency Research on Iron and Steel Enterprise from the Aspect of Scale and Ownership. China Soft Science, 16(1), pp.15-16.

Zhuang Yuliang, Wu Huijuan, He Chao,(2009). Research of the Dynamic Variation of Logistics based on Malmquist Index Method. Statistics and Decision-making. 15(5),pp.26-28.

Shao Lin,(2013). The Empirical Study on TFP of Logistics Indstry Based on DEA-Malmquist Index Method. Journal of Hubei University, 23(5),pp. 41-45.

Zhong Zuchang,(2010). Research of Logistics Efficiency Based on 3 Stage DEA Model. Journal of Finance and Economics,36(9),pp. 26-28.

Appendix: Abbreviation for Table 1, 2

Abbreviation	Stands For:	Abbreviation	Stands For:	Abbreviation	Stands For:
SD	Shandong	HB1	Hebei	IM	Inner Mongolia
JS	Jiangsu	AVEE	Average of East Area	NX	Ningxia
ZJ	Zhejiang	AH	Anhui	GX	Guangxi
FJ	Fujian	HB2	Hubei	XJ	Xinjiang
SH	Shanghai	HN2	Hunan	SX2	Shanxi2
GD	Guangdong	HN3	Henan	GS	Gansu
HN1	Henan	JX	Jiangxi	SC	Sichuan
BJ	Beijing	SX1	Shanxi	YN	Yunnan
TJ	Tianjin	AVEM	Average of Middle area	GZ	Guizhou
SC	Sichuan	CQ	Chongqing	HLJ	Heilongjiang
LN	Liaoning	TFP	Total factor productivity	AVEW	Average of West area
TIB	Tibet	JL	Jilin	Tec	Technology efficiency change
Tc	Technology change	PTEc	Pure technology efficiency change	SEc	Scale efficiency change
QH	Qinghai				