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An analysis of the regional logistics efficiency in china based on the DEA-Malmquist

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ABSTRACT

Choosing the data from 2008 to 2011, the paper divided the 30 provinces and cities into 2 classes based on the average of 4-year energy consumption and carbon emissions through cluster analysis, then analyses the 2 classes respectively with the DEA-Malmquist. The results show that the 4-year average Malmquist index of the type1 is in a downward trend;the type2 is just the opposite, however, the biggest increase belongs to the type1.

KEYWORDS

Cluster analysis; DEA-Malmquist index; Logistics efficiency.

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INTRODUTION

With the continuous increasing of the global population, economic scale and energy consumption, which lead to environment deterioration, more and more countries and regions begin to pay close attention to environmental problem; energy saving and emission reduction become the key focus as the third profit source, Modern logistics has become one of the hot spots of the world economy development[1]; however, energy consumption of transportation logistics, one of the functions of logistics, accounted for 25% of global energy consumption[2]. Under the background of low-carbon economy, the development of low-carbon logistics is the inevitable choice for sustainable development.

Data envelopment analysis (DEA) method is a non-parametric method used to evaluate the relative efficiency of multi- index input and multi-index output[3]. In recent years, more and more scholars use DEA method to study on the logistics efficiency. Liu Manzhi etc.[4] (2009) established city logistics efficiency evaluation model and index system and analyzed the efficiency of 13 cities logistics in Jiang Su province in 2006 by the CCR and BCC model; Le Xiaobing etc.[5] (2014) made a evaluation of the logistics efficiency of Guang Xi in 2004-2011 using the DEA model; Zhou lingyun etc. [6] (2014) established a model combining the DEA and compound system evaluation method. Tang Jianrong etc. (2013) added the carbon dioxide emissions to the input indicator and researched on the logistic data of the China's 10 eastern provinces and cities with the three stage DEA model.

Most of the above literatures about logistics research choose the traditional DEA method to study; most of the indicators are chose from three aspects: personnel, financing and properties. more and more scholars increasingly focus on carbon dioxide emissions, but don't classify the all decision-making units (DMU), which does not accord with the premise of the DEA research. Therefore, firstly this paper classify the all DMU through cluster analysis choosing the carbon emissions and energy consumption as low carbon logistics degree index; they are go into the same category as the similar degree of low carbon. and then use the traditional DEA Malmquist index for each type of decision making units respectively.

RESEARCH METHOD AND DATA SOURCE

Research method

Data Envelopment Analysis (DEA), is a new kind of system analysis method based on the concept of relative efficiency evaluation proposed by the famous American operations researcher A.C harnes, W.W.C ooper and E.R hodes in 1978, who founded the CCR model firstly. As a basic DEA model and constant returns to scale, CCR model aimes at comprehensive analysing and evaluating multiple inputs and outputs of decision making units, and optimal weight of each indicator and relative efficiency of each DMU can be obtained through linear optimization. Index analysis method is put forward by StenMalmquist, a Swedish economist, when he studied consumer problems in 1953; since then Charnes etc. applies Malmquist index to other areas, and combined with the data envelopment analysis (DEA), create a malmquist productivity index based on DEA method, after that it has been well utilized in all kinds of research fields, such as efficiency and productivity evaluation. When someone has panel data, one can use DEA-like linear programs and a (input-based or output-based) Malmquist TFP index to measure productivity change[7], and to decompose this productivity change into (Tech) and technical efficiency change (Efch) that can further be decompose into scale efficiency (Sech) and "pure" (VRS) technical efficiency (Ptech) components[8]. From the aspect of the dynamic efficiency changes, Malmquist TFP index can further analyze the influence factors behind the efficiency differences. As shown in formula 1:

$$\begin{aligned} M_0\left(x^{t+1}, y^{t+1}; x^t, y^t\right) &= \left\{\left[\frac{D_0^{\,t}\left(x^{t+1}, y^{t+1}\right)}{D_0^{\,t}\left(x^{t}, y^{t}\right)}\right]\left[\frac{D_0^{\,t+1}\left(x^{t+1}, y^{t+1}\right)}{D_0^{\,t+1}\left(x^{t}, y^{t}\right)}\right]\right\}^{\frac{1}{2}} \\ &= \frac{D_0^{\,t}\left(x^{t+1}, y^{t+1}\right)}{D_0^{\,t}\left(x^{t}, y^{t}\right)}\left[\frac{D_0^{\,t}\left(x^{t+1}, y^{t+1}\right)}{D_0^{\,t+1}\left(x^{t}, y^{t}\right)}\,\frac{D_0^{\,t}\left(x^{t}, y^{t}\right)}{D_0^{\,t+1}\left(x^{t}, y^{t}\right)}\right] \\ &= EC\left(x^{t+1}, y^{t+1}; x^t, y^t\right) \times TC\left(x^{t+1}, y^{t+1}; x^t, y^t\right) \end{aligned} \tag{1}$$

M_0 is total factor production rate (TFP). EC is the technical efficiency changes;TC the technical progress change; "1" is the critical value, when EC$\geq$1, means EC is greater than last year, and vice versa; similarly, when TC$\geq$1, means TC is better than last year, and vice versa; relationships of all indicators as follows:

$$TFP = Effch \times Techh = \left(Pech \times Sech\right) \times Tech \tag{2}$$

Data source

1)The setting of inputs and outputs

According to the existing literatures, this paper selects the variables as follows: Selected the logistics staff number(x_1), fixed asset investment(x_2), energy consumption(x_3) and co2 emissions(x_4) as inputs; the logistics industry output value(y) as output.

TABLE 1: Input and output indexes system

Type	Name of index	Note
Input	the logistics staff number(x_1)	Human resources
	fixed asset investment(x_2)	financial
	energy consumption(x_3)	The degree of environmental pollution
	co2 emissions(x_4)	The degree of environmental pollution
Output	the logistics industry output (y)	Development level and scale of logistics

2)The choice of sample

This article selects 30 provinces and cities as samples (except Tibet because of part of data missing). The raw data derived from 2008-2011, China energy statistical yearbook and other statistical yearbook of 30 provinces and cities. As for the carbon emissions coefficients, which refer to the values of the United Nations panel on climate change (IPCC) in 2006, the original data come from the Guidelines for National Greenhouse Gas Inventories in2006.

RESULT AND DISCUSS

Cluster analysis

Before running the DEA, firstly using the sofeware SPSS17.0, analyzes 30 decision making units with Ward's method. Clustering analysis refers to the method in mathematical study and deal with the classification of a given object. The purpose of this clustering is to divide the different DMU into the same class based on carbon emissions and energy consumption indexes, which makes the DEA efficiency value more accurate. During this clustering, a total of 30 provinces and cities in China is divided into two categories: the first category (type1) includes 21 provinces and cities, the second (type2) nine provinces and cities. According to the results of clustering analysis: the energy consumption and co2 emissions of the type1 are higher than the first kind of provinces; low carbon level is lower than the first kind of provinces. Results of classify as follows:

TABLE 2:Results of cluster analysis by Ward's method

Type	Name of provinces and cities
Type1 (21)	Beijing; Tianjin; Hebei; Shanxi; Jilin; Heilongjiang; Anhui; Fujian; Jiangxi; Henan; Hunan; Guangxi; Hainan; Chongqing Guizhou; Yunnan; Shanxi; Gansu; Qinghai ; Ningxia ; Sinkiang
Type2 (9)	InnerMongolia; Liaoning; Shanghai; Jiangsu; Zhejiang; Shandong; Hubei; Guangdong; Sichuan

Efficiency analysis Based on Malmquist TFP index

In this part, Using the deap2.1 software, analyzed the four-year data from 2008 to 2011; Efch is efficiency change; Tech is technical change; Pech means “pure” (VRS) technical efficiency; Sech means scale efficiency change;TFP is Malmquist total factor productivity. The Malmquist index and its related index (Efch, Tech, Pech, Sech and TFP) are shown on the TABLE3:

In the first kind of provinces and cities, only five provinces’ total efficiency are in a backward state,they are Shanxi, Fujian, Guizhou, Yunnan, Gansu, of which Malmquist productivity index of Fujian province improved 1%, progressive scope is very small, technical efficiency change (TC = 1.087) is its mainly driver. These provinces and cities need to intensify investment in technology and to expand the scale. The rest of the province's total efficiency has improved in different degree; the top three biggest progress are: Beijing(38.3%), Hainan(24.6%) and Ningxia(16.3%), which is higher than the average values 34%, 20.3%, 12%, respectively. The pure technical efficiency and scale efficiency are improved, and Malmquist TFP indexes are increased 19.4%, 22.6%, and 3.5%, respectively, which is far above average 20.3%, 23.1% and 7.2%. The results shows that development of logistics in these provinces and cities is in a good condition, technology and scale are well coordinated developed.

Among the second category of provinces and cities, Malmquist productivity index of seven provinces have increase in varying degrees: InnerMongolia (3.4%); Liaoning (5%); Shanghai (20.7%); Jiangsu (1.1%); Zhejiang (1.2%); Sichuan(3.9%), which mainly thanks to the technological progress and scale (Zhejiang province mainly rely on technological progress); The degeneration of Malmquist productivity index of Shandong, Hubei and Guangzhou is mainly depends on technical progress index, so these 3 provinces in the future should increase the investment of science and technology, improve the logistics technology and the efficiency of technology.

TABLE3: Results of 30 provinces and cities in China

Name	Efch	Tech	Pech	Sech	TFP	Name	Efch	Tech	Pech	Sech	TFP
Beijing	1.383	0.864	1.344	1.029	1.194	Shanxi	1.044	0.887	1.021	1.023	0.927
Tianjing	1.102	0.932	1.074	1.026	1.027	Gansu	0.915	0.864	0.876	1.045	0.79
Hebei	1	0.932	1	1	0.932	Qinghai	1.117	0.963	1	1.117	1.075
Shanxi	0.826	0.905	0.824	1.003	0.748	Ningxia	1.163	0.89	1	1.163	1.035
Jilin	1.034	0.868	1.006	1.028	0.898	Xinjiang	1.048	0.895	0.983	1.066	0.938
Heilongjiang	1.074	0.876	1.056	1.017	0.941	**mean**	1.043	0.924	1.009	1.033	0.963
Anhui	1.12	0.888	1.095	1.023	0.994	InnerMongolia	1.032	1.001	1	1.032	1.034
Fujian	0.929	1.087	0.933	0.996	1.01	Liaoning	1.123	0.935	1.107	1.015	1.05
Jiangxi	1.016	0.869	0.992	1.025	0.883	Shanghai	1.319	0.915	1.18	1.118	1.207
Henan	1.026	0.852	1.037	0.989	0.874	Jiangsu	1	1.011	1	1	1.011
Hunan	1	0.984	0.97	1.031	0.984	Zhejiang	0.949	1.066	1	0.949	1.012
Guangxi	1.082	0.92	1.049	1.032	0.996	Shandong	0.993	0.944	1	0.993	0.937
Hainan	1.246	0.984	1.139	1.093	1.226	Hubei	1.013	0.95	1.002	1.011	0.962
Chongqing	1	1.005	0.957	1.045	1.005	Guanggong	1	0.929	1	1	0.929
Guizhou	0.958	0.99	0.964	0.994	0.948	Sichuan	1.009	1.029	1	1.009	1.039
Yunnan	0.95	0.981	0.973	0.975	0.932	**mean**	1.044	0.974	1.03	1.013	1.017

Overall, the average values of the total efficiency and Malmquist productivity index of the first kind are lower than the second. In addition, the mean technological progress index is less than 1, in a state of setbacks, however, the mean scale efficiency changes have a certain growth, which means that all the type provinces and cities need to strengthen technology.

CONCLUSIONS

When selecting the inputs, most of which are chose from three aspects: personnel, financing and properties. however, with the speeding up of low carbon, index that reflects the environmental pollution should also put into inputs. Therefore, this paper adds energy consumption and carbon emissions indicators to input indexes; according to these 2 indexes, 30 decision making units can be divided into 2 groups, and analyzes the 2 kind of groups respectively with the DEA-Malmquist productivity index. The interrelated analyses concludes that average technical progress index of two classes are less than 1; scale efficiency index is improved,which indicates that the development of logistics is caused by scale; more attention should be paid on increasing the intensity of science and technology, improving the technological progress and scale efficiency, promote the ascension of China's total factor productivity.

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