Empirical Analysis of Logistics Park Efficiency Based on Malmquist Productivity Index Model

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Abstract
In order to research the actual operation of the logistics park, and provide decision support for the logistics park's follow-up development, this paper constructs the evaluation index system of logistics park operation efficiency based on the Data Envelopment Analysis method of Malmquist productivity model. Taking Hebei province as an example, the model of logistics park operation efficiency of Hebei province by empirical analysis was constructed. Malmquist index is decomposed into technological progress index, resource allocation efficiency index, pure technical efficiency index and scale efficiency index. Then it goes through analysis on model result. The conclusion shows that the Malmquist productivity index model in the field of performance evaluation of logistics park has advantages such as certain objectivity, feasibility and innovation.
Key words: LOGISTICS PARK, OPERATIONAL EFFICIENCY, MALMQUIST INDEX

1. Introduction

As the important nodes in logistics network and logistics park, the role of logistics park in the promotion of logistics and regional economic development is obvious to all. The definition of the logistics park in “Logistics terms”(GB/T18354-2006) is gathering point of some kinds of transportation modes with each other. In the area around the city, there are logistics facilities focused on large-scale construction, logistics industry are brought together a large number of logistics business gathering. And its purpose are to make logistics facilities centralized, the operation of logistics services at the same time, and logistics facilities layout rationalization .Logistics Park originated in Tokyo, Japan, and is called the logistics group at that time. It eased the distribution center of the logistics distribution in the city to bring with the adverse impact. Logistics Park is called freight village in Europe, which contains all the

activities of the transportation, logistics and distribution of goods within a certain region. The first logistics park in China is built in December 1, 1998 in Shenzhen Pinghu logistics base, the meaning of logistics base at the time is “the specific areas with the purpose of logistics development". After a period of operation, Logistics park improve the logistics industry development and service level, and driven the development of urban economy through industrial integration, resource aggregation and business optimization. With the concept of development to promote low-carbon today, it should not be overlooked in the role to improve the city environment.

At present, the main research studied the whole performance of logistics enterprise or supply chain. The research on the performance of logistics park is little. Qiu Hui-fang of Beiing Jiaotong University evaluates the performance of the construction of a logistics park, establishes the evaluation index system which considers the objective "hard performance" as well as the subjective "soft performance". Then a case study is conducted on the logistics park construction projectin a certain city using AHP and expert scoring[1]. YI Mei of Changsha University of Sciedce & Technology considers the Unascertained and fuzzy of logistics park location, utilizes AHP establishing location evaluation index system, by introducing triangle fuzzy number and language variable etc conception establishs math model getting fuzzy weight, then gets location scheme using triangle fuzzy number algorithm and sort method[2]. Xu Cheng of Southwest Jiaotong University considers the minimum of the logistics quantity, the close connection of each functional area and the maximum of land use rate, a mathematical model is established. Then, to solve the model, a hybrid genetic algorithm is constructed. Finally, the practical calculation of a domestic logistics park is given[3]. In the national logistics park construction, the technology of logistics park location, logistics park layout, investment scale control and so on technology has been more mature. However, the actual performance of the logistics park is seldom considered, to improve the logistics park, to provide reference for other logistics park. Therefore, along with the gradual construction of the logistics park area, a scientific and effective method for evaluating the performance of logistics parks is proposed to comprehensively analyze and evaluate the performance of Logistics Park. It has become the logistics industry to be solved urgently[4]. Malmquist productivity index based on DEA is used in this paper to calculate the growth of TFP, weigh the operation performance of logistics park. Both the research perspective and the research method are the innovations of this paper.

2. DEA evaluation of new perspective - Total Factor Productivity (TFP) theory

In 1978, A.Charnes, W.W.Cooper and E.Rhodes gave the Data Envelopment Analysis (DEA) for evaluating the relative validity of decision units[5].From the first model appear, so far, it has formed the complete theory, methods and models of DEA research for the concepts of efficiency, production and production frontier.

The Malmquist index proposed by the Swedish economics and statistician Sten Malmquist in 1953.The index was used to analyze the consumption changes of different periods. In 1982, Caves, Christensen and Diewert first introduced the Malmquist index into the field of production, And the concept of Malmquist productivity index is put forward[6].The study had a great impact at the time.But for a long time, the application of this theory is seldom studied. Until 1994, Rolf Färe and Grosskopf et al., gives a non-parameter linear programming algorithm for this theory. The Malmquist productivity index can be applied widely[7].

2.1 Malmquist index definition

Malmquist index proposed by Färe et al, based on the proposed distance from Shephard (1970), the expression is:

$$M_{t,t+1}=\left[\frac{D^{t}(x^{t+1},y^{t+1})}{D^{t}(x^{t},y^{t})}\times\frac{D^{t+1}(x^{t+1},y^{t+1})}{D^{t+1}(x^{t},y^{t})}\right]^{\frac{1}{2}} \quad (1)$$

Among them,

$$D(X,Y)=\inf\{\theta:(X,Y/\theta)\in P(X),X\in R^{m},Y\in R^{k},\theta\geq 0\}$$
$$=[\sup\{\alpha:(X,\alpha Y)\in P(X),X\in R^{m},Y\in R^{k},\alpha\geq 0]^{-1}$$

The Malmquist exponent can be obtained by calculating the following four DEA models:

$$D^t(X^t,Y^t)=\min\theta$$

$$\text{(CCR I)}s.t.\begin{cases}\sum_{j=1}^{n}X_j^t\lambda_j\le\theta X_k^t\\ \sum_{j=1}^{n}Y_j^t\lambda_j\ge Y_k^t\\ \lambda_j\ge 0,\ j=1,\cdots,n\end{cases}$$

$$D^{t+1}(X^{t+1},Y^{t+1})=\min\theta$$

$$\text{(CCR II)}s.t.\begin{cases}\sum_{j=1}^{n}X_j^{t+1}\lambda_j\le\theta X_k^{t+1}\\ \sum_{j=1}^{n}Y_j^{t+1}\lambda_j\ge Y_k^{t+1}\\ \lambda_j\ge 0,\ j=1,\cdots,n\end{cases}$$

$$D^t(X^{t+1},Y^{t+1})=\min\theta$$

$$\text{(CCR III)}s.t.\begin{cases}\sum_{j=1}^{n}X_j^t\lambda_j\le\theta X_k^{t+1}\\ \sum_{j=1}^{n}Y_j^t\lambda_j\ge Y_k^{t+1}\\ \lambda_j\ge 0,\ j=1,\cdots,n\end{cases}$$

$$D^{t+1}(X^t,Y^t)=\min\theta$$

$$\text{(CCR IV)}s.t.\begin{cases}\sum_{j=1}^{n}X_j^{t+1}\lambda_j\le\theta X_k^t\\ \sum_{j=1}^{n}Y_j^{t+1}\lambda_j\ge Y_k^t\\ \lambda_j\ge 0,\ j=1,\cdots,n\end{cases}$$

2.2 Malmquist exponential decomposition

When the constant returns to scale, The Malmquist index can be decomposed into Technical Change index(Technical Change, TC) and resource allocation efficiency index (Efficiency Change, EC).

$$M_{t,t+1}=\left[\frac{D^t(X^{t+1},Y^{t+1})}{D^t(X^t,Y^t)}\times\frac{D^{t+1}(X^{t+1},Y^{t+1})}{D^{t+1}(X^t,Y^t)}\right]^{\frac{1}{2}}=\left[\frac{D^t(X^{t+1},Y^{t+1})}{D^{t+1}(X^{t+1},Y^{t+1})}\times\frac{D^t(X^t,Y^t)}{D^{t+1}(X^t,Y^t)}\right]^{\frac{1}{2}}\bullet\frac{D^{t+1}(X^{t+1},Y^{t+1})}{D^t(X^t,Y^t)}\qquad(2)$$

Among them, technical change index : $TC=\left[\frac{D^t\left(X^{t+1},Y^{t+1}\right)}{D^{t+1}\left(X^{t+1},Y^{t+1}\right)}\times\frac{D^t\left(X^t,Y^t\right)}{D^{t+1}\left(X^t,Y^t\right)}\right]^{\frac{1}{2}}$

Resource allocation efficiency index :

$$EC=\frac{D^{t+1}\left(X^{t+1},Y^{t+1}\right)}{D^t\left(X^t,Y^t\right)}$$

When scale efficiency changes, the resource allocation efficiency index can be further decomposed into the pure technical efficiency index (Pure Technical Efficiency, PTE) and the scale efficiency index (Scale Efficiency, SE).The formula is as follows:

$$EC=\frac{D^{t+1}\left(X^{t+1},Y^{t+1}\middle|V,S\right)}{D^t\left(X^t,Y^t\middle|V,S\right)}\bullet\frac{S_t\left(X_t,Y_t\right)}{S_{t+1}\left(X_{t+1},Y_{t+1}\right)}\qquad(3)$$

When the Malmquist index is more than 1,TFP level is raised, When the index of technological change and resource allocation efficiency of Malmquist index is more than 1,It is the main source of TFP growth. Conversely, it is the root cause of the decline in TFP; The index of the scale efficiency and the pure technical efficiency index reflect the influence of the efficiency index of the resource allocation.

Divide the factor productivity into two parts, the technological progress and the efficiency. It have important significance, especially in developing countries, the growth of factor productivity is regarded as the result of technological progress. It will cover up the fact that factor productivity growth depends on the efficiency of the factor productivity growth. Therefore, when we introduce new technology, we should pay attention to the fact that the full potential of the existing technology is not fully excavated, instead of just focusing on the introduction of new technology [8].

3. The establishment of performance evaluation index system of Logistics Park

In the research of logistics park performance evaluation method, It's not enough to focus on theoretical studies. It should be combined with the characteristics of logistics park, and make the evaluation index and select the appropriate evaluation method, and carry out the empirical analysis. In this way, the sustainable development of the logistics park, the promotion of regional

economic industrial upgrading, optimizing the social resources to provide useful help. At present, the method of constructing the index is mainly aimed at the enterprise. There are DuPont Model, KPI, BSC, ABC, EVA and benchmarking method. However, these methods have some limitations to the performance evaluation of logistics park in a certain extent [9].

This paper presents the performance evaluation index system of logistics park based on Malmquist DEA productivity index. With the assistance of domain experts, identification of the impact of logistics park performance of the input indicators and output indicators system, the number of employees, costs, risks, benefits, quality, efficiency, environment, as shown in Table1[10].

Table 1. Establishment of performance evaluation index system of Logistics Park

Evaluation angle	Evaluation index	Index interpretation
Input index	Staff number x_1	Total logistics park staff
	Cost x_2	Infrastructure construction cost, business operation cost, human resource cost
	Risk x_3	Economic risks, technological risks, natural risks and other risks
Output index	Profit y_1	Business operations revenue, advertising revenue, other income
	Quality y_2	The goods in good condition, enterprises' status, customer satisfaction, treatment status
	Efficiency y_3	Input output status, loss degree, accurate and timely degree
	Environmental status y_4	Environmental impact of logistics park management

4. Empirical analysis

4.1 Data acquisition

This paper collects the basic data of 4 logistics parks in Hebei Province in 2008-2013. Data mainly come from the actual research of logistics park enterprise. The data collected are mainly used to reflect the annual input and output status of 4 logistics parks in Hebei province.

The research span is the change of the productivity of logistics parks in Hebei Province during the 6 years of 2008~2013.

4.2 Numerical calculation

With the research and utilization of the DEA model of the output angle, to process Panel Data 2008~2013 years of the 4 logistics parks in Hebei Province. The output distance function of the Malmquist index is calculated by the above mathematical programming method. And get the Malmquist productivity index, and then its decomposition, Thus, the change rate of TFP, the efficiency of technological progress, the efficiency of resource allocation, the pure technical efficiency and the chain index of the change of scale efficiency of the logistics park are obtained. The index is shown in Table 2.

Table 2. Malmquist productivity index and decomposition of logistics park in 2008~2013

Annual	Logistics Park	Technical change efficiency	Resource allocation efficiency	Pure technical efficiency	Scale efficiency	Malmquist index
2008-2009	1	1	1	1	1	1
	2	1.37857	0.589223	0.892914	0.659888	0.812286
	3	1.044666	1.5647	1.0641	1.470445	1.634589
	4	1.144459	0.989669	0.890155	1.111794	1.132635

	Hebei Province	1.103812	1	1	1	1.103812
2009-2010	1	0.905766	0.925583	1	0.925583	0.838361
	2	0.546346	2.264087	1.112516	2.035105	1.236975
	3	1	1	1	1	1
	4	0.674425	1.378909	1.089833	1.265248	0.92997
	Hebei Province	1	1	1	1	1
2010-2011	1	1.089353	1.0804	1	1.0804	1.176937
	2	1.694347	0.837568	0.979961	0.854695	1.419131
	3	1.888084	0.907804	0.989022	0.917881	1.71401
	4	1.478211	1.1161	1.0308	1.082751	1.649832
	Hebei Province	1.193231	1	1	1	1.193231
2011-2012	1	1	1	1	1	1
	2	1.104007	1.2713	1.033	1.230687	1.403524
	3	1.308794	1.074176	0.949033	1.131864	1.405875
	4	1.05882	1	1	1	1.05882
	Hebei Province	1.028786	1	1	1	1.028786
2012-2013	1	1.054087	1	1	1	1.054087
	2	1.131616	0.74217	0.989609	0.749963	0.839852
	3	0.974301	1.456963	1.04318	1.396655	1.41952
	4	1	1	1	1	1
	Hebei Province	1.008514	1	1	1	1.008514
Average	1	1.009841	1.001197	1	1.001197	1.013877
	2	1.170977	1.14087	1.0016	1.106068	1.142354
	3	1.131962	1.141387	1.009067	1.123369	1.254799
	4	1.071183	1.096936	1.002158	1.091959	1.154251
	Hebei Province	1.066869	1	1	1	1.066869

4.3 Evaluation results

4.3.1 Analysis of model

Table 2 is the change of TFP in 2008~2013, which is expressed by Malmquist productivity index. From the structure of TFP growth in Logistics Park, the growth of logistics park TFP is mainly from technological progress. This and the society generally believe that the logistics park TFP increase from the allocation of resources to improve the efficiency of the difference between the greater. During the 6 years, Logistics Park average TFP growth rate are 6.7 percentage points. Which logistics park technological progress for its contribution by 6.7 percentage points. Favorable to promote the logistics park TFP growth. The logistics park resource allocation efficiency remains unchanged. The growth of TFP did not play a role. The allocation efficiency of the logistics park is kept constant. Pure technical efficiency and scale efficiency remain unchanged. Therefore, their comprehensive role is the logistics park's resource allocation efficiency remain unchanged. From the above analysis can be seen, the growth of TFP in Logistics Park belongs to the growth mode of technology induced growth. The technological progress has the important influence on the growth of TFP in logistics park. The technical change efficiency becomes the decisive factor of TFP growth [11].

From the difference of TFP growth between logistics parks, horizontal comparison

can be used to distinguish and evaluate the differences in the overall performance of different logistics parks. Third logistics parks maintained an average of 25.5% growth rate, to be higher than first (1.4%), second (14.2%) and fourth (15.4%).And this state has been relatively stable in various years. It is a leading role in the industry. From the growth of TFP on the logistics park to see, the technical progress efficiency and the resource allocation efficiency have the different degree of contribution to the function. In the impact of resource allocation efficiency, the scale efficiency has the big promotion effect to the TFP growth. In the impact of resource allocation efficiency, the scale efficiency has the big promotion effect to the TFP growth. The pure technical efficiency of the TFP is not obvious.

The longitudinal comparison of the logistics park can be used to track the whole performance of logistics park as the time change. From table 2, we conclude that the 4 logistics parks in the period of TFP change index in the year 2008-2013, technology change efficiency, resource allocation efficiency, pure technical efficiency and scale efficiency of the change trends, figure 1, figure 2, figure 3, figure 4.Logistics park can be a benchmark for the period of high efficiency to determine their future direction of development.

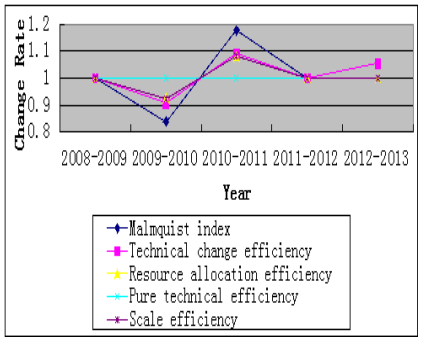

Figure 1. The first Logistics Park index change trend chart

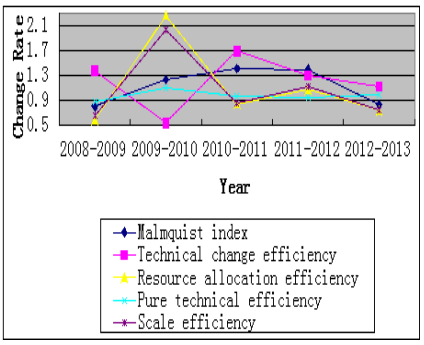

Figure 2. The second Logistics Park index change trend chart

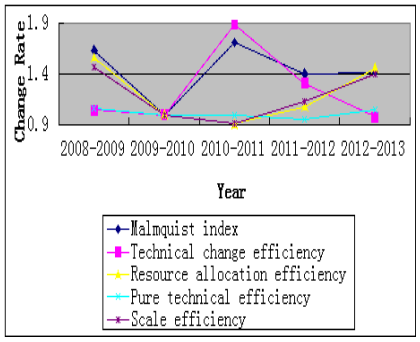

Figure 3. The third Logistics Park index change trend chart

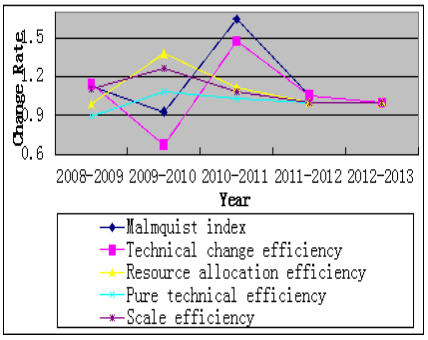

Figure 4. The fourth Logistics Park index change trend chart

4.3.2 Dynamic analysis of TFP growth

From the previous analysis can be seen, regardless of the overall development trend of the logistics park of 2008~2013,Or from the logistics park development differences, Technological progress is the main driving force of TFP growth in logistics parks. The volatility of the scale efficiency and the pure technical efficiency, the efficiency of resource allocation is not obvious for the TFP. In order to better explain the change of TFP in logistics park of Hebei Province during 2008~2013 and its influence on the factors, this paper, select the Malmquist index of 2008 and the index of each decomposition as the basis of the index. The rest of the years were compared with 2008.The Malmquist index and the change of the decomposition index are obtained, Figure 5.

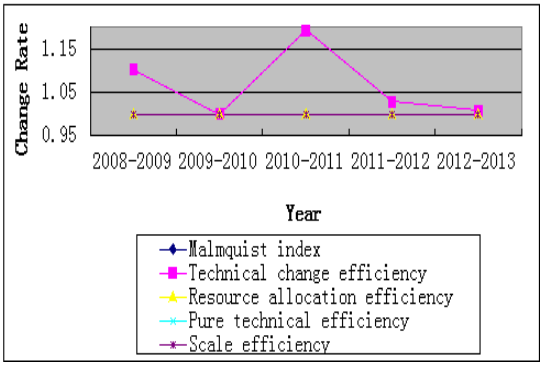

Figure 5. The change of TFP and the decomposition index of logistics park in Hebei Province

We can see from Figure 5, the change trend of the Malmquist index during the period of 2008~2013 was in complete agreement with the trend of the technical progress efficiency. The change efficiency of technology is the decisive factor that affects the efficiency of logistics park TFP. Technological progress comes from the improvement of quality and the progress of technology. These advances are embodied in the innovation of management system, logistics park resources allocation ability raise, staff quality of the rising, improve the logistics park facilities and the growing popularity of the diversification of the modern technology, logistics park into the diversification of sources of cost, internal management system of logistics park of modernization and scientific aspects[12].

The change of resource allocation efficiency of logistics park is smooth and always in 1 place. Pure technical efficiency and scale efficiency is always 1 too. The allocation efficiency of logistics park is not obvious to the growth of TFP. The pure technical efficiency index reflects the level of production technology and management. It measures the production technology and management level of the production units closer to the current production frontier. When $PTE > 1$,the efficiency of the production technology and management level of the decision making unit is improved. The scale efficiency index reflects the effective degree of the scale of production. That is, the scale of efficiency reflects whether the most appropriate investment scale for business. When $SE > 1$, Means it can get the economies of scale, expanding the scale always increases productivity growth; on the contrary, it means the scale is not economic.

5. Conclusions

Firstly, the paper has identified the input and output indicators of logistics park performance. The performance of logistics park in Hebei province has been evaluated based on Malmquist DEA productivity index method. In actual analysis, it has analysed and evaluated the logistics park performance from the TFP change rate, technological progress index, resource allocation efficiency index, pure technical efficiency index and scale efficiency index. And it has pointed out the intrinsic factor of these changes. In the field of logistics park performance evaluation has some innovative. The conclusion has showed that, the economic analysis based on Malmquist index is more advantageous for us to master the development of the whole industry. At the same time, the factor that can affect the economic growth of the park can be decomposed. It identify the key factors that affect the economic development of the industry, and promote the development of the logistics park and improve the overall efficiency of the industry.

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