An Evaluation of Urban Logistics Efficiency in Jiangxi Province Based on DEA-Malmquist Index

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Abstract—This paper, by means of DEA-Malmquist index, analyzes empirically urban logistics efficiency in Jiangxi province from 2004 to 2008, studies contrastively urban logistics efficiency indexes of Jiangxi province's 11 cities from three aspects of technical progress, pure technical efficiency and scale efficiency, and has classified the index result. The aim is designed to provide advice for decision-making adopting different types in order to increase urban logistics efficiency.

Keywords—DEA; Malmquist index; urban logistics efficiency; TFP;

I. INTRODUCTION

At present, many local governments had formulated the logistics development plan and related policy, and tried to speed up urban logistics specialized operation and socialized management to optimize the regional industrial structure, and then to promote the economy developing in that district. Now, what is the present condition of urban logistics in our cities? Did the implementation of the programs and related policies develop the function? Are there some problems waiting to solving at present? So, the initial task is to evaluate urban logistics efficiency.

Logistics efficiency evaluation and control are very necessary to supervise and regulate the organization's resources. Building up urban logistics index system and evaluating scientifically, are significant to objectively understand logistics developing level, optimize the existing logistics system, and promote urban competitiveness.

In literatures, there are many methods about the logistics efficiency evaluation, including Analytic Hierarchy Process (AHP), Fuzzy Comprehensive Evaluation, Data Envelopment Analysis (DEA), etc, and mainly concerning to evaluate the efficiency of enterprise logistics system, or analyze the efficiency of manufacturing enterprises’ supply chain system, or evaluate the cities’ input-output effectiveness. This paper, drawing lessons from other scholars’ research results concerning the index system of urban logistics efficiency evaluation, considering the comprehensiveness and feasibility, sets up multi input multi output index system based on urban logistics efficiency, analyzes empirically urban logistics efficiency of Jiangxi province’s 11 cities, and analyzes quantitatively the difference among the 11 cities about urban logistics input-output efficiency by means of DEA-Malmquist index and cause to provide basis for decision-making.

II. STUDY METHOD AND DATA SELECTION

A. Study Method

This paper utilizes DEA-Malmquist index non-parameter method built by Fare (1994) to analyze empirically urban logistics efficiency in Jiangxi province. The essence of Data Envelopment Analysis (DEA) is to utilize Linear Programming method to construct a DEA-efficient production frontier, and then make the non-DEA Effective Decision Making Unit (DMU) project to the DEA-efficient production frontier, and evaluate the relative efficiency of each DMU by the deviation degree between the non-DEA-effective DMU and the DEA-effective production frontier. According to different scale efficiency assumptions, DEA model can be divided into the Constant Returns to Scale model (CRS) and the Variable Returns to Scale model (VRS). Comparing with CRS model assuming that all DMUs are operating on superior scale, VRS model considering the situation in non-superior scale divides technical efficiency change (TECH) into pure technical efficiency change (PTECH) and scale efficiency change (SECH) in order to measure the DMU whether to be in the superior scale in condition of vested production technology.

According to panel data, utilizing Linear Programming method and Malmquist index based on DEA, the productivity change can be measured. Fare (1994) defined Malmquist index based on output:

\[
M_t(X_t, Y_t, X_{t+1}, Y_{t+1}) = \left[ \frac{D_t(X_{t+1}, Y_{t+1})}{D_t(X_t, Y_t)} \right] \left[ \frac{D_{t+1}(X_{t+1}, Y_{t+1})}{D_{t+1}(X_t, Y_t)} \right]^{1/2}
\]

Where \(X_t, Y_t, X_{t+1}, Y_{t+1}\) denote respectively period \(t\) and period \(t+1\) input-output vectors; \(D_t(X_t, Y_t)\) is distance function in productive point of period \(t\) for reference, \(D_t(X_{t+1}, Y_{t+1}), D_{t+1}(X_t, Y_t), D_{t+1}(X_{t+1}, Y_{t+1})\) as below.

Malmquist index is the geometric mean of productivity change as technology in period \(t\) and \(t+1\) for reference, repre-
sents productivity in the point \((X_{t1}, Y_{t1})\) as compared with in the point \((X_t, Y_t)\).

The further resolution of Malmquist index, as follow:

\[
M(X_t, Y_t, X_{t+1}, Y_{t+1}) = \frac{D_1(X_{t+1}, Y_{t+1}) \cdot D_1(X_t, Y_t)}{D_1(X_{t+1}, Y_t) \cdot D_1(X_t, Y_{t+1})}^{1/2}
\]

Let, \(EFFCH = \frac{D_{t+1}(X_{t+1}, Y_{t+1})}{D_t(X_t, Y_t)}\); 

\(TECHCH = \left[ \frac{D_t(X_{t+1}, Y_{t+1}) \cdot D_t(X_t, Y_t)}{D_{t+1}(X_{t+1}, Y_{t+1}) \cdot D_{t+1}(X_t, Y_t)} \right]^{1/2}\); 

\(TFPCH = M(X_t, Y_t, X_{t+1}, Y_{t+1})\).

Where TFPCH is the Total Factor Productivity (TFP) change, denotes a production unit (e.g., an enterprise, an industry, a nation, or a region), represents the ratio between total output and total input in a certain period. It is usually considered a comprehensive index used to evaluate an industry or a region economic situation. TFP growth is a comprehensive performance of technical progress and efficiency improvement. If TFPCH > 1, the productivity had an upward trend; If TFPCH = 1, the productivity unchanged; If TFPCH < 1, the productivity had a recessive trend.

TECHCH is the lapse degree of technical production frontier from period \(t\) to \(t+1\), that is, technical change index. If TECHCH > 1, technique progressed; If TECHCH = 1, technique unchanged; If TECHCH < 1, technique declined.

EFFCH is technical efficiency change degree relatively from period \(t\) to \(t+1\), that is, technical efficiency change index. If EFFCH > 1, technical efficiency improved; If EFFCH = 1, technical efficiency unchanged; If EFFCH < 1, technical efficiency declined.

If VRS, EFFCH further resolved into the pure technique efficiency change (PTECH) and the scale efficiency change (SECH).

\[EFFCH = PTECH \times SECH.\]

Where, \(PTECH = \frac{D_{t+1}(X_{t+1}, Y_{t+1})}{D_t(X_t, Y_t)} \frac{VRS}{VRS}\); 

\[SECH = \frac{D_{t+1}(X_{t+1}, Y_{t+1})}{D_{t+1}(X_t, Y_t)} \frac{CRS}{VRS} \frac{VRS}{CRS}\]

Malmquist index is represented as follow:

\[TFPCH = EFFCH \times TECHCH = PTECH \times SECH \times TECHCH.\]

**B. Index Selection**

On the basis of analyzing relevant literatures, concerning the index system of urban logistics evaluation, combining with the representation and availability of the index, this paper selects the person number of working in transportation, warehousing and postal service industry, the vehicle number of actually operating at the end of the year, the number of highway mileage as input, and the passenger turnover and the traffic turnover as output, as follow Table 1:

**TABLE I. THE INPUT-OUTPUT INDEX SYSTEM OF URBAN LOGISTICS EVALUATION**

<table>
<thead>
<tr>
<th>Index types</th>
<th>Index names(^a)</th>
<th>Variables(^b)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input index(^c)</td>
<td>The person number of working in urban logistics industry (million people).</td>
<td>(X_1)</td>
<td>Represent the person number of working in urban logistics industry to some extent.</td>
</tr>
<tr>
<td></td>
<td>The vehicle number of actually operating at the end of the year</td>
<td>(X_2)</td>
<td>Represent the main transportation means of urban logistics.</td>
</tr>
<tr>
<td></td>
<td>The number of highway mileage (kilometers)</td>
<td>(X_3)</td>
<td>Select the number of highway mileage instead of urban infrastructure input.</td>
</tr>
<tr>
<td>Output index(^d)</td>
<td>The passenger turnover (million people).</td>
<td>(Y_1)</td>
<td>Represent the passenger transportation efficiency.</td>
</tr>
<tr>
<td></td>
<td>The freight turnover (million ton-kilometer).</td>
<td>(Y_2)</td>
<td>Represent the freight efficiency.</td>
</tr>
</tbody>
</table>

The output of urban logistics industry is measured by the freight turnover and the passenger turnover. The freight turnover denotes the highway turnover, not including railway, waterway, and air transportation. The passenger turnover is not including aviation passenger transport. These two indexes can reflect total achievements of urban logistics industry to a certain extent, and are also the basic data of preparing the transportation programs, measuring transport efficiency and labour productivity of transportation, and accounting unit cost of transportation. The calculation formula as follow:

\[\text{The freight turnover} = \sum \text{The freight volume} \times \text{The number of highway mileage}\]

\[\text{The passenger turnover} = \sum \text{The passenger volume} \times \text{The number of highway mileage}\]
C. The Selection of Sample and Date

This paper takes Jiangxi province’s 11 cities as sample, selects the inter-temporal panel data of the 11 cities from 2004 to 2008 in order to calculate Malmquist index. Relevant data is collected from “City Statistical Yearbook of China” (2005~2009) and “Statistical Yearbook of Jiangxi” (2005~2009).

III. EMPIRICAL ANALYSIS

According to relevant data, with the help of DEAP2.1 programed by Tim Coelli[1], the result of Malmquist index of urban logistics and other relevant indexes are obtained, showing Table II as follow.

<table>
<thead>
<tr>
<th>Firm</th>
<th>EFFCH</th>
<th>TECHCH</th>
<th>PECH</th>
<th>SECH</th>
<th>TFPCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanchang</td>
<td>0.985</td>
<td>1.069</td>
<td>1.000</td>
<td>0.985</td>
<td>1.053</td>
</tr>
<tr>
<td>Jingdezhen</td>
<td>0.770</td>
<td>1.054</td>
<td>0.841</td>
<td>0.915</td>
<td>0.811</td>
</tr>
<tr>
<td>Pinxiang</td>
<td>0.984</td>
<td>1.087</td>
<td>1.000</td>
<td>0.984</td>
<td>1.070</td>
</tr>
<tr>
<td>Jiujiang</td>
<td>0.969</td>
<td>1.109</td>
<td>0.978</td>
<td>0.990</td>
<td>1.075</td>
</tr>
<tr>
<td>Xinyu</td>
<td>0.980</td>
<td>1.121</td>
<td>0.922</td>
<td>1.063</td>
<td>1.098</td>
</tr>
<tr>
<td>Yingtan</td>
<td>1.064</td>
<td>1.294</td>
<td>1.000</td>
<td>1.064</td>
<td>1.376</td>
</tr>
<tr>
<td>Ganzhou</td>
<td>1.000</td>
<td>1.175</td>
<td>1.050</td>
<td>1.175</td>
<td></td>
</tr>
<tr>
<td>Ji’an</td>
<td>1.047</td>
<td>1.065</td>
<td>1.046</td>
<td>1.100</td>
<td>1.115</td>
</tr>
<tr>
<td>Yichun</td>
<td>1.000</td>
<td>1.117</td>
<td>1.000</td>
<td>1.117</td>
<td></td>
</tr>
<tr>
<td>Fuzhou</td>
<td>0.996</td>
<td>1.095</td>
<td>1.047</td>
<td>0.951</td>
<td>1.091</td>
</tr>
<tr>
<td>Shangrao</td>
<td>1.000</td>
<td>1.162</td>
<td>1.000</td>
<td>1.162</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.978</td>
<td>1.121</td>
<td>0.983</td>
<td>0.995</td>
<td>1.096</td>
</tr>
</tbody>
</table>

From Malmquist indexes in Table II, all cities of Jiangxi province’s TPV have been increased in different extent except Jingdezhen. According to Malmquist indexes of the 11 cities, this paper divides the urban logistics level of the 11 cities into 3 types, there are inefficient type (TFPC<1.000), low growth type (1.000<TFPCH<1.100), and high growth type (TFPC>1.100).

High growth type, including Yingtan, Ganzhou, Ji’an, Yichun and Shangrao, their TPV indexes are respectively 1.376, 1.175, 1.115, 1.117 and 1.162, presents that urban logistics efficiency of these cities is increasing in high amplitude, which Yingtan performance is particularly outstanding with increasing by 37.6%. In these cities, TECHCH>1.100 and EFCH>1.000, mean that efficiency increasing mainly depends on the increasing of technical change in high amplitude. At the same time, scale efficiency index which is a factor of technical efficiency index, maintaining 1.000 or so, presents scale efficiency unchanged, means that the increasing of urban infrastructure input has not improved the increasing of urban logistics efficiency.

Finally, see from the mean, urban logistics productivity index in Jiangxi province is 1.096, presents low growth trend which mainly receives benefit from the increasing of technical progress. At the same time, the level of the pure technique efficiency and the scale efficiency is low, urban infrastructure input has not played a due role.

Therefore, we should take different measures to improve urban logistics efficiency, according to different actual situation of urban logistics in each city.

IV. CONCLUSION AND SUGGESTION

From the analysis above, there are 55% cities’ TFP indexes of urban logistics less than 1.000 in Jiangxi province. The overall urban logistics operating efficiency of the 11 cities is low. At the same time, the level of the pure technique efficiency and the scale efficiency is low, urban infrastructure input has not played a due role.

Therefore, we should take different measures to improve urban logistics efficiency, according to different actual situation of urban logistics in each city.

For the city of low growth type, local government should keep appropriate investment scale and reasonable investment structure, focus on rationally using of existing technology resources, optimize the allocation of resources, and improve the logistics operating quality.

For the city of inefficient type, local government should implement technical innovation and management, draw up various policy measures adapting to local conditions, and make the urban logistics industry to a new stage.

For the city of high growth type, local government should seize the opportunity of ecological economic zone construction in Poyang Lake, steadily improve the logistics development environment, insist on open innovation, further enhance the industry operating efficiency, focus on improving innovation ability and whole competition ability, and lead the development of urban logistics industry in the whole province.

REFERENCES


