STUDY ON REGIONAL LOGISTICS CAPACITY BASED ON PRINCIPAL COMPONENT ANALYSIS

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Abstract: This article views quantitatively the study method that used to assess regional logistics capacity, by using the method of principal component analysis (PCA). And then, it performs empirical study on the horizontal and vertical level respectively, by using Hubei province as an example to verify the efficiency of the model. Further, it conducts correlation analysis between Hubei economy and Hubei logistics capacity by using integrated principal components. With this analysis, it intends to explore the pulling or pushing effects that regional logistics capacity has imposed on the development of regional economy.
Key words: Regional logistics, Principal component analysis (PCA), Logistics capacity

Introduction

Nowadays, some of Chinese and overseas scholars attempt to study the development of regional logistics from different aspects, and methods such as fuzzy integration assessment (Yao Yang& Huang Xiaoxia, 2008), and panel unit toot and panel con-integration analysis (Liao Ying& Ruan Lunning, 2008) are widely adopted. However, the methods mentioned above are subjectively random to some extent when ascertaining the weight of indices, which either results the assessment results' departure from reality, or results a similarity between assessment results and reality while accompanied with a reluctant rational process. And thus, scholars at present are adopting some more objective and sounder integration assessment methods to advance the development of regional logistics related theories and practices research. Viewing the headway of the overseas research in this field, we could find that those countries, such as America, Japan and Europe, whose logistics industry are comparatively developed, perform research on regional logistics from two facets mainly. Firstly, they view from enterprise logistics, and commonly apply quantitative tools to explore problems faced by multinational corporations, such as logistics infrastructure, harmony of cooperated programs; strategic distribution system and logistics supply chain operation. Secondly, they view from a macro level to explore the governments' role, logistics collaboration and sustainable development related problems. Aikens (1985) paid early attention to principal logistics facilities location problems, and formulated a complicated model which put factors such as single laden team, multi goods, and limited production capacity into consideration. However, the Aikens' model didn't come down to random altered distribution problems across region. Verter and Diner (1995) analyzed the location problem of multinational corporations, and proposed that production-distribution network was an important tool to construct an enterprise's global supply chain. Keohane etc. (1984) proposed a new liberalism system related economic theory, in which it suggested that it was cooperation other than competition among countries that could bring benefit, and we could realize inside regions' economic cooperation under many circumstances. While in China, Hai Feng (2006) pointed out that regional logistics was what existed in certain geography environment and relied on big and medium sized cities as hub to combine logistical radiant Available In, to serve regional economy development. Liu Xiaofeng (2005) viewed from micro and macro level to explore the promotion effect that regional logistics had exerted on regional economy. And further, he suggested that modern logistics had played important role in advancing the molding of new type of industry and optimizing industry structure, and in enhancing employment opportunity in addition, to reduce the operation cost of enterprises and improve the allocation efficiency of resource.

However, those limited researches on regional logistics and regional logistics capacity were limit to concept confirmation and qualitative description, neither did they take into consideration the overall role of logistical system components, nor did they go further analysis into regional logistical inner components, and thus, the conclusions they obtained were unilateral to some extent. This article firstly adopts the method of PCA to assess regional logistics capacity. And secondly, it performs empirical study on the horizontal and vertical level respectively, by using Hubei province as an example to verify the efficiency of the model. And thirdly, it conducts correlation analyses between Hubei economy and Hubei logistics capacity by using integrated principal components as indices. With this analysis, it intends to explore the pulling or pushing effects that regional logistics capacity has imposed on the development of regional economy.

1 - Construction of Assessment Model on Regional Logistics Capacity

1.1 - Construction of assessment indices system on regional logistics capacity

Assessment study of the development of regional logistics is a complicated systems engineering. There are four principles for us to follow when selecting indices. (1) Complication. When selecting regional logistics capacity indices we should synthetically consider the correlation among macro environment, logistics infrastructure, logistics performance and human resources, and should synthetically depict each factor. (2) Objectivity. The indices system we selected should reflect the relation between goals and indices objectively and factually, and the data we collected are reliable, trustful and impersonal. (3) Acquirability. Each of the assessment indices has definitude meaning and convergence information, and the data are easily obtained and can be easily calculated as well. (4) Comparability. When selecting the indices system, we should take into consideration not only the horizontal comparability of the conclusions among different regions, but also the vertical comparability of the conclusions among different periods, and the comparability of the conclusions between goals and status quo in addition. With analyzing the existed literatures and consulting with specialists, the author constructs an assessment indices system for regional logistics capacity by selecting index from six aspects, which reflect the characteristics of regional logistics development, as follows, (1) Value added in traffic, transportation, storage and telecommunication industries (x_1, Hundred million RMB). (2) Value added in wholesale, retail, trade and restaurant industries (x_2, Hundred million RMB). (3) Employee proportion in logistics industry (x_3, %). (4) Freight quantities (x_4, Ten thousand Tons). (5) Turnover amounts of passengers (x_5, Million person kilometers). (6) Value added in manufacturing industry (x_6, Hundred million RMB). The above indices reflect the demand status and supply scale of regional logistics services, the development status of human resource in logistics industry, and the development of logistics infrastructures, respectively.

Since six indices, among those ascertained assessment index system for regional logistics capacity, are selected in this paper, which makes it more complicated to perform integrate assessment, this study applies PCA to simplify the indices we selected in the first place. By using of dimensionality reduction idea, the PCA replaces the former indices with lesser integrated principal components, and the latter components hold most of information that the original indices have presented, which can make the complicated problems easy to solve.

2   Assessment steps of regional logistics capacity by using of PCA

Assume that we have n year (here, n=10), the number of assessment index is p, and the calculation steps of PCA are as follows,

Step 1, construction of original data matrix for the assessment indices system of regional logistics capacity,

$$X = \begin{pmatrix} X_{11} & X_{12} & .... & X_{1p} \\ X_{21} & X_{22} & ... & X_{2p} \\ M & M & M & M \\ X_{n1} & X_{n2} & ... & X_{np} \end{pmatrix} \qquad (1)$$

Step 2, if the original indices are signed as $x_1, x_2, \ldots, x_p$, their integrated indices can be signed as $Z_1, Z_2, \ldots, Z_m (m \leq p)$, and thus,

$$\begin{cases} Z_1 = L_{11} x_1 + L_{12} x_2 + \ldots + L_{1p} x_p \\ Z_2 = L_{21} x_1 + L_{22} x_2 + \ldots + L_{2p} x_p \\ \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots \quad \ldots\ldots \\ Z_m = L_{m1} x_1 + L_{m2} x_2 + \ldots + L_{mp} x_p \end{cases} \qquad (2)$$

Step 3, to calculate the correlated coefficient matrix,

$$R = \begin{pmatrix} r_{11} & r_{12} & \ldots & r_{1p} \\ r_{21} & r_{22} & \ldots & r_{2p} \\ M & M & M & M \\ r_{p1} & r_{p2} & \ldots & r_{pp} \end{pmatrix} \qquad (3)$$

In formula (3), r_{ij}(I, j=1, 2, $\ldots$, p) is the correlation coefficient of original indices x_i and x_j, and obtained from the following formula,

$$r_{ij} = \frac{\sum_{k=1}^{n} (x_{ki} - \overline{x}_i)(x_{kj} - \overline{x}_j)}{\sqrt{\sum_{k=1}^{n} (x_{ki} - \overline{x}_i)^2 \sum (x_{kj} - \overline{x}_j)^2}} \qquad (4)$$

Since R is a solid symmetry matrix (where, $r_{ij}=r_{ji}$), it is only needed to calculate its upper-triangle variables or lower-triangle variables.

Steps 4, to calculate the eigenvalues and the eigenvectors,

Firstly, to solve the character equation of $| \lambda I - R | = 0$ and obtain the eigenvalues λ_i (i=1 , 2 , $\ldots$, p) ranked by size, where, $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_i \geq 0$. And then, to calculate the corresponding eigenvectors e_i (i=1 , 2 , $\ldots$, p) .

Steps 5, to calculate the contribution ratios and the accumulated contribution ratios of principal components,

The contribution ratio and the accumulated contribution ratio of principal component z_i are obtained from formulas $r_i / \sum_{k=1}^{p} \gamma_k (i = 1,2,\ldots, p)$ and $\sum_{k=1}^{m} \gamma_k / \sum_{k=1}^{p} \gamma_k$, respectively. The eigenvalues whose accumulated contribution ratios reach 85%~95% are selected, and the ingredients they correspond to are ascertained as principal components, the number of which are signed as m (where, m≤p).

Step 6, to calculate the load of the principal components,

$P(z_k, x_i) = \sqrt{\gamma_k} e_{ki}$ (i,k=1 , 2 , $\ldots$, p) **(5)**

And further, the integrated components' score is obtained through the following matrix,

$$Z = \begin{pmatrix} z_{11} & z_{12} & .... & z_{1m} \\ z_{21} & z_{22} & ... & z_{2m} \\ M & M & M & M \\ z_{n1} & z_{n2} & ... & z_{nm} \end{pmatrix} \qquad \textbf{(6)}$$

Finally, to obtain the integrated assessment function by using each of the principal components' contribution ratio as weight to do linearity sums,

$$Z_i = \sum_{j=1}^{m} e_i y_j \qquad \textbf{(7)}$$

Z_i reflects the integrated logistics development degree of the ith region (or year), Where, higher Z_i corresponds to higher degree of regional (or annual) logistics development.

3 - Empirical Study of Regional Logistics Capacity Assessment: with Hubei Province as An Example

3.1 - Horizontal comparative analysis of regional logistics capacity

Since Hubei province is located in middle China, the author compares it with other five provinces located in middle China and several coastal provinces with advanced logistics industry, to assess horizontally the development degree of Hubei logistics capacity.

We can accurately realize the PCA and further obtain the integrated assessment function with standardization process $z_{ij} = (x_{ij} - \overline{x_j}) / \sqrt{var(x_j)}$, by applying the module of Data Reduction in the software of SPSS13.0.

$Z_i = 0.2453x_1 + 0.3018x_2 + 0.0545x_3 + 0.2888x_4 + 0.0894x_5 + 0.3006x_6$

Region	JS	ZJ	AH	SX	JX	SD	HN1	HB	HN2	GD
Total score	3.33	3.58	0.96	1.20	0.86	2.91	1.86	1.24	1.07	3.94
Order	3	2	9	7	10	4	5	6	8	1

Table 1 - The Integrated Score of Logistics Capacity in Hubei and Other Regions (2006)

Further, we obtain the integrated score of logistics capacity in Hubei and other regions, as Table 1 has shown,

We could find from Table 1 that the logistics capacity of Hubei ranks six among the regions listed above. It shows that the development of logistics capacity of Hubei is under that of Henan, and also it is distinctively different from those of coastal regions, such as Guangdong, Jiangsu, Zhejiang and Fujian. As a whole, the logistics capacity of Hubei is still in developing, and which has a biggish space to go ahead. Although the reasons that results into the underdevelopment of Hubei logistics capacity are closely correlated with the development of macroeconomic, the faultiness of factors in logistics system is another important reason, such as the deficiency of means of transportation and the related lack of transportation network that resulted with special geography situation, and the lowlihead of other correlated logistics factors.

3.2 Vertical assessment of regional logistics capacity

We now apply the software of SPSS13.0 to conduct vertical assessment of Hubei logistics capacity by using the related data from the year of 1997 to 2006, the integrated scores are listed in Table 2,

2006									
Year 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Total score 1.83	2.19	2.47	2.97	3.39	3.7	4.05	4.31	4.48	4.66

Table 2 - The Integrated Scores of Hubei Logistics Capacity from the Year of 1997 to

Source: Settled according to 《Hubei Stat. Yearbook (1996-2007)》.

We can conclude from Table 2 that, the integrated score of logistics development in Hubei takes on increase by degrees year after year, which indicates that the regional logistics capacity of Hubei is advancing annually.

3.3 Correlation analysis between regional logistics capacity and regional economy

Since regional economy is the foundation of regional logistics and which determines the demand structure and development level of regional logistics, regional economy has assumed a pushing effect on regional logistics capacity. While on the other hand, regional logistics is the main inscape of regional economy, and which assumes a pulling effect on the layout of regional productivity, the turnabout of production manner, and the rise of regional economy. In other words, the pushing effect is the rise of regional logistics capacity that pushed by the rise of regional economy, while the pulling effect is the rise of regional economy that induced from the rise of regional logistics capacity. The pushing and pulling effects as a whole structure the mutual motivation effect between regional economy and regional logistics.
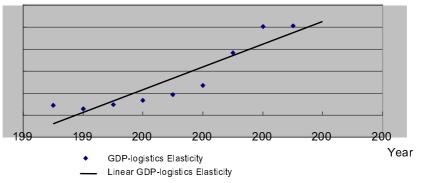

Figure 1 - Varying Instances of Hubei GDP-Logistics Elasticity with Regard to Time

The pushing and pulling effects assume opposite and uniform relationship at the same time in a regional economy system, where the pulling effect is relatively less if the pushing effect is comparatively great, and v.v. The relationship between the pushing effect and the pulling effect can be reflected by regional economy-logistics elasticity (E), which is the ratio of regional economy (we use GDP index, sign it as Y) increase rate to regional logistics capacity (W) increase rate, and can be formulated as $E = W \cdot dY / (Y \cdot dW)$, which indicates the increase rate of regional economy (GDP) that induced from per 1% increase of regional logistics capacity. It indicates that the speed of regional economy increase is faster than that of regional logistics capacity increase, and the pulling effect is greater than the pushing effect under the condition that E>1, where the demand of regional logistics is greater than the logistics supply. And the opposite is true when E<1. While E=1 indicates a balance between the demand and the supply of regional logistics, where the pulling effect is greater than the pushing effect, and

the regional economy increase is synchronized with regional logistics capacity increase. On point has to be emphasized is that the balance between the demand and the supply of regional logistics is a favorable state, which is also the goal of constructing regional logistics capacity (Tan Qingmei et al, 2003).

Since the carrying capacity of logistics facilities, the capability of logistics communication networks, the rationality of logistics centers' void layout, the adaptability of logistics management system, the turnover pace of freights and passengers (labor forces), and et. al., are main indices to weigh regional logistics capacity, we look the integrated assessment score obtained through PCA as the integrated index of weighing regional logistics capacity, and protract the economy-logistics elasticity figure as Figure 1 has shown, from which we could clearly obtain how the GDP-logistics elasticity of Hubei is changing with time.

We could find from the above empirical analyses that there exists a linearity connection between Hubei GDP and logistics capacity, and the Hubei GDP-logistics elasticity, E, is ascending ever since the year of 1997. The pushing effect that thrown by economy increase outweighed the pulling effect that thrown by logistics capacity before the year of 2002, while, the pulling effect has got a breakthrough ever since the year of 2003. The Hubei GDP-logistics elasticity is fluctuating around 4.05 since 2006, which indicates that the Hubei GDP will increase by 4.05% when logistics capacity gets 1% increase averagely, and the supply is distinctively less than the demand of regional logistics, and the pulling effect is obvious. And thus, to vigorously develop logistical industry, and further to improve regional logistics capacity should become one of the important tasks of Hubei economy construction.

4 - Conclusions and Suggestions

As a quantitative method that used to analyze the importance of components, PCA not only can be used to accurately distinguish the principal components that affect regional logistics capacity, but also can be used to construct regional logistics capacity assessment model, and further provides us information to evaluate the logistics capacity level in certain region. And thus, we can find from the above study that it is of great theoretical and realistic significance for us to adopt the method of PCA, and we can draw the following three conclusions. Firstly, the article constructs an assessment model to evaluate the development level of regional logistics capacity, and the idiographic application of the model should accord with the background of different regional economy development. Secondly, we could find from the empirical study that, although Hubei is a cock province among those provinces in middle China, the pushing effect of its logistics capacity is thin, and its ample logistics supply can't induce enough logistics demand. Thirdly, since regional logistics capacity is settled by regional logistics components, the improvement of regional logistics capacity should accord with the construction of regional logistics components. And how to gradually perfect and further realize the improvement of regional logistics capacity is what the author seeks to study in the near future.

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