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Scheme Design and Empirical Research on an Index System for Road Freight in Ningbo Region

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Abstract

As the barometer of the transport market, the freight index reflects the price fluctuations and the variation of the supply-demand relationship. A road freight index system is designed based on the current situation of Ningbo road freight transport market for the necessity of setting the freight index in Ningbo. Models to calculate the average freight indicator are formulated from different perspectives respectively in this paper. Taking the fixed-base index as an example, an empirical case for Ningbo road freight index is analyzed, and the corresponding results prove the validity of the proposed models.

Keywords: Road transport; freight index; modeling; fixed-base index; scheme design; empirical research

1. Introduction

Relying on a natural harbor, Ningbo, a major comprehensive logistics center in Zhejiang Province, an important component of Shanghai international shipping center, and an international logistics hub in northeast Asia, plays an important role in the global supply chain (Yang et al., 2012). With the issue of the Logistics Industry Adjustment and Revitalization Plan by The State Council in March 2009, the strategy position for Ningbo logistics development is emphasized further. On one hand, the plan provides new favorable opportunities for speeding up the infrastructure of the logistics construction, promoting the adjustment and upgrade of logistics industry, and accelerating the modern logistics service system construction. On the other hand, new requirements are imposed on Ningbo.

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As a useful tool to improve the efficiency in road transport market, road freight has obvious regional characteristics. Almost all the regional transport centers have their own transport exchange, they compile and issue freight index according to certain rules (Cai, 2012). As a major logistics node city, road transport plays an important role in internal and external trade in Ningbo. Compared with other modes of transportation, freight rates are highly market-oriented and affected by more factors (Wu et al., 2012). Currently, there are lots of problems such as low efficiency and virulent price competition in the field of road freight transport (Lu, 2007). Therefore, Ningbo has issued **Guidances for promoting balance development between the city road and waterway capacity** which proposed the goal of compiling and issuing freight index for Ningbo.

In terms of freight index calculation model, shipping index has been investigated deeply, including Baltic Dry Index (Yang, 2011) and China Container Freight Index (Liang, 2013). In terms of road freight index, national road freight index (Zhang, 2009) and Yiwu road transport price index (Zhu, 2011) have been established in China, while numbers of studies have been made by foreign researchers in this filed (Eduardo, 2010). Presently, few models of road freight index are formulated and corresponding studies are conducted recently especially for the regional freight index.

A freight index system is designed to ensure the scientificity, reliability and practicality of road freight index for Ningbo. Mathematical models to calculate the average freight indicator are formulated respectively from five perspectives (transport routes, transport sub-regions, transport services, special transport areas and generality) in this paper. Taking the fixed-base index (Cui, 2011) as an example, an empirical case for Ningbo road freight index is analyzed, and the corresponding results prove the validity of the proposed models.

**Nomenclature**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z$</td>
<td>transport sub-region code</td>
</tr>
<tr>
<td>$r$</td>
<td>transport route code</td>
</tr>
<tr>
<td>$c$</td>
<td>transport service code</td>
</tr>
<tr>
<td>$s$</td>
<td>transport sub-service code</td>
</tr>
<tr>
<td>$e$</td>
<td>enterprise which provide basic data code</td>
</tr>
<tr>
<td>$x$</td>
<td>number of areas</td>
</tr>
<tr>
<td>$P$</td>
<td>actual freight rates</td>
</tr>
<tr>
<td>$ar{P}$</td>
<td>average freight rates</td>
</tr>
<tr>
<td>$L$</td>
<td>length of transport route</td>
</tr>
<tr>
<td>$ar{L}$</td>
<td>average length</td>
</tr>
<tr>
<td>$n$</td>
<td>report period for index calculation</td>
</tr>
<tr>
<td>$b$</td>
<td>base-period</td>
</tr>
<tr>
<td>$I$</td>
<td>fixed-base index</td>
</tr>
<tr>
<td>$I_b$</td>
<td>basic point</td>
</tr>
<tr>
<td>$U$</td>
<td>different container types for container</td>
</tr>
<tr>
<td>$V$</td>
<td>different vehicle types for truck-load</td>
</tr>
<tr>
<td>$W$</td>
<td>different vehicle types for liquid hazardous materials</td>
</tr>
</tbody>
</table>
2. Road Freight Index System for Ningbo

In order to inflect the trend of price fluctuations and the variation of the supply-demand relationship in the transportation market, the freight index should be consistent with the principles of scientificity, objectivity, inheritance, systematicness, specificity, practicality, and dynamics. Based on the early surveys, the freight indices of different transport services that occupy a high market share and statics' necessity and feasibility are analyzed. This analysis can basically cover all the transport services and reflect real situation in Ningbo road transport market. The specific freight index system follows as:

![Road freight index system for Ningbo](image)

The road freight index system for Ningbo consists of interconnected four-layer indices (Fig. 1). Having a better syntheses than any others, the first-level index is a comprehensive index of all the transport service freight rates for Ningbo in specific period and can be divided into three second-level indices (freight comprehensive index of container, freight comprehensive index of truck-load, and freight comprehensive index of liquid hazmat) according to main transport service types. In addition, each second-level index can be further divided into several third-level indices according to vehicle or container types: the freight comprehensive index of container is divided into container freight index of 20 feet (standard), and container freight index of 40 feet; the freight comprehensive index of truck-load is divided into truck-load freight index of 8-11 meter, truck-load freight index of 11-15 meter (standard), and truck-load freight index of over 15 meter; the freight comprehensive index of liquid hazmat is divided into liquid hazmat freight index of 10-20 tons, liquid hazmat freight index of 20-30 tons (standard), and liquid hazmat freight index of over 30 tons. Depended on different routes, each third-level index can be divided into several forth-level indices which are regarded as the bases of various indices calculation.
Transport route is the basic unit for road freight index calculation and analysis. Owing to the domination of the short-distance transport in the road transport, the routes for provincial and inter-provincial transport are determined respectively according to the situations of the distance and administrative region division. For the container transport, districts such as Beilun, Haishu, Jiangdong, Jiangbei, Yinzhou, and Zhenhai are all included as the origins, while the destinations are divided into provincial ones (consisted of certain country-level cities and municipal districts with appropriate combinations) and inter-provincial ones (only Shanghai). For truck-load transport, the urban areas of Ningbo constitute the origins, the inter-provincial destinations compromise the prefecture-level cities in Jiangsu and Shanghai, and the provincial destinations are the same as these of the container transport. For liquid hazmat transport, the origins and destinations are same as these of the truck-load transport.

3. Mathematical Models for Average Freight Rates Indicator

For given time and location during calculation, different average freight rates are formulated upon the transportation trade price of each enterprise according to different enterprise types, cargo types, transport services, transport routes, origins, and destinations of transport. However, different calculation methods are demanded in the process of calculating the average freight rates, due to different characteristics and weights in calculating for the freights with different properties.

3.1. Models for different routes and services

The average freight rates with the same transport service and the same route are based on the bidding provided by all the enterprises. For the case that the quantity of the sample exceeds four, we take a arithmetic average method with the extreme value removed. On the contrary, the arithmetic average method is used directly when the quantity of the sample is less than four.

For the routes whose origin is Ningbo, the formula of average freight rates with considering the distinction between transport service and sub-service is written as:

$$
\bar{P}_{cs} = \frac{\sum_{z}^{E_{cs}} \sum_{c}^{Z_{cs}} (P_{ecs}^{r} \times L_{ecs}^{r})}{\sum_{z}^{E_{cs}} \sum_{c}^{Z_{cs}} L_{ecs}^{r}}
$$

(1)

where \(r \in R\), \(R\) is the sum of transport routes in Ningbo. \(E_{cs}\) and \(Z_{cs}\) are respectively the number of enterprises and sub-regions for sub-service \(s\) of transport service \(c\) on route \(r\).

Alternatively, we can obtain the average freight rates of transport services by calculating the sum of sub-services instead of the above approach. The formula is:

$$
\bar{P}_{c} = \frac{\sum_{s=1}^{S} \sum_{z}^{E_{cs}} \sum_{c}^{Z_{cs}} (P_{ecs}^{r} \times L_{ecs}^{r})}{\sum_{s=1}^{S} \sum_{z}^{E_{cs}} \sum_{c}^{Z_{cs}} L_{ecs}^{r}}
$$

(2)

(1) With the consideration of differences caused by container or vehicle types

In Eq. (1), 1) for \(c = 1\), \(\bar{P}_{c1}\) is the average freight rates of container for a container type on transport route \(r\), \(s\) is equal to 1-\(U\). 2) for \(c = 2\), \(\bar{P}_{c2}\) is the average freight rates of truck-load for a certain vehicle type on transport route \(r\),
s is equal to 1-\(V\). 3) for \(c = 3\), \(\overline{P}_{esr}^{L}\) is the average freight rates of liquid hazmat for a vehicle type on transport route \(r\), \(s\) is equal to 1-\(W\).

(2) With no consideration among different container or vehicle types

In Eq. (2), for \(c = 1, 2,\) and 3, \(\overline{P}_{cs}^{r}\) are respectively the average freight rates of container, truck-load, and liquid hazmat on transport route \(r\).

3.2. Models for different sub-regions

(1) The average freight rates of each service for each route in various sub-regions

For the routes whose origins is Ningbo, the formula of average freight rates with considering the distinctions among different transport services and different sub-services is written as:

\[
\overline{P}_{esr}^{zr} = \frac{\sum_{e} E_{esr} (P_{escs}^{zr} \times L_{ecs}^{zr})}{\sum_{e} L_{ecs}^{zr}}
\]  

(3)

Where \(r \in R^z\), \(R^z\) is the sum of transport routes for each sub-region in Ningbo. Also, we can obtain the average freight rates of transport services for sub-regions by calculating the sum of sub-services, the formula is:

\[
\overline{P}_{cs}^{zr} = \frac{\sum_{s} \sum_{e} E_{ecs}^{zr} (P_{escs}^{zr} \times L_{ecs}^{zr})}{\sum_{s} \sum_{e} L_{ecs}^{zr}}
\]  

(4)

(2) The average freight rates of each transport service for each sub-region

For the sub-regions in Ningbo, the formula of average freight rates with considering the distinctions among different transport services is written as:

\[
\overline{P}_{c}^{zr} = \frac{\sum_{s=1}^{S_z} \sum_{r=1}^{R_z} \sum_{e=1}^{E_z} (P_{escs}^{zr} \times L_{ecs}^{zr})}{\sum_{s=1}^{S_z} \sum_{r=1}^{R_z} \sum_{e=1}^{E_z} L_{ecs}^{zr}}
\]  

(5)

where \(E_{esr}^{zr}\), \(R_{esr}^{zr}\), and \(S_z^{zr}\) are respectively the number of enterprises, the number of effective routes for each enterprise, and the number of the sub-service groupings for transport service \(c\) in sub-region \(z\).

In Eq. (5), for \(c = 1, 2,\) and 3, \(\overline{P}_{c}^{zr}\) are respectively the average freight rates of container, truck-load, and liquid hazmat for sub-region \(z\).

3.3. Models for different services
For the routes whose origin is Ningbo, the formula of average freight rates with considering the distinctions among different transport services is given as:

$$\bar{P}_c = \frac{\sum_{x=1}^{X} \sum_{c=1}^{C} \sum_{z=1}^{Z} (P_{c,z,x}^x \times L_{c,z,x}^x)}{\sum_{c=1}^{C} \sum_{x=1}^{X} \sum_{z=1}^{Z} L_{c,z,x}^x}$$

(6)

In Eq. (6), for $c = 1$, 2, and 3, $\bar{P}_c$ are respectively the average freight rates of container, truck-load, and liquid hazmat in Ningbo.

3.4. Models for special areas

For special area whose origins are Ningbo, the formula of average freight rates with considering the distinction between transport services is written as:

$$\bar{P}^x_c = \frac{\sum_{x=1}^{X} \sum_{c=1}^{C} \sum_{z=1}^{Z} (P_{c,z,x}^x \times L_{c,z,x}^x)}{\sum_{c=1}^{C} \sum_{x=1}^{X} \sum_{z=1}^{Z} L_{c,z,x}^x}$$

(7)

where $R_{c,x}^x$ is the number of routes that depart from Ningbo and finally arrive in area $x$ for transport service $c$.

In Eq. (7), for $c = 1$, 2, and 3, $\bar{P}^x_c$ are respectively the average freight rates of container, truck-load, and liquid hazmat that depart from Ningbo and finally arrive in area $x$.

3.5. Models for all transport services

For all routes and transport services whose origins is Ningbo, the formula of average freight rates is written as:

$$\bar{P} = \frac{\sum_{c=1}^{C} \sum_{x=1}^{X} \sum_{z=1}^{Z} \sum_{c=1}^{C} (P_{c,z,x}^x \times L_{c,z,x}^x)}{\sum_{c=1}^{C} \sum_{x=1}^{X} \sum_{z=1}^{Z} L_{c,z,x}^x}$$

(8)

4. Empirical Analysis on Road Freight Index for Ningbo

Price index can be divided as fixed-base index, chain price index and year-base price index in statistics (Zeng, 2006). Taking the fixed-base index as an example, the road freight index is tested, and analyzed for Ningbo in the following passages.

The road freight index scheme compilation for Ningbo started in April 2012, and the basic data collection started in May 2012. We set the base-period as November 2012, considering the stability of the basic data collection methods, sample enterprises size, and other factors during the study period.

4.1. Comprehensive and various services freight fixed-base index for Ningbo

The relationship between comprehensive freight fixed-base index and various services freight fixed-base index for Ningbo from November 2012 to June 2013 is shown in Fig. 2.
As shown in Fig. 2, the value of curve fluctuate smoothly (±10), around 1000. The value for truck-load varies from high to low, while the liquid hazardous materials curve has an opposite trend. By contrast, the freight fixed-base index of container is relatively stable, and consistent with the trend of comprehensive freight fixed-base index. Thus, the price trend of various transport services differs significantly in Ningbo road transport market, especially for truck-load, and liquid hazmat. Based on these, relevant departments should pay more attention to the phenomenon mentioned above.

![Fig. 2. Comprehensive and various services freight fixed-base index](image)

4.2. Freight fixed-base index of various services and sub-services for Ningbo

Apart from the freight fixed-base indices of containers, truck-load, and liquid hazmat, the sub-services freight fixed-base indices of them during the period of November 2012 to June 2013 are shown respectively in the following figures as well.

(1) As shown in Fig. 3, there is little difference for three curves in the specific time history, which indicates that the variation of the freight rates for container is stable relatively.

(2) In Fig. 4, the curve for vehicle of 8-11 meters fluctuates more intensely than others that have a similar trend, the value of this curve is lower than others. Therefore, we can find that the freight rates of small type vehicle is more fluctuant than the rates of any other types in truck-load transport market.

![Fig. 3. Freight fixed-base index of container and its sub-service](image)

![Fig. 4. Freight fixed-base index of truck-load and its sub-service](image)
(3) Except for the curve for liquid hazmat, the other three curves all experience an intense fluctuation in Fig. 5. Among the four, the freight fixed-base index for vehicle of 20-30 tons is the highest, the freight fixed-base index for vehicle of 10-20 tons is lowest and keeps a rising trend, and the freight fixed-base index for vehicle of over 30 tons is relatively low and has an intense fluctuation.

4.3. Freight fixed-base index of various services and major routes for Ningbo

During the period of November 2012 to June 2013, the freight fixed-base indices of containers, truck-load, and liquid hazmat are shown in the following figures, as well as indices of the main routes for the transport services.

(1) As shown in Fig. 6, the curve of the route of Ningbo-Shanghai is significantly lower and more fluctuant than the other three routes that have a similar trend in the time history.

(2) In Fig. 7, the curve of the route of Ningbo-Hangzhou is significantly higher and keeps a rising trend. With an intense fluctuation, the freight fixed-base index of Ningbo-Ningbo and Ningbo-Shanghai is equal or relatively high. The freight fixed-base index of truck-load is lower than that of other three main routes, owing to other routes not-mentioned are mainly low.
(3) As can be seen from Fig. 8, the freight fixed-base index of the route of Ningbo-Cixi is significantly higher than others, while the value of the route of Ningbo-Shaoxing remains a low level, and the curve of the route of Ningbo-Ningbo is accompanied by an intense fluctuation.

Based on the analysis of the freight fixed-base index, we can see that container transport remains domination in Ningbo road transport market, and the role of hazmat transport should not be ignored, while the status of truck-load transport is weak comparatively. The conclusion is consistent with the actual situations of Ningbo road transport market, which further confirms the rationality of the freight index system and mathematics models that the paper designed.

5. Conclusions

According to the demand of promoting supply-demand trading efficiency, preventing vicious price competition, and improving industry regulatory decision-making information foundation, an effective feasible road freight index system for Ningbo was designed. Mathematical models of average freight indicator were formulated in the study and proved to be scientific, reliable, and applicable in calculating the road freight index for Ningbo through empirical analysis of fixed-base index.

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References


