Algorithms Comparison and Empirical Analysis of Ningbo Road Container Transport Freight Index

Nan-xi Zhao [1,a], *Rong-na Xiao [1,b], Lin Yang[2], Xin-zi Wang[1], Da-Chun Ding[1]

[a] nx.zhao@rioh.cn

[b *] Corresponding author: rn.xiao@rioh.cn

[1]Research Institute of Highway Ministry of Transport, Beijing, China

[2]Research Center of Ningbo Transportation Development, Ningbo, China

Nan-xi Zhao and Rong-na Xiao contributed equally to this paper

Abstract— Aiming at the problems existing in the Ningbo Road Container Transport Freight Index, targeted improvement methods are proposed from the aspects of calculation methods, weight settings, etc. In terms of index calculation method: the original simple synthesis method has been changed to the internationally accepted Laspeyres chain index calculation method. In terms of weight setting, the subcategory index adopts turnover as the weight, and the comprehensive index adopts the equal weight method of two category indices. Finally, the correlation coefficient method is used to analyze the correlation between the Ningbo Container Transport Price Comprehensive Index and the road container market, as well as macroeconomic situation in Ningbo.

Keywords- Transportation economy, Freight index, Laspeyres chain index, Road freight, Container transport

1. INTRODUCTION

Road transportation is a fundamental and service-oriented industry for national economic and social development, playing an important role in the construction of a comprehensive transportation system. According to data from 2021, road transportation accounts for 75% of the total cargo volume [1], which makes it become one of the important transportation methods to meet social logistics needs. Ningbo is an important hub in the global supply chain, a major comprehensive logistics center in China, and an important port for coastal import and export containers. In 2022, Ningbo Port completed a container throughput of 30.78 million TEUs and a cargo throughput of 637.22 million tons, second only to Shanghai Port.

Road transportation is the main mode of cargo transportation in Ningbo. Compared with other modes of transportation, it has a high degree of marketization and is mainly dominated by small and medium-sized enterprises. This means that road transportation enterprises have weak

ICIDC 2023, June 02-04, Nanchang, People's Republic of China

DOI 10.4108/eai.2-6-2023.2334664

discourse power, lack the ability to sign long-term fixed contract prices and negotiate with cargo owners. Meanwhile, transportation price information is not transparent, and the supply of road transportation far exceeds demand, resulting in a vicious competition in prices. Therefore, to promote the healthy and stable development of the road freight market in Ningbo, starting from 2013, Ningbo has carried out road freight index analysis and dynamic monitoring of the transportation and logistics industry. By establishing the Ningbo Road Freight Transport Price Index (see **Figure 1.**) and Prosperity Index System, regularly publish information such as the Ningbo Road Freight Transport Price Comprehensive Index, Container Transport Price Comprehensive Index, General Cargo Vehicle Transport Price Comprehensive Index, and Liquid Dangerous Chemicals Transport Price Comprehensive Index. to provide data support for macro decision-making of transportation enterprises and industry management departments [2].

From recent monitoring work, it has also been found that there are some problems with the weight setting, algorithm rationality, and collection frequency of the highway freight transportation price index in Ningbo City. Based on this, this paper mainly conducts in-depth research on the compilation method of the Ningbo Highway Container Transport Price Index, using more suitable index calculation methods to consummate the container transport price index, thereby improving the predictive ability of container transport prices, and more comprehensively reflecting the changing trends of Ningbo Highway Container Transport.

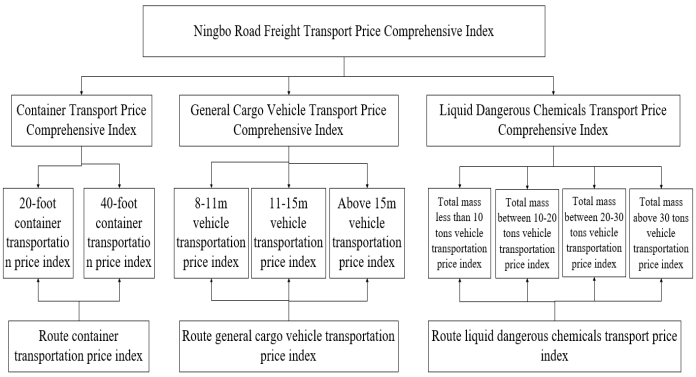

Figure 1. Ningbo Road Freight Transport Price Index

2. OVERVIEW OF THE CURRENT NINGBO ROAD CONTAINER TRANSPORT FREIGHT INDEX

2.1 Data collection plan

According to 2021 data, there are a total of 2163 container transportation enterprises in Ningbo, accounting for 56.7% of the total number of container transportation enterprises in Zhejiang Province. At present, container transportation at Ningbo Port is mainly carried out by road, accounting for 43%. The road container freight volume is mainly in Beilun port, accounting for 63%, followed by Yinzhou District, accounting for 18.7%.

Therefore, the current data source of Ningbo Road Container Transport Freight Index mainly relies on 64 sample container enterprises, with a total of 238 sample lines (including 123 20-foot container sample lines and 115 40-foot sample lines). The starting point of sample lines are mainly focused on the road transportation line of Ningbo Port container collection and distribution port, divided into Ningbo Beilun district and Ningbo five districts (which including Haishu districts, Jiangdong districts, Jiangbei districts, Zhenhai districts and Yinzhou districts), and the endpoint of sample lines are within Zhejiang Province and Shanghai City [3]. The specific content of the data survey is shown in **Table 1.** The frequency of data collection is once a month for investigation.

Table 1. Main collection indicators for container transportation prices

category	collection indicators
20-foot container	Starting point of sample line
	End point of sample line
	Average freight rate for this period (unit: yuan/container)
40-foot container	Starting point of sample line
	End point of sample line
	Average freight rate for this period (unit: yuan/container)

2.2 Calculation method of transportation price index

2.2.1 Calculation method for Ningbo average container transport price.

The average containers transportation price in Ningbo is weighted by the route transportation distance and calculated based on the enterprise transportation prices of all sample routes under each subcategory. The calculation formula sees (1).

$$\overline{P_c} = \frac{\sum_{s=1}^{S}\sum_{r=1}^{Rs}\sum_{e=1}^{E_s^r}\left(P_{es}^r \times L_{es}^r\right)}{\sum_{s=1}^{S}\sum_{r=1}^{Rs}\sum_{e=1}^{E_s^r} L_{es}^r} \tag{1}$$

Equation (1): $\overline{P_c}$ is Ningbo average container transportation price; E_s^r is number of enterprises in subcategory S. R_s is total transportation routes for subcategory S. S represents the subcategory of Ningbo container transportation, including 20-foot containers and 40-foot containers. P_{es}^r represents the container transportation price of enterprise E in the R sample line under subcategory S. L_{es}^r represents the transportation distance of the R sample line under the subcategory S.

2.2.2 Calculation method for Ningbo average container transport price.

Fixed base index. Based on a fixed period, calculate the index for subsequent periods. The base period of the price index is December 2011, with a base period value of 1000. The calculation formula sees (2).

$$I = \frac{\overline{P_{cn}}}{\overline{P_{co}}} \times I_0 \tag{2}$$

Equation (2): $\overline{P_{cn}}$ is average container transportation price during the reporting period. $\overline{P_{co}}$ is average container transportation price during the base period. I_0 is the base point, with a value of 1000.

2.3 Existing probles

From the actual index operation, the following issues can be seen. Firstly, the container transportation price index algorithm adopts a simple synthesis method, which compares the synthesis of product prices during the reporting period with the synthesis of product prices during the base period. This method may have an implicit weighting phenomenon. Secondly, the considerations for setting weights are incomplete. At present, when calculating the average container freight rate, the weight is based on the transportation distance. However, transportation prices are not only affected by transportation distance, but also by freight volume. In general, the longer the transportation distance, the more freight volume, and the lower the unit freight rate. Therefore, considering the distance is incomplete. Thirdly, the data collection time is relatively short. At present, the collection time for freight rates is from the 15th to the 20th of each month, with an average price of 5 days collected, and the time coverage is relatively short.

3. IMPROVEMENT OF THE NINGBO ROAD CONTAINER TRANSPORT FREIGHT INDEX ALGORITHM

3.1 Common calculation methods for price index

The calculation methods of price index can be roughly divided into three categories: simple index method, weighted comprehensive index method, and weighted average index [4]. The weighted composite index method includes commonly used Laspeyres index, Paasche index, Fisher index, etc. Each index has its own advantages and disadvantages. The International Organization for Economic Cooperation and Development (OECD) recommends the use of the Laspeyres chain index in the compilation of price indices (such as CPI, PPI, etc.), and in practice, in most cases, the chain index shows very reliable results [5]-[6]. The Laspeyres chain index mainly considers revising the relative weights of different types in the entire historical series. In the case of annual linkage, this index can reduce the uncertainty caused by the assumption of a stable relationship between operating income. In addition, each year automatically becomes a link year, so there is no need to make subjective choices [7].

Therefore, this paper focuses on the algorithmic issues of the container freight index in Ningbo, and use the internationally recognized Laspeyres chain index calculation method to recalculate the Ningbo road container transport freight Index with the weight of transportation enterprise turnover.

3.2 Improvement of Price Index Method

The data processing and index compilation are as follows:

Step 1. Calculate the average price of a sample line during the reporting period. The calculation formula see (3).

$$\overline{P_{t,s}^{r}} = \frac{\sum\left(P_{t,e,s}^{r} \times A_{t,e,s}^{r}\right)}{\sum\left(L_{t,e,s}^{r} \times A_{t,e,s}^{r}\right)} \tag{3}$$

Equation (3): $\overline{P_{t,s}^{r}}$ is average container transportation price of R sample line in subcategory S at the T period. $P_{t,e,s}^{r}$ is the container transportation price of enterprise E in the R sample line under subcategory S at T period. $A_{t,e,s}^{r}$ is the turnover of enterprise E in the R sample line under subcategory S at T period. $L_{t,e,s}^{r}$ is the transportation distance of the R sample line under the subcategory S.

Step 2. Calculate the average price month on month of a sample line during the reporting period. The calculation formula see (4).

$$G_{t,s}^{r} = \frac{\overline{P_{t,s}^{r}}}{\overline{P_{t-1,s}^{r}}} \tag{4}$$

Equation (4): $G_{t,s}^{r}$ is the relative month on month ratio between the average container price during the reporting period and the average container price of the previous period.

Step 3. The month on month price index of operator business categories.

According to the monthly month on month price index of all sample lines in all transport enterprises under the subcategory, the geometric mean method is used to calculate. The calculation formula see (5).

$$K_{t,s} = \sqrt[n]{\prod_{r=1}^{n} G_{t,s}^{r}} \tag{5}$$

Equation (5): $K_{t,s}$ is month on month price index for subcategory S.

Step 4. Calculate subcategory base index. The calculation formula see (6).

$$I_{t:s} = I_{t-1:s} \times K_{t,s} \tag{6}$$

Equation (6): $I_{t-1,s}$ is base index of S subcategory in the previous period of the reporting period.

Step 5. Calculate the Ningbo container freight comprehensive index. The calculation formula see (7).

$$I_t = I_{t-1} \times W_0 \tag{7}$$

Equation (7): $I_{t-1,s}$ is the weight of subcategories at the base period. At present, the sub business categories include 20-foot containers and 40-foot containers, calculated based on equal weight.

3.3 Analysis of trial results

According to the new method of Ningbo road container transport freight index, calculate the 20-foot Container Freight Index, 40-foot Container Freight Index, and Container Transport Price Comprehensive Index for each month from January 2020 to December 2022. The results are shown in **Figure 2.**

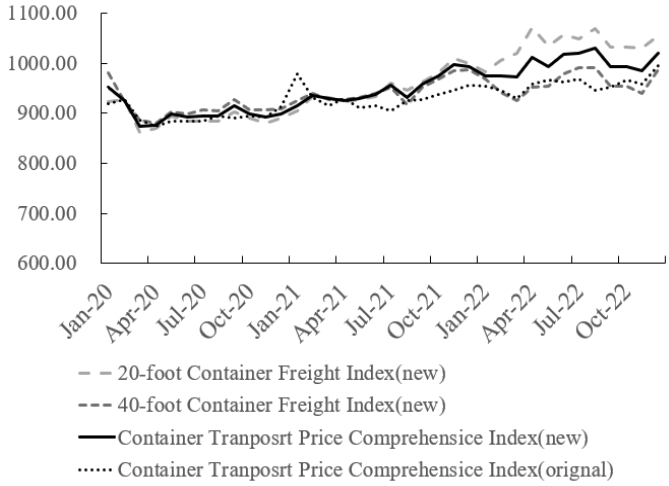

Figure. 2. Ningbo Road Container Transport Freight Index (New Method)

Overall, the Ningbo Container Freight Index is relatively stable, showing an upward trend year by year. At the beginning of 2020, affected by the COVID-19, exports were blocked, and domestic export trade orders were delayed or even cancelled repeatedly. The insufficient demand for import and export trade has led to a slow recovery of container transportation demand in Ningbo, with the freight index showing a downward trend from January to March and stabilizing and rebounding in April. At the end of 2020, the foreign trade market gradually recovered, and the volume and value of container exports steadily increased. The growth continued until the end of 2021, and Ningbo Container Freight Index also showed a fluctuating growth trend. In the second quarter of 2022, affected by the COVID-19 in Shanghai, the demand for container freight overflowed. The container throughput of Ningbo

port exceeded 3 million TEUs for three consecutive months, and the strong demand for container truck transportation drove up freight rates. In the third quarter of 2022, due to insufficient trade demand from major exporting countries such as Europe and the Americas, coupled with the gradual return of overflow demand from Shanghai Port, container transportation demand significantly decreased, and the container freight index showed a decline. In December 2022, due to the gradual relaxation of epidemic control and the continuous recovery of foreign trade demand, the container freight index showed a slight increase.

Stationarity Test. In general, time series are assumed to be stationary, but due to the inertia of the economic system, most economic time series are non-stationary. If non-stationary time series are directly used for analysis and research, the model may have pseudo regression problems [8]. This paper uses the Augmented Dickey-Fuller test (ADF) method to test the data stationarity of the index. The results show that: The Ningbo 20-foot Container Freight Index (new method) shows significance at a 90% confidence level when the difference is of rhe 2nd order, with p=0.0882<0.1, rejecting the original assumption that the series is a stationary time series. The Ningbo 40-foot Container Freight Index (new method) shows significance at a 99% confidence level when the difference is of the first order, p=0.0024<0,01, rejecting the original assumption that the series is a stationary time series. The Ningbo Container Transport Price Comprehensive Index (new method) shows significance at a 99% confidence level with a difference of the first order, p=0.000<0.01, rejecting the original hypothesis that the series is a stationary time series (see **Table 2.**).

Table 2. ADF Inspection Form

	Difference	**t-Statistic**	**Prob.**	**Test critical values**		
				1%	**5%**	**10%**
20-foot Container Freight Index (new method)	0	-0.4004	0.8965	-3.6793	-2.9678	-2.6229
	1	-2.6880	0.0882	-3.6793	-2.9678	-2.6229
	2	-6.4575	0.0000	-3.6702	-2.9639	-2.6210
40-foot Container Freight Index (new method)	0	-2.1683	0.2208	-3.6329	-2.9484	-2.6129
	1	-4.2312	0.0024	-3.6617	-2.9604	-2.6191
	2	-8.8021	0.0000	-3.6463	-2.9540	-2.6158
Container Transport Price Comprehensive Index (new method)	0	-0.4458	0.8891	-3.6537	-2.9571	-2.6174
	1	-6.2470	0.0000	-3.6537	-2.9571	-2.6174
	2	-3.0853	0.0413	-3.7378	-2.9919	-2.6355

4. METHOD COMPARISON OF NINGBO ROAD CONTAINER TRANSPORT FREIGHT INDEX

4.1 Descriptive analysis

Descriptive analysis usually provides statistical descriptions from the perspectives of mean, median, maximum, minimum, standard deviation, kurtosis, skewness, and sample size. The standard deviation can determine the degree of dispersion of the data, and combined with the characteristics of the data, it can reflect the volatility of the freight index. Skewness and kurtosis can reflect the distribution of data [9]. From the descriptive analysis results (see Table 3.), the Ningbo Container Transport Price Comprehensive Index (new method) has a larger standard deviation than the index (original method), indicating stronger volatility of the index (new method). However, the skewness of both indexes is greater than 0, indicating a right skewed distribution. At the same time, the kurtosis deviates from 3 to a large extent, which cannot be regarded as normal distribution. Therefore, it is recommended to use the Spearman correlation coefficient method in correlation analysis.

Table 3. Descriptive analysis results

	Container Transport Price Comprehensive Index (new method)	**Container Transport Price Comprehensive Index (original method)**
Mean	949.414	928.472
Median	944.544	31.408
Maximum	1029.988	995.34
Minimum	873.897	873.78
Std. Dev.	46.422	31.408
Skewness	-1.24	-0.909
Kurtosis	0.083	0.055
CV	0.049	0.034
Observations	36	36

4.2 Descriptive analysis

To further verify the relationship between the Ningbo Container Transport Price Comprehensive Index, the actual average freight rate of Ningbo containers and the macroeconomic situation [10]-[11], this paper selects several indicators for analysis and research. Using the Spearman correlation coefficient method, calculate the degree of correlation between the Ningbo Container Transport Price Comprehensive Index (new method) and the Container Transport Price Comprehensive Index (original method) with the selected indicators.

The results (see **Table 4.**) show that the Ningbo Container Transport Price Comprehensive Index (new method) has a high correlation with the average container freight rate, with a correlation coefficient of over 0.9, meanwhile, the correlation coefficient with the Ningbo's industrial sales value above designated size and the import and export amount index of Ningbo can also reach a correlation coefficient of over 0.7, indicating that the index can also reflect the macroeconomic fluctuations of Ningbo. The correlation of the Ningbo Container Transport Price Comprehensive Index (new method) is higher than that of the Ningbo Container

Transport Price Comprehensive Index by the original method, indicating that the index calculated using the new method can better reflect the trend of actual freight rates.

Table 4. Spearman correlation coefficient results

	Container Transport Price Comprehensive Index (new method)	**Container Transport Price Comprehensive Index (original method)**
Container Transport Price Comprehensive Index (new method)	1	0.848
Container Transport Price Comprehensive Index (original method)	0.848	1
Ningbo's average price of container transportation	0.908	0.787
Ningbo's industrial sales value above designated size	0.761	0.657
Ningbo's import and export amount	0.719	0.636

5. CONCLUSION

Regarding the issue of Ningbo Road Container Transport Freight Index, the Container Transport Price Comprehensive Index recalculated using the Laspeyres chain index method. has a higher correlation with the Ningbo's road container transport market and macroeconomic activities. The specific conclusions include the following:

In terms of index calculation methods. At present, the container transportation price index algorithm adopts a simple synthesis method, which has a certain implicit weighting phenomenon. Usually, when compiling price indices (CPI, PPI, etc.) internationally, the Laspeyres chain index method is used. In most cases, the index results are relatively reliable. The Ningbo Container Transport Price Comprehensive Index, which was recalculated using the Laspeyres chain index method in this paper, also passed the ADF stationarity test. From the monthly index from 2020 to 2022, it shows that the fluctuation is more consistent with the original index and better reflects the situation of the highway container market.

In terms of index weight setting. The original index used transportation distance as the weight, and the weight considerations were not comprehensive enough. This paper uses turnover as a weight in calculating the category index, considering transportation volume and market conditions. The comprehensive index adopts the method of equal weights for two category indices, namely the 20-foot Container Freight Index and the 40-foot Container Freight Index, which can better reflect the impact of category indices on the comprehensive index.

In terms of index economy. By using the Spearman correlation coefficient method to analyze the correlation between the Ningbo Container Transport Price Comprehensive Index (new method) and the Ningbo Container Transport Price Comprehensive Index (original method) with road container freight price and macroeconomic indicators, it can be seen that the correlation coefficient between the Ningbo Container Transport Price Comprehensive Index

(new method) and the average container freight price is above 0.9, meanwhile, the correlation coefficient with the industrial added value index above designated size and the import and export amount index of Ningbo is above 0.7. This indicates that the Ningbo Container Transport Price Comprehensive Index (new method) can better reflect the actual fluctuations in the highway container market.

ACKNOWLEDGMENT： This paper is a part of a research results. I will express my deep gratitude to my group members.

REFERENCES

[1] MOT. (2022) Statistical Bulletin on the Development of the Transportation Industry in 2021. https://xxgk.mot.gov.cn/2020/jigou/zhghs/202205/t20220524_3656659.html.

[2] LIU, B., JIANG,G., CHEN, J., CHEN, L., HU H.Z., (2015) Research: Road Freight Index for Ningbo. Journal of Ningbo University (NESS), 127-131.

[3] LIU, Y.X., (2018) Study on Fluctuation and Relevance of Freight Tranposty Price Index in Ningbo Shippping Market and Highway Freight Market. Chang'an University.

[4] ZHU, K.J., (2017) Laspeyres Method Based Road Freight Price Index Model and Its Application[D]. Beijing JiaoTong University.

[5] IMF, ILO, Eurostat, OECD, UNECE, (2020) The World Bank. Consumer Price Index Manual: Concepts and Method, International Monetary Fund, Washington, D.C.

[6] XU, X.C., JING, Q.Y. (2023) Updates of International CPI Manual and Its Implications for China's CPI Compilation. Journal of Statistical Research. 40.02(2023):16-28. doi:10.19343/j.cnki.11-1302/c.2023.02.002.

[7] SUN,L. (2021) Compilation and Empirical Research of China's Service Industry Production Index. Zhongnan University of Economics and Law.

[8] LUO, Y. (2020) Study on Compiling Method and Application of Railway Freight Price Index. China Academy of Rail Way Sciences.

[9] Wang, Y.F.. (2021) Research on the Influencing Factors Analysis and Forecast on the Yangtze River Containerized Freight Index. Nanjing Audit University.

[10] ZHAO, N.X., XIAO, R.N., SU, S., (2020) Analysis on Influencing Factors of Highway Freight Transport Pricing Based on Grey Correlation Method. Journal of Highway and Transportation Research and Decelopment, 37(S1):80-85.

[11] XIAO, R.N., ZHAO, N.X., SU, S., WANG, X.Z., (2020) Study on Correlation between Road Freight Activities and National Economy. Journal of Highway and Transportation Research and Decelopment, 37(S1): 70-74+109.