Port Energy Level-Evaluation Research on the Coordinated Development of Hinterland Economy-Taking Chongqing Port as an Example

Qiwei Deng¹a, Haihong Yu²b*

¹ Maritime Academy of Ningbo University, Ningbo, Zhejiang, China
² Maritime Academy of Ningbo University, Ningbo, Zhejiang, China

a18328583271@163.com
b*yuhaihong@nbu.edu.cn

Abstract: With economic development, ports assume more responsibilities. However, the level of coordination between ports and hinterlands in my country's inland river ports needs to be improved. By constructing a comprehensive evaluation system of port energy level-hinterland economic system, entropy method and coupling coordination Degree model for coordination analysis. The article takes Chongqing Port as an example to study the characteristics of coordinated development between port energy level and hinterland economy from 2010 to 2019. The results found that: 1) The coordination evaluation model effectively reflects the development status of Chongqing Port in the past 10 years; 2) With the increase of time, the port energy level and hinterland economic level of Chongqing Port are in a relatively stable state of improvement; 3) Port energy The degree of coordinated development between the economic system of the Hinterland and the hinterland shows a steady upward trend overall, but there is still room for improvement.

1. Introduction

As an important strategic resource, ports are the key to enhancing regional competitiveness and overall national strength. The development level of the port city is an important factor for the sustainable development and competitiveness of the port city. The "port-hinterland" area is a special economic regional system with inherent inevitable connections. The development of the port and its hinterland regional economy has obvious interaction.

Establish an evaluation index system to study the changes in the port energy level of Chongqing Port in recent years, the economic development status of Chongqing City in the immediate hinterland of Chongqing Port, and the coordinated development relationship between the two, so as to better understand the inland river in the development of cities along the river. The interaction mechanism between the port and the economic development of its hinterland requires an efficient way to achieve the rapid economic development of the hinterland in the process of upgrading the energy level of the port.

Next, this article mainly elaborates from four parts: related research status, indicator system establishment and research method introduction, Chongqing Port empirical analysis and conclusions.
2. Current status of related research
Domestic and foreign related research on ports and hinterland is mainly in three aspects: the influence of ports on the economic development of hinterland, the influence of hinterland economy on ports, and the interactive development of port economy and hinterland economy.

Regarding the research on the interactive development of port economy and hinterland economy, scholars such as Rimmer and Hoyle\[2,3\] proposed a dynamic model of port spatial structure evolution, a five-stage evolution model of ports and hinterland; as well as methods of qualitative analysis. Domestic scholars conduct quantitative research through models, including input-output models, multiplier models, gray correlation methods, linear regression models, and Panel Data models\[4-6\].

To sum up, the research on the economic relationship between ports and hinterland mainly focuses on the world's major seaports, and the research methods are different. Therefore, this article takes Chongqing Port as the research object, analyzes the characteristics of the coordinated development of port energy level and hinterland economic development through coupling theory, in order to provide reference for the coordinated development of the same type of inland river ports.

3. Index system and research methods

3.1. Index selection
The establishment of the evaluation index system must follow the principles of scientific, systematic, and operability. The port energy level evaluation system selects 4 evaluation indicators. The hinterland economic development level evaluation system selects 9 evaluation indicators; as shown in Table 1.

| Target layer | Criterion layer | Index layer | Unit | Weights |
|--------------|----------------|-------------|------|---------|
| Port Energy Level Subsystem(X) | Port logistics scale | Port-wide cargo throughput(X1) | Ten thousand tons | 0.2463 |
| | | Container throughput(X2) | Ten thousand TEU | 0.2462 |
| | Port infrastructure | Wharf length(X3) | m | 0.2543 |
| | | Number of berths(X4) | general classifier | 0.2532 |
| | Hinterland economy | GDP(Y1) | Billion | 0.1108 |
| | | Total social production and retail sales(Y2) | Billion | 0.1114 |
| | | Total import and export trade(Y3) | Ten thousand dollars | 0.1097 |
| Hinterland Economic Subsystem(Y) | Hinterland economic structure | Industrial output value as a proportion of GDP(Y4) | percentage | 0.1106 |
| | | The output value of the tertiary industry as a proportion of GDP(Y5) | percentage | 0.1153 |
| | | Fixed asset investment as a proportion of GDP(Y6) | percentage | 0.1100 |
| | The economic quality of the hinterland | Resident disposable income(Y7) | yuan | 0.1109 |
| | | GDP per capita(Y8) | yuan | 0.1108 |
| | | Social productivity(Y9) | percentage | 0.1106 |

3.2. Research method

3.2.1. Entropy method
Entropy method has the advantage of objectivity and is widely used in various research fields.
Figure 1 Data processing process of entropy method

In the formula: “m” is the number of evaluation years; “n” represents the number of indices; “k” represents the adjustment coefficient.

3.2.2. The comprehensive evaluation function
Comprehensive benefit functions of port energy level:

\[ f(X) = \sum_{i=1}^{m} a_i Z_i \]  

Comprehensive benefit functions of the hinterland economy:

\[ g(Y) = \sum_{j=1}^{n} b_j Z_j \]  

Where: \( a_i \) represents the weight of the i-th index in the port energy level evaluation system; \( Z_i \) represents the proportion of the standard value of the i-th index in the port energy level evaluation system, \( m=4 \); \( b_j \) represents The weight of the j-th index in the hinterland economic evaluation system, \( Z_j \) represents the proportion of the standard value of the j-th index in the hinterland economic evaluation system, \( n=9 \).

3.2.3. Coupling coordination degree model
Degree of coupling:

\[ C = \left( \frac{f(X)g(Y)}{f(X)g(Y)+r(X)g(Y)} \right)^n \]  

Coupling and coordination:

\[ D = \sqrt{C \times T} \]  

\[ T = \alpha \times f(X) + \beta \times g(Y) \]  

In the formula: \( C \) represents the degree of coordination (0≤C≤1). The higher \( C \) value indicates that the higher the degree of coordination between systems, the worse it is, n=0.5. \( D \) is the degree of coordinated development; \( T \) is the comprehensive evaluation index of the two systems; “\( \alpha \)”is the weight of the port energy level system, and “\( \beta \)” is the weight of the hinterland economic system, “\( \alpha \)”= “\( \beta \)”=0.5.

4. Empirical analysis of Chongqing Port
Through the previous in-depth study of port energy levels and hinterland economy, the constructed coupling coordination degree evaluation model is used to analyze actual cases of Chongqing Port to verify the feasibility and accuracy of the evaluation model.

4.1. Analysis of comprehensive evaluation results of port energy level of Chongqing Port
The single index evaluation score for each year and the comprehensive evaluation value of port energy level can be obtained according to the standardized value. As shown in Figure 2.
It can be seen from the port energy level evaluation trend chart of Chongqing Port during the ten-year period that the port-wide cargo throughput, container throughput, terminal length and number of berths and other index values and comprehensive evaluation values have increased significantly. In a relatively stable growth state, Chongqing Port has also changed from a low port energy level to a high port energy level. Through the analysis of the previous ten years, it can be predicted that Chongqing Port will still maintain sufficient vitality in the next ten years.

4.2. Analysis of the comprehensive economic evaluation results of the hinterland of Chongqing Port
The single index evaluation score of each year can be obtained according to the standardized value, and the comprehensive evaluation value \( g(Y) \) of the economic development level of the hinterland. As shown in Figure 3.

It can be seen from the trend of the indicator values and comprehensive scores of the economic evaluation of the hinterland in the past ten years, including the regional GDP, the total retail sales of consumer goods, the total import and export trade, the proportion of tertiary industry output in GDP, the disposable income of residents, and the per capita The gross regional product, the labor productivity of the whole society, and the comprehensive evaluation value of the hinterland economy have generally shown a relatively stable growth. The two indicators of industrial output value in GDP and fixed asset investment in GDP have shown a downward trend after 2014.

4.3. Analysis of the results of the coordinated development of port energy level and hinterland economy
From the analysis of the coupling degree (Figure 4), the coupling degree between the port energy level
of Chongqing Port and the hinterland economic system was at a relatively high level during the ten years from 2010 to 2019, indicating that the port energy level of Chongqing Port has a relatively high degree of interaction with the hinterland economic system in the past 10 years and is relatively stable.

![Figure 4 The economic evaluation trend of the hinterland of Chongqing Port from 2010 to 2019](image)

From the analysis of coupling coordination degree, the coupling coordination index of port energy level and hinterland economic system increased from 0.155 in 2010 to 0.759 in 2019, realizing the upgrade from low coordinated development to highly coordinated development. And the lagging development of the hinterland economy has become the main feature of the coupling and coordinated development of the port energy level and hinterland economic system of Chongqing Port in recent years. It can be seen from the port energy level, the economic development trend of the hinterland and the growth rate of the coupling coordination degree that there is still much room for improvement in the coupling and coordination degree of the port energy level of Chongqing Port and the hinterland economy.

5. Research conclusion
(1) Starting from the mutual influence between the two, this paper constructs an economic evaluation index system for the hinterland of Chongqing Port.

   (2) The entropy method is used to calculate the objective weight of each indicator. Through the comprehensive benefit function model of the port energy level system and the hinterland economic system, the results show that the port energy level and hinterland economy of Chongqing Port are at a relatively low level in the initial stage, but as time goes by The overall growth is relatively stable.

   (3) The coupling degree model and the coupling coordination degree model can be used to obtain the coupling degree and coupling coordination degree value between the two systems in Chongqing Port in 10 years. The classification table can be used to classify Chongqing Port in terms of port energy level and hinterland economic development coupling coordination type. The results show that the coordinated development between the port energy level and the hinterland economic system from 2010 to 2019 is generally on a steady upward trend, indicating that the two systems are more closely related to each other, but there is still room for improvement, which requires reasonable government policy guidance and the market actively reflect.

Acknowledgements
This work was supported by the Natural Science Foundation of Zhejiang Province [grant number LGG21G010002].

References
[1] Zhenqiang, L., Qiuyang, Z. (2020) Research on the interactive relationship between port development and hinterland economy. Wuling Academic Journal, 45 (03): 81-88.
[2] Rimmer, PJ. (1967) The search for spatial regularities in the development of Australian seaports. Geografisna Annaler, 49B: 42-54.
[3] Hoyle, B.S., Charlier, J.J. (1995) Inter-port competition in developing countries: an East African cause study. Journal of Transport geography, 2: 87-103.
[4] Yu, L., Peng L. (2005) On several theoretical issues of economic integration between Hong Kong and the hinterland. Economic Geography, 11.

[5] Fei, T. (2008) Research on the Interaction between Dalian Port and Hinterland Economy. Dalian Jiaotong University, Dalian.

[6] Xiaofei, D., Rongcheng, W., Zenglin, H. (2010) Analysis of the evolution of the spatial structure of the port-hinterland system: A case study of the Dalian Port-Liaoning economic hinterland system. Economic Geography, 11: 1761-1766.