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Retraction

Retracted: Evaluation of Coordinated Level between Coastal Ports and Urban Economics Based on DEA and Coordination Degree Model: Case of Jiangsu Province

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Security and Communication Networks has retracted the article titled "Evaluation of Coordinated Level between Coastal Ports and Urban Economics Based on DEA and Coordination Degree Model: Case of Jiangsu Province" [1] due to concerns that the peer review process has been compromised.

Following an investigation conducted by the Hindawi Research Integrity team [2], significant concerns were identified with the peer reviewers assigned to this article; the investigation has concluded that the peer review process was compromised. We therefore can no longer trust the peer review process, and the article is being retracted with the agreement of the Chief Editor.

The authors do not agree to the retraction.

References

[1] X. Zhang, Y. Deng, and C. Li, "Evaluation of Coordinated Level between Coastal Ports and Urban Economics Based on DEA and Coordination Degree Model: Case of Jiangsu Province," *Security and Communication Networks*, vol. 2022, Article ID 3406760, 7 pages, 2022.

[2] L. Ferguson, "Advancing Research Integrity Collaboratively and with Vigour," 2022, https://www.hindawi.com/post/advancing-research-integrity-collaboratively-and-vigour/.

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Research Article

Evaluation of Coordinated Level between Coastal Ports and Urban Economics Based on DEA and Coordination Degree Model: Case of Jiangsu Province

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The coordinated development of coastal ports and urban economy has great significance to realize the high-quality development of marine economy. Under the requirements of high-quality development, this article theoretically analyzes the interactive relationship between port economics and urban economics, then based on the data envelopment analysis (DEA), static coordination degree model, and dynamic coordination degree model, constructs the vertical evaluation index system and evaluation model to evaluate the coordinated development level of port economics and urban economics, and evaluates the actual situation of the three coastal cities of Jiangsu province as an example. The results show that the average effectiveness ranking of the coastal ports to urban economics is the same as that of urban economics to coastal ports, but the degree of impact varies from region to region, and the degree of coordination follows a phenomenon of Lianyungang >Nantong >Yancheng. Finally, the article gives strategic suggestions to promote the high-quality development of the three coastal cities in Jiangsu Province.

1. Introduction

High-quality development is the theme of China's economic and social development in the 14th five year plan and beyond. In 2018, the state proposed that the ocean is an important strategic place for high-quality development, and the coastal economy of Jiangsu Province is an important part of the national marine economy. However, in the coastal economy of Jiangsu Province, neither cargo throughput nor GDP is in the lower middle level among China. There are 10 ports in Jiangsu Province, including 3 coastal ports, which are located in Nantong, Yancheng, and Lianyungang. The three coastal cities are close to each other. In addition, the neighboring ports such as Shanghai port and Qingdao port have a large-scale, complete port infrastructure, efficient port supporting services, low economic cost and time cost, and the competition among ports is fierce, and the output of the coastal ports in Jiangsu Province is obviously insufficient.

Therefore, this article takes Jiangsu Province as an example to evaluate the coordinated development relationship between the coastal ports and urban economy, in order to speed up the high-quality development of coastal areas in Jiangsu Province and to provide theoretical basis and reference for other province.

2. Review of Relevant Research Literature

Scholars have done a lot of research on the relationship between ports and regional economic development, which can be summarized into two aspects: (1) discussion on the relationship between port and regional economy. For example, port and regional economy are in an interactive development relationship; port development depends on regional economy and will also bring regional economic prosperity [1]. They made a qualitative analysis on the problems existing in the industrial economy and in the port development of Nantong, and then put forward the strategy of coordinated development [2]. (2) A multi-index quantitative analysis based on the model was conducted. For example, based on the time series method and the panel data,

Li believed that ports had an obvious positive effect on regional economy by taking Nantong port, Yancheng port, and Lianyungang port as examples, and Lianyungang port is the strongest [3]. Based on the grey correlation model, Si considered that there is a strong correlation between the port infrastructure and the urban economy, and there are obvious differences in the correlation between the different port cities [4]. Jose compared and evaluated the efficiency of the container ports in Australia and other countries based on the DEA method [5]. Based on the DEA method, Lv and Chang quantitatively analyzed the interactive development effectiveness of inland ports and direct hinterland economies such as Beijing in 2010 from four aspects, but failed to quantitatively analyze the coordination degree [6].

At present, the quantitative analysis of the relationship between ports and regional economy is mostly limited to efficiency evaluation by using the grey correlation model, the time series model, the DEA, and other models, and the coordination degree evaluation is few. The coordination degree model is mostly used in the field of transportation. For example, Xiong et al. evaluated the coordinated development of various transportation modes and comprehensive transportation system in China based on the DEA method and the state coordination degree [7]. Ren empirically analyzed the coordinated development of transportation infrastructure investment and economic growth by using the principal component analysis and the coordinated development evaluation model [8].

Therefore, this article comprehensively uses DEA and the coordination degree model to construct the vertical evaluation index system and the evaluation model of the coordinated development of port economy and urban economy. Taking the three coastal cities of Jiangsu Province as an example, this article makes an empirical analysis from two levels: the input-output efficiency between the port and urban economic development, and the degree of coordinated development of the port and the city. This article improves the quantitative analysis of the port city coordinated development to a certain extent, and provides a reference for the evaluation of the coordination level.

3. Theoretical Analysis of Port-City Coordinated Development

3.1. Coordinated Development Mechanism of Port and Urban Economy. On the one hand, the development of port drives the development of urban economy [1]. With the enhancement of port function, it will also form the demand for other industries and service industries, such as urban logistics, transportation, and finance, which will lead to the optimization of the industrial structure, technological progress, and employment increase [9]. The port function of the port enables the city to have its own access to the sea, improves the opening-up level of the city, and improves the urban economic structure [6].

On the other hand, the prosperity of the city promotes the development of the port; urban economy is the basis of port development and affects the scale of the port [4]. Cities are the main source of goods for ports [1]. Port development also needs the city's information and network support, customs clearance, and other service support [6].

Thus, the port and urban economy complement each other, but there is also a certain resource competition. Under the requirements of sustainable and high-quality development, only the port and urban economy develop in coordination will enhance the competitiveness of the port and the city.

3.2. Evaluation Index of Port-City Comprehensive System. Urban economic pursues the goals of GDP increase, industrial structure, and scale expansion, better quality of life, and so on, but the port mainly focuses on the scale of port industry and port production efficiency, and pursues greater throughput and more convenient logistics [10].

Many scholars have studied the evaluation indexes of the port and the urban economy but most of them are evaluated separately. For example, Gao et al. proposed that the input indicators to measure the urban economy include fixed-asset investment and employees, the output indicators include GDP and retail sales, the input indicators to measure the development of the port include number of berths and the yard area, and the output indicators include container throughput [11]. When studying the influencing factors of the port city coordination, Huan et al. proposed that the port indicators include cargo throughput, foreign trade throughput, container throughput, wharf length, and the number of berths; urban economic indicators include GDP, per capita GDP, total volume of import and export, export volume, gross industrial production, foreign investment in actual use, fixed-asset investment, retail sales, freight volume, average wage of employees, etc [12]. Lin and Chen. pointed out that the cargo throughput is an important promotion index for the port to affect the urban economy of Xiamen [13]. From the perspective of Western economics and trade theory, per capita income, economic structure, production factors, industrial structure, and social consumption level have an important impact on urban economic development. GDP includes the production of various industries, which can reflect its economic and industrial development level to a certain extent. Disposable income can better reflect people's quality of life than per capita income.

Therefore, this article selects cargo throughput as the port index, which is the most comprehensive of the port indexes, GDP, total volume of import and export, per capita disposable income, fixed-asset investment, retail sales, and foreign investment in actual use are selected as urban economic indicators.

4. Calculation Method and Evaluation Model Construction

4.1. DEA Method. DEA (data envelopment analysis) is mainly used to evaluate the relative input-output efficiency between decision-making units (DMU). It is suitable for the comprehensive evaluation of the effectiveness of multi-input and multi-output. This article assumes that the optimal scale

is not fully achieved, and the BCC model with variable return to scale is selected to, respectively, evaluate the operation efficiency of the port to urban economy and urban economy to port. The BCC model can be used to measure the comprehensive efficiency, pure technical efficiency, and scale efficiency. The value range of the three is between 0 and 1, and the former is the product of the latter two. If the value of comprehensive efficiency is 1, it shows that the DEA is effective and the optimal combination of the production factors is realized. If only value of technical efficiency is 1, it indicates that DEA invalidity comes from the invalid scale, and the production scale structure is unreasonable. If all three are less than 1, it indicates that the existing management or technical level needs to be improved. Dual transformation of the BBC model can be expressed as

$$\text{s.t}\begin{cases} \min\left[\theta - \varepsilon\left(e^T s^- + e^T s^-\right)\right], \\ \sum_{j=1}^{n} X_j \lambda_j + s^- = \theta X_0, \\ \sum_{j=1}^{n} X_j \lambda_j - s^+ = Y_0, \\ \lambda_j \geq 0, s^-, s^+ \geq 0, \\ \sum_{j=1}^{n} \lambda_j = 1. \end{cases} \tag{1}$$

X and Y are input and output vectors, and $j = 1, 2, \ldots, n$ represented the decision-making unit [14].

4.2. Coordination Degree Model. The coordination degree is a quantitative measure of the degree of coordination between systems, which can be divided into static and dynamic. The former mainly measures the degree of harmony between systems at a certain time point, and the latter is used to measure the operation process. The value usually varies from 0 to 1. 0 indicates complete disharmony, and 1 indicates complete coordination.

Using the membership function in fuzzy mathematics, the static coordination degree between the port system g and the economic system j is defined as $U(g, j)$, and the calculation formula is

$$U(g, j) = \frac{\min\{U(g/j), U(j/g)\}}{\max\{U(g/j), U(j/g)\}}, \tag{2}$$

where $U(g/j)$ is the coordinated development coefficient of the port development as input to urban economy as output, $U(j/g)$ is the coordinated development coefficient of urban economy as input to port development as output, and $U(g/j)$ and $U(j/g)$ can be calculated by the DEA method.

The dynamic coordination degree between the port system g and the economic system j is defined as $U_d(g, j)$, and the calculation formula is

$$U_d(g, j) = \frac{1}{T} \sum_{i=0}^{t-1} U(g, j)_{t-i}, \quad 0 \leq U_d(g, j) \leq 1, \tag{3}$$

where $U(g, j)_t$ is the static coordination degree at a time t. If $U_d(g, j)$ is in an increasing state, it indicates that the system is moving from disorder to order [8].

4.3. Determination about Input and Output and Data Collection. The DEA calculation results are greatly affected by the selection of input and output indicators. Combined with the principle of data availability and the characteristics of coastal ports and cities in Jiangsu Province, the input and output indicators in this article are as follows.

4.3.1. Effectiveness of Ports to Urban Economic

Input indicator: cargo throughput

Output indicator: GDP, total volume of import and export,and per capita disposable income

4.3.2. Effectiveness of Urban Economic to Port

Input indicator: GDP, fixed-assets investment, retail sales, and foreign investment in actual use

Output indicator: cargo throughput

After the breakthrough of the port construction in 2006, the Yancheng port began to take shape. This article uses the effective data of the port and economic development of Nantong, Yancheng, and Lianyungang from 2007 to 2021. The data come from the Nantong statistical yearbook, Yancheng statistical yearbook, Lianyungang statistical yearbook, and the website of the National Bureau of Statistics.

5. Analysis of Empirical Results

5.1. DEA Evaluation Results. In this article, the efficiency grade is divided as follows: below 0.9 is invalid, 0.9 ~ 1 is basically effective, 1 is valid.

Taking the time series from 2007 to 2021 as DMU, DEA efficiency analysis is conducted on the ports and the economic systems of Nantong, Yancheng, and Lianyungang, respectively; results are as shown in Table 1. The last row shows the average effectiveness; the ports on urban economy are 0.88 (Nantong), 0.84 (Yancheng), and 0.94 (Lianyungang), and the urban economy on ports are 0.82 (Nantong), 0.72 (Yancheng), and 0.96 (Lianyungang). If $U(g/j)$ is 1, it shows that the port effectively promotes urban economy and the port has high input-output efficiency to urban economy. If $U(j/g)$ is 1, it shows that the urban economy effectively promotes ports, and the input-output efficiency of urban economy to port is high.

(1) The DEA efficiency of Nantong port to economic development shows an upward trend as a whole, but fluctuates slightly. In the past 15 years, only two years showed effectiveness, and it had been ineffective until 2012, but the efficiency has gradually increased to effective and maintained near effective after 2009, mainly because the scale of Nantong port in the early stage lags behind the scale of economic development

and the port carrying capacity was tight. Nantong Port has planned to upgrade the port supporting facilities year by year since it has invested hundreds of millions of yuan in the new berths in 2008; with the improvement of the port scale, the role of promoting economic development has been enhanced, but the port has not yet become a growth point of urban economic development.

The DEA efficiency of Nantong economy to port development was only effective in 2007, showing a declining development trend and decreasing in scale. However, the pure technical efficiency in the whole period was effective or nearly effective, which shows that under the existing system, technology and management level, the input, and use of Nantong's economic resources were effective. Therefore, decreasing in scale, that is, the input was same but the output decreased year by year, and this is the main reason for inefficiency of Nantong economy to port. So the focus of Nantong's future development is to vigorously develop port economies of scale.

(2) The DEA efficiency of Yancheng port to economic development had been effective for only three years, and the overall trend is first rising and then declining. The DEA efficiency of Yancheng economy to port development shows a trend of first decline and then rise (effective-ineffective-effective), and the two trends were opposite. The period from 2009 to 2015 was the high efficiency period (basically effective) of port to urban economy, but it was the rough period (efficiency value was only about 0.5) of urban economy to port efficiency. It was mainly because the provincial government of Jiangsu put forward the three-year action plan for coastal development in 2009. During this period, Yancheng attached great importance to port development, and the port entered a new stage of unprecedented prosperity, which promoted urban economy well; the efficiency of Yancheng port to economic development had gradually improved. On the other hand, urban resources were given priority over the port during this period and the economic development slowed down, the port could not obtain sufficient supply of goods, transportation, and other infrastructure support from the city, so the operation efficiency of urban economy to port decreased year by year.

In addition, from 2007 to 2021, the pure technical efficiency of Yancheng port to economic development was between 0.9 and 1, which shows that under the existing system, technology and management level, the input, and use of Yancheng port resources were effective. The reason for low efficiency was that Yancheng port was a regional port, built late and small, and had an unreasonable port scale structure. Therefore, the focus of Yancheng's future development was to speed up the construction of port infrastructure, to improve the scale of the port and to optimize the port structure.

(3) The DEA efficiency of Lianyungang port to economic development was only slightly lower than 0.9 in three years, which was effective or basically effective in other years, with overall stability but slight fluctuation. The DEA efficiency of economy to port had been effective for 7 years, showing a stable development trend. Lianyungang port played a good role in promoting the urban economy, and the economy also promoted the port.

From the perspective of horizontal comprehensive comparison, although the three coastal cities have not reached the completion effectiveness, the average effectiveness ranking of their ports to urban economy is consistent with that of urban economy to ports. Lianyungang had the best effectiveness and was close to effectiveness, followed by Nantong, then Yancheng; the degree of influence varied by region. Compared with the two input or output indicators, Nantong port and Yancheng port played a more effective role in promoting the economy. The efficiency of Lianyungang port to urban economy was similar to the efficiency of economy to port.

5.2. Coordination Evaluation Results. Based on the calculation results in Table 1, the static coordination degree between the port and urban economy can be calculated by the formula (2), as shown in Figure 1.

In this article, the coordination level is divided as follows: below 0.7 is uncoordinated, $0.7 \sim 0.8$ is low coordination, $0.8 \sim 0.9$ is moderate coordination, and $0.9 \sim 1$ is high coordination.

From the static coordination degree in Figure 1, Lianyungang is the best, followed by Nantong, and Yancheng is the worst. Lianyungang had the highest efficiency, the lowest fluctuation, and the best coordination effect between the port and the urban economy. Only 2008, 2012, and 2016 were in the medium coordination state, and the other 12 years were in the most ideal coordination state. Nantong had been in the state of coordination or medium coordination for nearly half of the time, but after 2011, the development of static coordination had shown a downward trend. Especially after 2018, Nantong's economy had developed rapidly under the background of the integration of the Yangtze River Delta, while the port was in the transition period and port development lagged behind the local economic development, the two were gradually in an uncoordinated state. In the past 15 years, Yancheng was in a moderately coordinated state in 2008, 2016, and 2017, while the other 12 years had been in an uncoordinated or nearly uncoordinated state. The development relationship between Yancheng port and the economy was poor, the contribution of mutual operation efficiency was low, and the static coordination degree fluctuated greatly.

Based on the annual static coordination degree, the dynamic coordination degree between ports and urban economy of the three coastal cities can be calculated by formula (3), as shown in Figure 2.

From the perspective of dynamic coordination degree, Lianyungang is the best, at a high level of coordination,

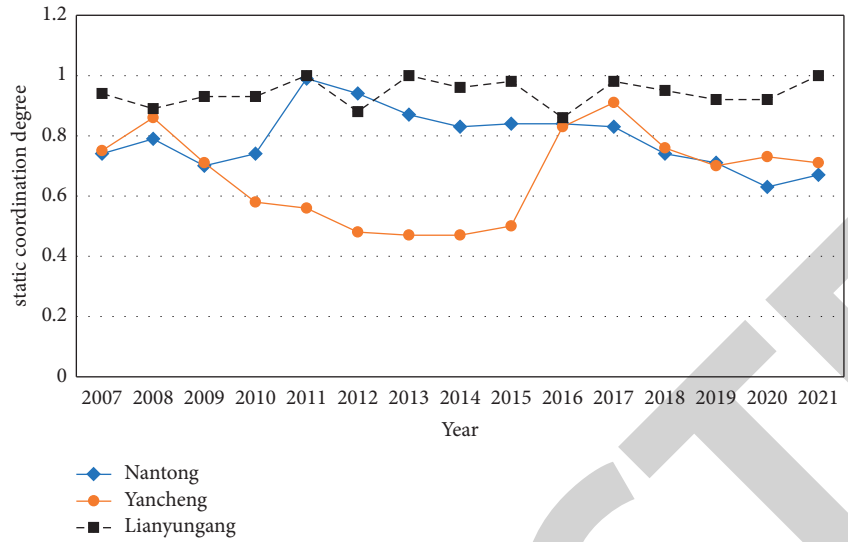

Figure 1: Static coordination degree between ports and economy of the three coastal cities.

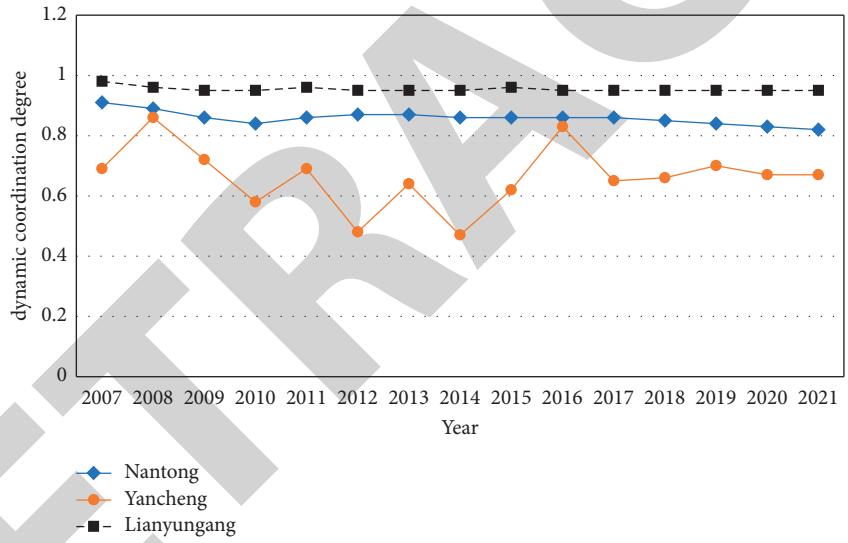

Figure 2: Dynamic coordination degree between ports and economy in the three coastal cities.

relatively stable, and maintaining the trend of dynamic coordination. Nantong takes the second place, which is basically above the level of medium coordination, but it shows a downward trend in recent years. Yancheng is the worst, at an uncoordinated level, and has been fluctuating.

On the one hand, Lianyungang port is located in a favorable position, which is the most convenient sea port in the central and western regions, and the port scale and maturity are the best among the three. On the other hand, the economic development of some port economic hinterlands, such as the cities along Long Hai-Lan Xin Economic Zone, is lower than that of the national average. In addition, Lianyungang's GDP is the smallest among the three coastal cities, so the port scale matches the economic scale better. Although the throughput of Nantong port is the best in the three ports, the matching degree between the port scale and the economic scale is not as good as that of Lianyungang port because Nantong has the best economic development and the largest economic volume. In addition, Nantong nears Shanghai, and the operation efficiency of Shanghai port is high and the logistics cost is low. Some goods, especially foreign trade goods, are chosen to transit through Shanghai port instead of Nantong port. Yancheng port started late and has been planned to become an important regional port, while ports of the other two cities are the main ports of the country. In addition, Yancheng port is geographically located between the Nantong port and the Lianyungang port, and its development is restricted by these two ports. Yancheng has a single industrial structure, poor carrying capacity caused by lack of railway and highway supporting ports in transportation, so the coordination between Yancheng port and economy is the worst.

Table 1: DEA evaluation results.

D	Nantong				Yancheng				Lianyungang			
M	$U(g/j)$		$U(j/g)$		$U(g/j)$		$U(j/g)$		$U(g/j)$		$U(j/g)$	
U	C	V	C	V	C	V	C	V	C	V	C	V
2007	0.74	0.77	1.00	1.00	0.75	0.97	1.00	1.00	1.00	1.00	0.94	0.97
2008	0.73	0.79	0.93	0.96	0.83	0.99	0.97	0.98	0.89	0.89	1.00	1.00
2009	0.68	0.73	0.96	1.00	0.91	1.00	0.64	0.67	0.93	0.93	1.00	1.00
2010	0.70	0.75	0.95	1.00	0.96	1.00	0.56	0.63	0.93	0.97	1.00	1.00
2011	0.85	0.88	0.84	0.98	0.95	0.97	0.53	0.62	1.00	1.00	1.00	1.00
2012	0.81	0.84	0.86	1.00	1.00	1.00	0.48	0.57	0.87	1.00	0.99	1.00
2013	0.94	0.96	0.81	0.97	1.00	1.00	0.47	0.58	0.92	1.00	0.92	0.95
2014	1.00	1.00	0.83	1.00	1.00	1.00	0.47	0.67	0.96	0.97	1.00	1.00
2015	0.96	0.96	0.81	0.98	0.97	1.00	0.49	0.69	0.99	1.00	0.97	1.00
2016	0.98	0.98	0.82	1.00	0.75	0.90	0.63	0.99	0.80	0.81	0.93	1.00
2017	0.97	0.97	0.80	1.00	0.75	1.00	0.68	0.94	0.91	0.91	0.89	1.00
2018	0.97	0.97	0.72	0.99	0.68	0.97	0.90	0.99	0.93	0.93	0.88	0.95
2019	0.94	0.95	0.67	0.98	0.70	0.94	1.00	1.00	0.92	0.93	1.00	1.00
2020	1.00	1.00	0.63	1.00	0.71	1.00	0.97	0.99	0.98	0.98	0.91	0.98
2021	0.98	1.00	0.65	1.00	0.68	1.00	0.96	1.00	1.00	1.00	1.00	1.00
Average	0.88	0.9	0.82	0.99	0.84	0.98	0.72	0.82	0.94	0.95	0.96	0.99

*$U(g/j)$ refers to the DEA efficiency of ports on urban economy, $U(j/g)$ refers to the DEA efficiency of urban economy on ports, C refers to the comprehensive technical efficiency, and V refers to the pure technical efficiency.

6. Conclusions and Policy Recommendations

6.1. Conclusion. By constructing the vertical evaluation index system and the model of the coordinated development of port and urban economy, this article calculates the operation efficiency of port to economy and economy to the port in Nantong, Yancheng, and Lianyungang, and the static coordination degree and the dynamic coordination degree from 2007 to 2021. The results show that the average effectiveness ranking of coastal ports to urban economy in Jiangsu Province is consistent with that of urban economy to coastal ports, but the degree of impact varies according to regions. In terms of the coordinated development of coastal ports and urban economy, Lianyungang has high coordination and a stable situation, Nantong has a medium coordination and a declining situation, and Yancheng has uncoordinated and fluctuating situation, which is related to the port scale, economic scale, and industrial structure of the coastal cities. Port and economic development complement each other.

6.2. Suggestion

(1) Actively promote the synchronous rise of port and urban economy in Lianyungang

In terms of port, due to good port infrastructure and port scale of Lianyungang, the cargo throughput can be increased by increasing the supply of goods. The reason for goods shortage in Lianyungang port is that Northern Jiangsu is the direct source of the port, and industry of Northern Jiangsu is relatively backward. Lianyungang can take advantage of the location of the east bridgehead and road transport advantages to reduce the cost, and strive for Southern Shandong and central and western regions of China as it is a source of goods. In terms of urban economy, Lianyungang establishes a high-tech port industrial agglomeration zone with high and new technologies such as biology and carbon fiber as the core, and relies on the increasingly mature port conditions, so as to optimize the industrial structure, and improve the regional industrial output value and per capita disposable income. As the most convenient estuary in central and western regions of China, Lianyungang should issue relevant policies to highlight the support and incentives for foreign investment attraction and increase foreign investment in actual use and total amount of import and export.

(2) Reduce operation cost of Nantong port and strengthen infrastructure construction of Yancheng port.

Construction capacity of the port determines its operation capacity, so port construction of Yancheng and Nantong will be accelerated in the next few years. According to the previous input-output efficiency calculation results, urban economy to port of Nantong and Yancheng are in a decreasing trend, so port input cannot be increased blindly during construction. Therefore, it is suggested that Nantong should vigorously develop port economies of scale and port supporting services, and use communication network technology and automation technology to strengthen the automation level of port loading and unloading, transportation, and storage systems, so as to reduce port operation costs. Yancheng uses advanced information technology and equipment such as Internet of things, sensor network, big data, and cloud computing to improve the port facility configuration and industrial equipment of Yancheng port.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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