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Research on the Interaction between Port and City of Huai'an

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Abstract

Port economy is an important part of city economic development, Huai'an is one of the important cities in Yangtze River Delta integration and Nanjing metropolitan area, the interactive development of port and city economy is conducive to promoting the high-quality development of Huai'an city. In this paper, we analyze the intrinsic relationship of the indicators within the port-city system of Huai'an port, construct a system dynamics model, and conduct simulations by adjusting the policy indicators such as the water transport sharing rate of Huai'an port, the proportion of port investment amount, and the proportion of adjusted industrial output value. A scheme favorable to the interactive development of the port city is derived.

Keywords

Huai'an City, System Dynamics, Interactive Development.

1. Introduction

The development of port promotes the development of port hinterland city, and the improvement of city economic development level promotes the high quality development of port,this is the general rule of interactive development of port cities.

Kautz [1] was the first to propose the application of industrial location theory to port planning to provide theoretical support for reducing the cost of port location and construction.Mori [2] and others were the first to apply the theory of stages of port-city interaction to argue the importance of transportation for ports and cities. Bart [3] enriched the theory by taking the development of Dutch port cities as an example to analyze its development process on The impact of urban space and land.

The earliest study by foreign scholars on the economic relationship of port cities was published in 1953 by American scholars on the economic value of each ton of goods to the region, which was the first international study on the economy of port cities [4]. the Taaffe- Morrill -Gould [5] model was the first to use the dynamical model to study the development relationship of modern port cities.Jae-wook [6] and others have a strong connection between port cities in several fields such as planning and construction, economic interaction.McConnell [7] and others looked at the port's impact on the surrounding The green and sustainable development of ports is proposed in terms of the driving effect of ports on the surrounding economy and the impact on the environment.Harry Geerlings [8] et al. consider ports as nodes in a global network, and port accessibility is an important indicator of economic performance, using the SD model for dynamic modeling studies.Argall M G et al. through a combination of objectives and measures, classify the global 365 ports were classified to study their green development strategies through a combination of objectives and measures [9].Yochum [10] derived the impact of ports on the regional economy by analyzing the dependency of port industries on ports.Luan [11] used the SD model to study the port-city relationship and derived recommendations through simulated policy simulations.

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Domestic scholars started their research on port-city relationship late, and some studies were conducted on the basis of relevant theoretical studies by foreign research scholars combined with the interaction cases of major port cities in China.

Wu Chuanjun [12] was the first to qualitatively analyze port-city relations and proposed the evolution of growth dynamics structure, classifying the evolutionary dynamics into three types, such as direct port-city linkage, indirect port-city linkage, and city self-growth effect. Wang Nuo [13] et al. pointed out that the evolution of port generations is diverse but fey stepwise, and proposed that the evolution of port generations is functional transformation. Wu Qitao [14] et al. argued that four types of factors such as technological progress, shipping market, politics and location influence the evolution of port systems.

Quantitative study on the relationship between port and city.

Xuelan Zhou [15] used the DEA model to evaluate and analyze the input-output index data, taking the economic development of Yibin port city as an example, and proposed corresponding improvement suggestions accordingly. Fan Xiaoyue [16] constructed the SD model of Qingdao port city, and through this model, predicted the future development of port city and related policy adjustment in Qingdao city by simulation, and came up with countermeasures to promote its interactive and coordinated development.

This study applies the system dynamics model to the inland port of Huai'an, uses the model to make predictions and conduct simulations, compares and analyzes it, then gives relevant suggestions for creating a new engine of Huai'an's economic development and promoting its high-quality development.

Huai'an, as an important central city in northern Jiangsu province, is an important intersection of Yangtze River Delta high-grade channel network and main waterways, and has significant advantages in inland waterway shipping. However, under the influence of multiple factors such as the current epidemic at home and abroad, the slowdown of the world economy and the transformation of the domestic economy to high-quality development, the development of port shipping industry is facing greater challenges. How Huai'an port can grasp the development opportunities, face the difficulties and challenges, take the port economy as a new growth point of the city's economic development, and create a new engine of Huai'an economic development, is worth further analysis and exploration. At the same time, it is important to build "Huaihai Economic Zone" and "Nanjing Metropolitan Circle", to build an important economic growth pole in East China, and to promote the high-quality development of northern Jiangsu.

2. Interaction mechanism between inland river port and city development

Throughout the development history of global port cities, the development of city economy is inseparable from the benign interaction of ports. As the main transit point for import and export trade, the port has the characteristics of large volume and low price, which facilitates the trade of large volume of goods and promotes the economic development of the city. At the same time, the development of the port also depends on the economic strength of the city where it is located and the economic hinterland and inland transportation capacity. A port wants to take advantage of the competition with other ports, can not be separated from the support of the city it relies on, the interaction between the port and the city development generally exists in the following relationship.

2.1. The influence of benign interaction on the relationship between port and city.

The benign interactive development of the port and the city is reflected in the fact that the port drives the development of the city's import and export industries, provides resources and material support for the development of the city's industries, and enhances the gross regional

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product. The development of the port will also attract more industrial enterprises and create more employment opportunities for the development of the city, such as logistics, shipping-related freight forwarding, ship management, shipping finance and other service industries, and promote the benign development of the port city.

2.2. Insufficient interaction has an impact on port-city relations.

Although ports and cities are in the same large system of port and city, they also have their own characteristics, and there is a certain degree of competition between the port system and the city system in the process of development, and sometimes even conflicts. In the process of operation, the port, ship docking operations, terminal loading and unloading equipment, cargo transshipment and other activities will also bring a certain degree of adverse impact on the city's traffic and environment. On the one hand, the lack of port throughput capacity and port infrastructure will lead to its inability to meet the normal import and export needs of the city, which will to a certain extent restrict the development of the city economy; on the other hand, the blind construction and repeated construction of the port will lead to a certain amount of idle port resources and waste of funds and resources.

Only through scientific and reasonable analysis of these gaps can we find out how to make the port and city develop synergistically so as to improve the development level of the whole port and city system.

3. Dynamics model of inland port and city system

3.1. System boundary

To analyze the interactive development relationship between Huai'an inland river port and the city, the first step is to construct a system dynamics model of port-city development, based on the modeling steps of the SD model, first to clarify the preconditions of modeling and and the boundary of the system, and then to dissect the structural characteristics of the system, draw the cause-effect relationship diagram, and finally construct a system flow diagram. High GDP reflects the scale and level of economic development of a city to a large extent. Analyzing the value added of primary, secondary and tertiary industries can understand the economic condition of the city economy, and the demographic factor is an important factor to determine the development potential of the city. Port system analysis can be considered from two dimensions: demand and supply. Demand dimension: the increase of import and export trade of the city and its hinterland directly affects the throughput of the port; supply dimension: the city's investment in port facilities and infrastructure enhances the throughput capacity of the port. Based on the analysis of the port-city interaction, the boundaries of the studied system are determined as follows.

Table 1 : System type Boundary elements

System type	Boundary elements
Urban economic population	Urban GDP
	Total City Population
Inland river port	Inland river port Port throughput
	Port throughput capacity

3.2. Causal Analysis

In this paper, the causal relationship between the GDP of Huai'an, the total population of Huai'an, the cargo throughput of Huai'an port and the throughput capacity of the port is divided into five main feedback loops.

Loop 1 , (positive economic-demographic feedback loop)

+ GDP→+ GDP per capita →+ net population migration rate →+ total population →+ employed population →+ GDP.

Loop 2 , (economy-population-transport mode positive feedback loop)

+ GDP→+ GDP per capita →+ per capita consumption level →transport demand + demand for other modes of transport →shortage of other modes of transport →GDP .

Loop 3 , (economy-population-port negative feedback loop)

+GDP → +GDP per capita →+Consumption level per capita →+Transport demand +Port throughput demand →+Port throughput shortage→+Port cargo backlog →-GDP.

Loop 4 , (positive economic-population-port feedback loop)

+GDP →Transportation investment→+Water transport investment→+Water transport capacity→ +Port supply→+Port throughput→ +Employed population→+GDP.

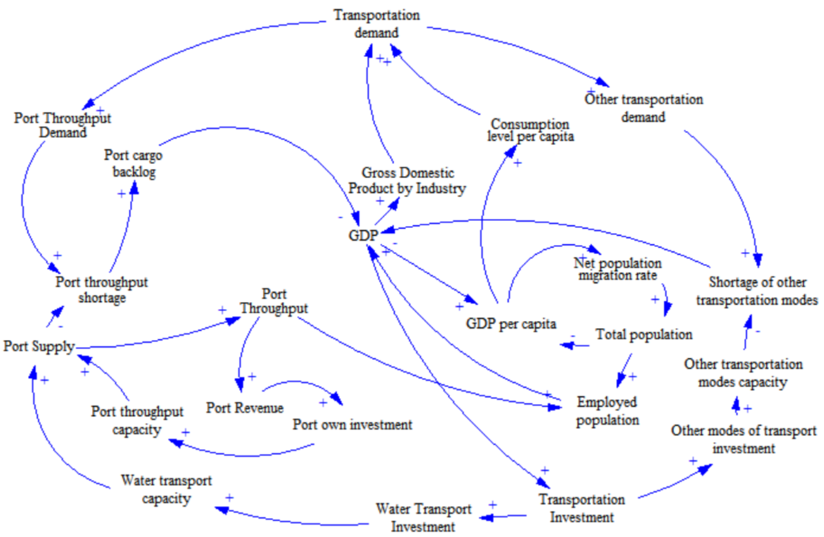

Figure 1: Cause-effect diagram of port-city interaction system

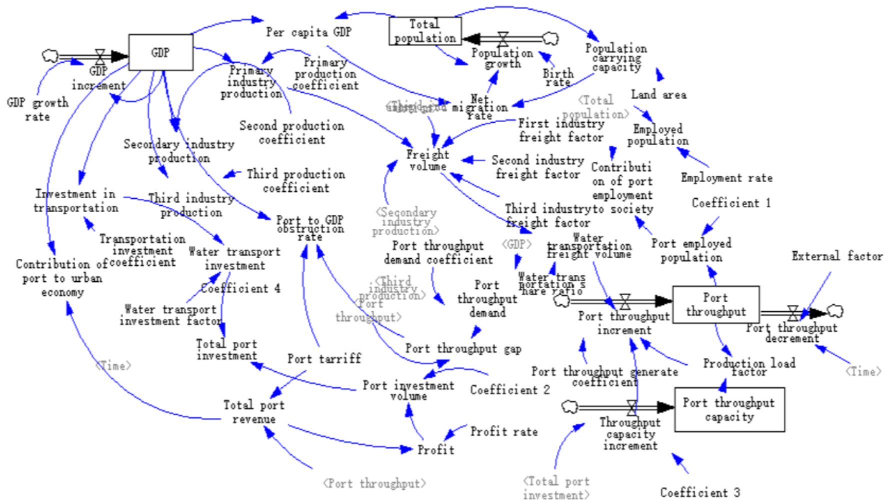

Figure 2: The flow diagram of port-city interaction system

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4. Empirical analysis

4.1. Parameter Determination

In the SD model, the parameter equation is the key to the quantitative analysis, which represents the quantitative linkage between each indicator. In this paper, data processing software such as SPSS is used to estimate the relevant indicator parameters and then obtain the system equations.

The main state equations are as follows.

(1) GDP= INTEG (GDP Growth,1935.93) Units: 100million

(2) GDP Growth = GDP*GDP Growth Rate Units: 100million

(3) Primary Output = GDP*Percentage of Primary Production + 102.674 Units: 100million

(4) Output Value of Tertiary Industry = GDP*Tertiary Industry Ratio Coefficient-324.337 Units: 100million

(5) Secondary Industry Output = GDP*Secondary Industry Proportionality Factor + 221.663 Units: 100million

(6) Secondary Industry Proportionality Factor = 0.354 Units: **undefined**

(7) Transportation Investment = GDP*Transportation Investment Coefficient + 30.01 Units: 100million

(8) Population increment = Total population*(birth rate + net in-migration rate) Units: 10thousand people

(9) Population carrying capacity = total population/land area Units: 10thousand people/square kilometer

(10) GDP per capita = GDP/total population/10000 Units: 100million yuan/person

(11) Net migration rate = GDP per capita/population carrying capacity

(12) Profit = Total port revenue * Profit margin + 0.3494 Units: 100million

(13) Total population = INTEG (incremental population , 475) Units: 10thousand people

(14) Water transport freight volume = freight volume * water transport share rate Units: million tons

(15) Port Throughput = INTEG (Incremental Port Throughput, 5697) Units: million tons

(16) Port Throughput Increment = Waterborne Cargo Volume * Throughput Generation Factor + Throughput Capacity Increment * Production Load Factor Units: million tons

(17) Port Throughput Shortfall = IF THEN ELSE(Throughput Demand - Port Throughput>0,Throughput Demand - Port Throughput,0) Units: million tons

(18) Port hindrance rate to GDP=Port throughput gap*Port rate/GDP Units: million tons/100million

(19) Port economic contribution to city = total port revenue/GDP Units: **undefined**

(20) Total investment in port = investment in water transport + investment in port itself Units: 100million

(21) Total port revenue = port throughput * port tariff rate - 25.162 Units: 100million

(22) Port's own investment = profit * factor 2 + 0.014 Units: 100million

(23) Port throughput capacity = INTEG (incremental throughput capacity, 11000) Units: million tons

(24) Production load factor = Port throughput/port throughput capacity Units: **undefined**

(25) Cargo volume = Proportional coefficient of primary cargo*LN(value of primary production) + Proportional coefficient of secondary cargo*LN(value of secondary production) +

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Proportional coefficient of tertiary cargo*LN(value of tertiary production) + 14,659.6 Units: million tons

4.2. Model testing

After the model is established, it should be tested for validity, and the invalid model should be revised repeatedly to meet the basic requirements of model establishment. If the error is within ±5%, the model is proved to be valid.

Therefore, four important indicators of the model such as GDP, port throughput, total population, port throughput capacity has been simulated and tested to verify the validity of the model so that it can be better applied to policy adjustment and simulation.

The model simulation time period is 2012-2019, and the data related to the initial values of state variables and related constants in 2012 are obtained by reviewing the literature. Using SPSS software, Excel and econometrics, the auxiliary variables (Table 2) were derived by combining the historical data of Huai'an city, and the main several variable equations in the model were explained.

1) Regression analysis between the output value of primary production and GDP. The regression analysis between the output value of primary production and GDP will be conducted. The regression equation constructed is.

$$Y = aX + b \tag{1}$$

where: a - the proportional coefficient of primary production； b - the constant term;

The regression equation is solved by SPSS with a =0.074, b =102.674

The solved regression equation is

$$Y = 0.074X + 102.674 \tag{2}$$

2) For the relationship between freight volume and the output value of the three industries, but there is no obvious linear relationship between them, so in order to find out the proportion coefficient between the output value of the three industries and freight volume, the following logarithmic equation is established as

$$Y = a + b_1 LnX_1 + b_2 LnX_2 + b_3 LnX_3 \tag{3}$$

where: a - constant term; b_1, b_2, b_3 - the proportional coefficients of freight transportation of primary, secondary, and tertiary industries, respectively.

Through regression analysis, the relevant parameters are estimated as:

$a = 14659.643$, $b_1 = 14222.322$, $b_2 = -1251.595$, $b_3 = 12233.96$

Thus the regression equation obtained between the output value of the three industries and the freight volume is

$$Y = 14659.643 - 14222.322 LnX_1 - 1251.595 LnX_2 + 12233.96 LnX_3 \tag{4}$$

Table2: Related initial data for 2012

Name	Data
Gross production value / 100million yuan	1935.93
Population / 10,000 people	475
Value of primary industry/100million yuan	247.98
Secondary industry value / 100million yuan	902.51

Value of tertiary industry/100million yuan	785. 44
Cargo volume	8987
Throughput	5697
Primary Cargo Coefficient	-14222.3
Freight Coefficient of Secondary Industry	-1251.59
Third industry freight coefficient	12234

Table 3: Comparison of actual freight volume and simulated freight volume of Huaian city

Year	Actual throughput / 10 thousand tons	Simulated throughput / 10 thousand tons	Relative error
2012	8987	9358	4.1%
2013	10298	10131	-1.6%
2014	11343	10803	-4.7%
2015	12023	11385	-5.3%
2016	12214	11886	-2.6%
2017	12674	12314	-2.8%
2018	12914	12675	-1.8%
2019	13178	12976	-1.5%

Table 3: Comparison of actual GDP and simulated GDP of Huai’an city

Year	Real GDP/100million	Simulated GDP/100million	Relative error
2012	1935	1936	0
2013	2234	2145	-4%
2014	2478	2377	-4.1%
2015	2756	2633	-4.4%
2016	3091	2918	-5.6%
2017	3341	3233	-3.2%
2018	3615	3582	-0.9%
2019	3840	3969	3.3%

From Table 3, we can see that the average errors of freight volume and total GDP of Huai'an city from 2012 to 2019 are 2.4% and 2.0%, respectively. The errors are much less than 5%; thus, the proposed model fits the real system well and can accurately predict the short-term real system development.

4.3. Policy Simulation Analysis

Scenario 1: Policy simulation analysis of the ratio of secondary and tertiary industries.

Based on the analysis of the basis for the formulation of the scheme in the previous section, the proportion of output value of primary, secondary and tertiary industries in Huai'an is 0.074 : 0.354 :0.572, and the proportion of output value of primary industry is small, so only the proportion coefficient of output value of secondary and tertiary industries is adjusted in the adjustment of the proportion of output value of industries. In this scenario, there are mainly two sub-schemes. The first scenario is to make the proportion coefficient of the second output value decrease by 10% and the proportion coefficient of the tertiary output value increase by 10% (scenario 1(a)). The second scenario is to increase the proportion coefficient of secondary output value by 10% and decrease the proportion coefficient of tertiary output value by 10%. The simulation results show that the average port throughput increases by 4.7% in scenario one (a) and decreases by 5.5% in scenario two (b), and the development of tertiary industry can significantly increase the port throughput.

Scenario 2: Water transport freight volume share policy simulation analysis.

The current water transport share in the development of Huai'an port city system is 0.495, and its share will be increased by 10% respectively (Scenario II (a)) and the original data will be compared and analyzed. The changed parameters are brought into the model and simulations are performed to clearly show that a 10% increase in the water transport sharing rate is better than the original scenario.

In the last year of the simulation, 2025, for example, the port throughput is 14,231,000 tons in the original scenario and 156,103,000 tons in Scenario II (a), an increase of 13,790,000 tons. Scenario II (a) is better than the original scenario.

Scenario 3: Policy simulation analysis of water transport investment ratio

The current water transport investment rate in the development of the Huaian port and city system is 0.101, and the water transport investment rate is adjusted to 0.1111 and the original data for comparison and analysis.

Taking the last year of simulation 2025 as an example, the original scenario of port throughput is 142.31 million tons, and scenario 3 is 144.96 million tons, with an increase of 2.61 million tons. The growth rate is 1.9%, compared to the original scenario there is a certain growth, but the growth is not obvious, which also shows that simply rely on water transport investment to promote the port throughput increase effect is not significant.

5. Conclusion

The study establishes a system dynamics model for the interactive development of Huai'an inland port city, and adjusts the model to analyze its development trend, so as to clearly identify favorable policies favorable to the development of Huai'an port city and promote the high-quality development of the city's economy. The recommendations for the future development of Huai'an port city are as follows.

(1)Increase the investment in water transportation and improve the water transportation share.

Improve the service capacity of the port by improving the construction of infrastructure to create a modern inland waterway port that is fully functional and efficient. Take advantage of the cost of inland river transportation, improve the share of waterway transportation, and form a comprehensive three-dimensional transportation system with waterway transportation as the core and the interconnection of highway, railroad, air and other transportation modes.

(2)Adjusting the industrial structure to help the development of the port city

Huai'an City, as a more developed city in northern Jiangsu Province, the primary industry accounts for very little, the proportion of secondary and tertiary industries is 0.354:0.572, the proportion of secondary and tertiary industries is relatively reasonable, but the secondary industry is the main source of high energy consumption and environmental pollution in the city, by increasing the proportion of tertiary industries for program simulation, the loss of throughput brought about by the reduction of secondary industry can be compensated by various aspects of tertiary industry, but also conducive to the Huai'an City will become a city with a high level of service industry led by tertiary industry, and promote the positive interaction and high quality development of the port city.

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