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Logistics Ports Layout Planning of Dangerous Chemicals Based on Regression Analysis

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As dangerous chemicals have the attribute of potential risks, in the logistics and storage process, we need to ensure their safety, therefore, it is of great practical significance and guiding significance to study the layout planning of logistics ports for dangerous chemicals. This paper first takes the logistics ports layout for dangerous chemicals on the main line of Yangtze River as an example, uses regression analysis to analyze the relationship between the throughput of dangerous goods on the main line of Yangtze River and the GDP, so as to obtain reliable prediction of total throughput of dangerous goods in ports on the main line of Yangtze River. Second, this paper comprehensively considers the predicted throughput of dangerous goods in ports on the main line of Yangtze River and the influencing factors of port logistics layout, and then formulates three logistics ports layout plans for the dangerous goods in ports on the main line of Yangtze River. Finally, this paper optimizes and selects three plans according to the actual situation, and the final plan for logistics ports layout of dangerous chemicals on the main line of Yangtze River is obtained. This provides important theoretical analysis basis for improving the efficiency of logistics transportation of dangerous goods on the main line of Yangtze River and achieving sustainable development.

1. Introduction

With the rapid development of China's industry, the economy is taking off and the demand for dangerous goods such as oil, natural gas, and chemical raw materials is also growing. The development of chemical industry has reached 1.5 times the rate of economic growth. The increase in the production of dangerous chemicals has directly driven the development of the logistics of dangerous goods, especially the development of logistics ports. However, due to the special nature of dangerous chemicals, it may easily lead to potential risks, such as the 8.12 explosion accident in Tianjin Binhai New Area. The accident was a fire and explosion accident in the dangerous goods warehouse of Ruihai Company located in Tianjin Port, Binhai New Area, Tianjin City. 165 people were killed, 8 people were missing, 798 people were injured, 304 buildings, 12428 commodity vehicles, and 7,533 containers were damaged. (Klose and Drexl, 2005). Therefore, economic and safety layout planning for dangerous chemicals logistics ports is a very important research topic, which has guiding significance for the actual situation.

However, there's few researches on port layout planning of dangerous goods (Erkut and Neuman, 1989). Zhang Nan et al. analyzed the development layout of the coastal ports in China and pointed out that we need to consider the port layout from the perspective of influencing factors, motivation mechanisms and development modes. Feng Qing used the analytic hierarchy process (AHP) to establish the evaluation index fuzzy clustering model of the port layout. The main line of Yangtze River is an important logistics transportation line in China and has contributed tremendously to China's economic development and has made remarkable achievements. However, there are very few researches on the layout of logistics ports for dangerous chemicals on the main line of Yangtze River.

Therefore, this paper takes the layout situation of dangerous goods logistics ports on the main line of Yangtze River as an example, to solve problems such as unbalanced development, unreasonable structure, repeated construction, and low service quality, this paper uses regression analysis to analyze the throughput of dangerous goods logistics ports on the main line of Yangtze River, proposes an optimized layout plan for the dangerous goods logistics ports on the main line of Yangtze River, which improved the efficiency of logistics

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transportation of dangerous goods on the main line of Yangtze River, reduced the costs and achieved sustainable development, so that enormous economic and social benefits were generated.

2. Regression analysis

Regression analysis was proposed by the British statisticians F. Galton and K. Pearson as a statistical method to deal with the relationship between variables (Faschan et al., 1996). According to the number, type and relationship of variables, regression analysis can be divided into one-dimensional linear regression analysis, multiple linear regression analysis, nonlinear regression analysis, curve estimation, time series curve estimation, regression analysis of virtual variables, and logistic regression analysis, etc.

The throughput of the port is a decisive indicator for determining the scale of the port and is the main criterion for measuring the status of the port, especially the throughput of dangerous goods. The factors affecting the port throughput include the economic development level of the hinterland, its economic structure, transportation system, and the competition of surrounding ports, etc. The prediction of the throughput of dangerous chemicals is an important theoretical basis for the layout planning of dangerous goods logistics ports on the Yangtze River.

Based on the analysis of the relationship between the throughput of dangerous goods in the ports on the main line of Yangtze River and the economy, this paper selects the gross domestic product (GDP) as an independent variable, selects the throughput of dangerous chemicals as the dependent variable, and establishes a regression analysis model. Among them, the mathematical expression of the regression model is: $\hat{Y}_t = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \cdots + b_n x_n$.

The GDP data is the total GDP of the provinces (cities) on the Yangtze River main line from 1998 to 2008, as shown in Figure 1. Through regression analysis, the average annual growth rate of GDP is 9.2% (2009-2010), 7.6% (2011-2015), and 6.8% (2016-2020) respectively. From this, we can see that the predicted total GDP of the provinces (cities) on the main line of Yangtze River in 2009-2020 is shown in Figure 2.

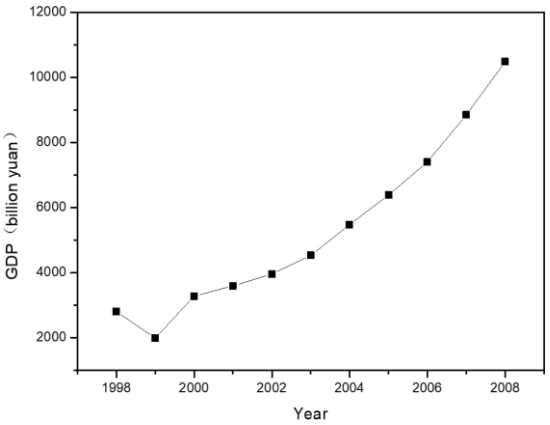

Figure 1: Total GDP of provinces (cities) on the main line of Yangtze River over the years

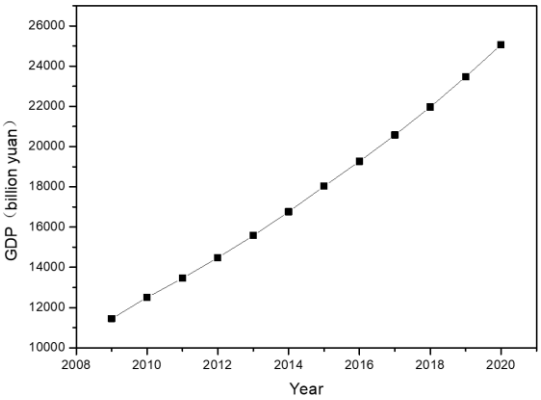

Figure 2: Predicted total GDP of provinces (cities) on the main line of Yangtze River in 2009-2020

The data of dangerous chemicals is the total throughput of dangerous goods in ports on the main line of Yangtze River in 1998-2007, as shown in Figure 3, using regression analysis we can get the predicted total throughput of dangerous goods in ports on the main line of Yangtze River in 2008-2020, as shown in Figure 4.

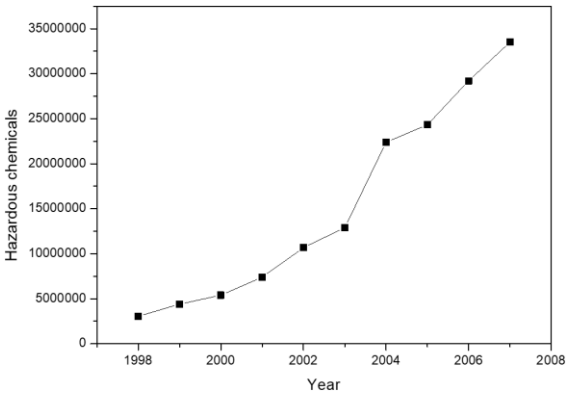

Figure 3: Statistics on total throughput of dangerous goods in ports on the main line of Yangtze River

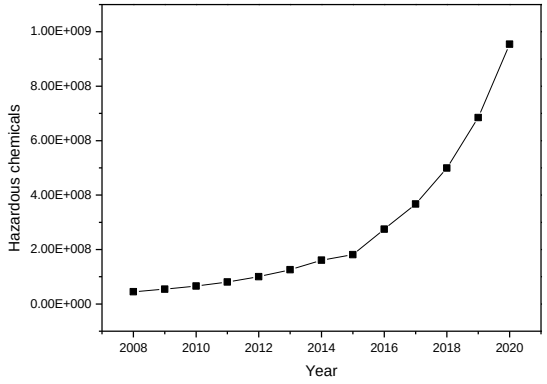

Figure 4: Predicted total throughput of dangerous goods in ports on the main line of Yangtze River in 2008-2020

From Figure 4 we can see that the total throughput of dangerous chemicals in the ports on the main line of Yangtze River is increasing year by year, which is consistent with the national policy of vigorously developing the Yangtze River Economic Belt. Calculating by the average growth rate of 31.7%, by 2020, the total throughput of dangerous chemicals is similar to the predicted value, indicating that the result predicted by the regression analysis method has a higher credibility.

3. Influencing factors

The regional port layout is to perform specific planning by classifying ports according to their status in the logistics system, mainly to solve structural problems, achieve rational construction of ports, integrate port resources, and form an orderly competition mode (Alumur and Kara, 2007). The ports on the main line of Yangtze River can be divided into major regional ports, important regional ports and common regional ports according to their economic development situations.

In addition to the port throughput mentioned above, according to the theory of port layout, the main factors affecting port layout planning are natural and geographical conditions, social and economic conditions, and regional economic development demands, as shown in Figure 5.

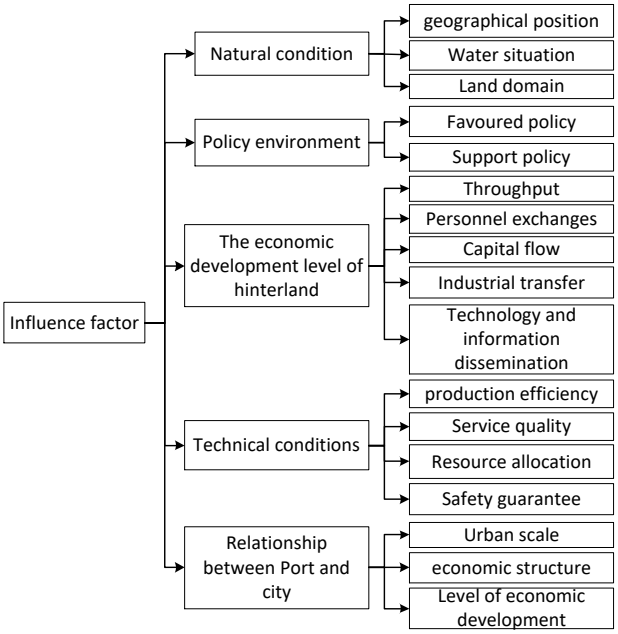

Figure 5: Main influencing factors of port layout planning

Among them, the natural conditions are mainly geographical location, water conditions, and land conditions, which are the most fundamental basis for the layout of the port; the policy environment refers to the government's plans for the layout of the port and the supportive and preferential measures; the economic development level of hinterland determines the demand for dangerous chemicals of the port location, it is a direct factor for the expansion development of the port; technology is an important way to improve port efficiency, improve port services, provide security and other facilities and management (Berman et al., 2000; Jacobs and Warmerdam, 1994); the relationship between port and city is complementary to the development of ports.

Table 1: Layout plans of three kinds of ports for dangerous goods logistics ports on the main line of Yangtze River

Category	Scheme I	Scheme II	Scheme III
Main port	Nanjing port, Jiangyin port, Suzhou port	Nanjing port	Nanjing port, Jiangyin port, Suzhou port
Important port	Chongqing port, Yueyang port, Wuhan port, Jiujiang port, Anqing port, Zhenjiang port,Wuhu port, Nantong port	Chongqing port, Yueyang port, Wuhan port, Jiujiang port, Anqing port, Zhenjiang port, Jiangyin port, Suzhou port、Nantong port	Chongqing port, Yueyang port, Wuhan port, Anqing port, Zhenjiang port, Nantong port
General port	Luzhou port, Yichang port	Luzhou port, Yichang port, Wuhu port	Luzhou port, Yichang port, Jiujiang port, Wuhu port

Therefore, comprehensively considering the predicted throughput of the dangerous goods of the Yangtze River main line ports and the influencing factors of the logistics port layout, under the principle of adapting to the economy, highlighting key points, comprehensive transportation, resource conservation, and focusing on coordination, referring to the national port layout planning standards, the dangerous goods logistics ports on the main line of Yangtze River are divided into three kinds: major ports, important port and common ports, and a logistics ports layout plan for dangerous goods on the main line of Yangtze River is proposed as shown in Table 1.

4. Plan optimization

This paper selects 6 indicators of location, channel, berth, dangerous goods throughput, collection and distribution, policy to analyze the 13 ports in the above three plans. The port parameters are quantified using a standardized method, the mathematical expression is: $r_{ij}^{i} = \frac{r_{ij} - \min r_{ij}}{\max r_{ij} - \min r_{ij}}, j = 1,2,\ldots,m.$

After processing the above formula, the standard values of the related parameters of the 13 ports are obtained, as shown in Table 2.

Table 2: Standardized parameters of each port

Port	Location	Channel	Berth	Total throughput of hazardous chemicals	Collection and transportation	Policy
Luzhou	-0.002	-0.002	0.058	0.01	-0.002	-0.002
Chongqing	0.089	0.018	0.183	0.065	0.569	0.198
Yivhang	0.18	0.018	0.031	-0.002	0.141	-0.002
Yueyang	0.271	0.1	0.161	0.071	0.427	-0.002
Wuhan	0.362	0.182	0.449	0.097	0.569	0.198
Jiujiang	0.453	0.182	0.427	0.037	0.712	-0.002
Anqing	0.543	0.335	0.047	0.065	0.569	0.198
Wuhu	0.634	0.335	0.183	0.017	0.427	-0.002
Nanjing	0.725	0.794	0.998	0.998	0.998	0.998
Zhenjiang	0.816	0.794	0.373	0.124	0.855	0.798
Jiangyin	0.907	0.998	0.335	0.323	0.998	0.798
Suzhou	0.998	0.998	0.666	0.304	0.998	0.798
Nantong	0.998	0.998	-0.002	0.174	0.855	-0.802

Using SPSS software to import and analyze the above data, we can draw the final optimization results of the logistics port layout plan for the dangerous goods on the Yangtze River, as shown in Figure 6.

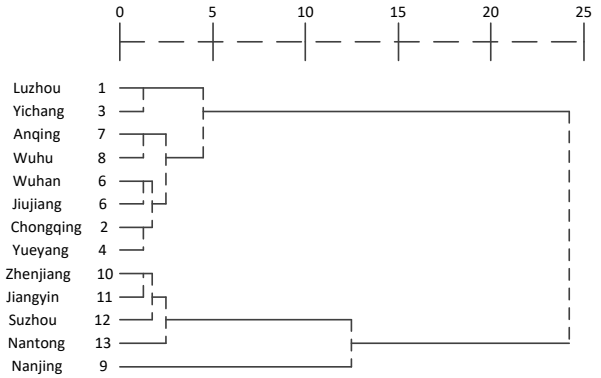

Figure 6: Optimization of layout plan for dangerous chemicals logistics ports on the Yangtze River

When the distance value is selected as 5-10, the ports can be divided into three kinds according to Figure 6. The first kind is Nanjing Port, the second kind is Zhenjiang Port, Jiangyin Port, Suzhou Port, Nantong Port, and the third kind is Luzhou Port, Chongqing Port, Yichang Port, Yueyang Port, Wuhan Port, Jiujiang Port, Anqing Port, Wuhu Port.

According to the actual situation, the indicators and throughput of Nanjing Port, a first kind port, are far higher than those of other ports. For the ports of the second kind, Zhenjiang Port, Jiangyin Port, Suzhou Port, and Nantong Port, their locations have advanced transportation, the city and urban agglomeration has developed economy, and their demand for dangerous chemicals is big. Chongqing Port and Wuhan Port of the third kind are major cities in the country, and they are administrative and economic centers and their developing momentum is fierce in recent years, so they can be categorized into the second kind, the rest are the third kind. Therefore, the final plan for the logistics ports layout of dangerous goods on the main line of Yangtze River is shown in Table 3 and Figure 7.

Table 3: Final layout plan for dangerous chemicals logistics ports on the Yangtze River

Category	Final distribution scheme of dangerous goods logistics port on the Yangtze River trunk line
Main port	Nanjing port
Important port	Chongqing port, Wuhan port, Zhenjiang port, Jiangyin port, Suzhou port, Nantong port
General port	Luzhou port, Yichang port, Yueyang port, Jiujiang port, Anqing port, Wuhu port

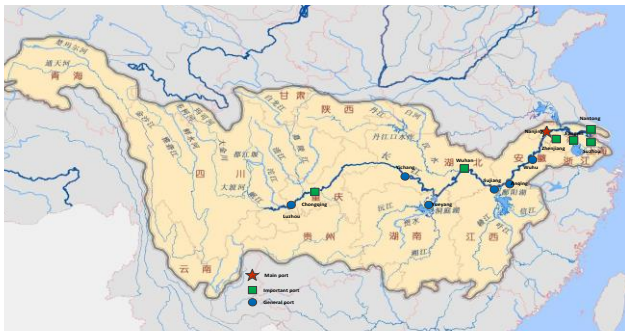

Figure 7: Final layout plan for dangerous chemicals logistics ports on the Yangtze River

5. Conclusion

With the progress of reform and opening up, the main line of Yangtze River has been contributing to China's economic development and has achieved remarkable achievements. Its total cargo volume is approximately 17 times of the Beijing-Guangzhou railway line. As the end point of various modes of transport, the main line of Yangtze River plays an invaluable role in the logistics of dangerous chemicals. Research on the logistics port layout plan of dangerous chemicals on the main line of Yangtze River can improve the efficiency of logistics transportation of dangerous goods on the Yangtze River main line, reduce operating costs, achieve sustainable development, and thus produce huge economic and social benefits, which has important practical significance.

(1) Through regression analysis, this paper analyzes the relationship between the throughput of dangerous goods on the main line of Yangtze River and the GDP, and predicts the total throughput of dangerous goods in the main line ports of Yangtze River during 2008-2020. The reliability of the predicted value is relatively high.

(2) Combining the predicted values of the dangerous goods throughput of the Yangtze River main line ports and the influencing factors of logistics ports layout, the logistics ports of the Yangtze River main line were divided into three kinds: major ports, important ports and common ports, and three layout plans were formulated for the dangerous goods logistics ports on the main line of Yangtze River.

(3) Using SPSS software and the standard processing method to optimize the three plans, a final layout plan for dangerous chemicals logistics ports on the main line of Yangtze River was obtained, namely the major port is Nanjing Port, the important ports are Chongqing Port, Wuhan Port, Zhenjiang Port. Jiangyin Port, Suzhou Port, and Nantong Port, and the common ports are Luzhou Port, Yichang Port, Yueyang Port, Jiujiang Port, Anqing Port, and Wuhu Port.

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