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Research on the Development Strategy of Sea-Railway Multimodal Container Transport in Qingdao Port

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Abstract: In order to decide on whether Qingdao port container should be improved by the government, this paper studies the development of Qingdao port container sea rail combined transport, using the SWOT analysis method to analyze the development of Qingdao port container sea rail intermodal advantages, disadvantages, opportunities and challenges, points out the problems existing in the development of Qingdao port container sea rail combined transport, then set up the grey Markov Forecasting method of combination forecasting model based on, for the future development of Qingdao port container sea rail intermodal were quantitative prediction analysis, and points out reasonable suggestions and Countermeasures from perspectives of economic and governance and the port container itself for the development of Qingdao port container sea rail combined transport.

Keywords: Container, Sea-railway Muiltmodal, SWOT Analysis, Gray Markoff

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1. INTRODUCTION

From the perspective of international economy, the high speed of international trade and the economy needs more space and less time. Therefore, the sea-railway multimodal container transport conforms to the development of global economy, which becomes the most important method of the distribution system in port due to low cost, long distance, and large capacity. From the perspective of the economy in our country, the economy develops at a high speed and the volume of trade increases every year, which requires the better development of the port. The resources are abundant in western parts of our country whereas are scarce in eastern. However, regarding the railway transportation, the railways in western develop very slowly whereas those in eastern are in good conditions. Therefore, there is a paradox between the number of railways and the demand for goods, restricting the development of our economy directly. Hence, it is of great significance for import and export trade to develop the sea-railway multimodal container transport.

Qingdao port, as the typical port in our country, is the seventh port in the worldwide and the third port in our country. As the expansion of the economy in Qingdao port, the specific requirements such as long distance, large amounts, much working time and low fee make the railway multimodal container transport attract more attention. With the improvement of the railway transport, the proportion of railway transportation becomes larger and larger, and the amount of port transportation increases continuously. Therefore, studying the development of the sea-railway multimodal container transport has a significant realistic meaning.

Based on the status of Qingdao Port, our paper analyzes the advantages, disadvantages, opportunities, and threats of the sea-railway multimodal container transport by SWOT model, and then summarizes the problems of the sea-railway multimodal container transport. In addition, this paper uses the gray model to forecast the trend of the development of sea-railway multimodal container transport in the future and then modifies the model by Markov model to improve the accuracy of the forecast. Based on the conclusions, this paper provides some suggestions for the development of the sea-railway multimodal container transport.

2. LITERATURE REVIEW

This paper reviews relevant literature about the sea-railway multimodal container transport and comments on those from three aspects. They are the theory, the evaluation and the forecast of the sea-railway transport, respectively.

Regarding the theory of the sea-railway transport, Reis V[1] studies the mode of multimodal transport and analyzes the advantages and disadvantages of the multimodal transport related to the railway and the coordination with the air transport. Guerrero D [2]studies two different types of ports in France and demonstrates the economy expands fast in the worldwide, but whether the influence of them exceeds secondary ports depends on the types of goods, most of which are limited by distances. Jianwei Xiao[3] analyzes the status of multimodal container transport, points out the problems and emphasizes the importance of the development of multimodal container transport and sea-railway transport.

Regarding the evaluation of sea-railway transport, Jiang B[4]considers that the reasonable proportion of sea-railway transport and sea-river transport can realize the huge economic and environmental benefits. Moon D[5] compares the six channels from Korean to Europe and finds the most competitive channel by Topsis model. Xiangyu Jin[6] analyzes the procedures of the sea-railway multimodal container transport in Tianjin and provides the solutions for them.

Regarding the forecast for the sea-railway transport, Ling Gao[7] builds the gray Markov model to forecast the throughput of goods and containers in Fuzhou. Huirong Wu[8] uses dynamic system model to forecast the throughput of sea-railway multimodal container transport. Hongmao Wei[9] constructs the gray model to study the influence of regional economic growth, foreign investment, the throughput of port, and gross of regional production on the trend of the sea-railway transport in Fujian.

3. PROBLEMS AND STATUS IN QINGDAO PORT

By using SWOT model, we conduct a field research to explore the main factor of the sea-railway multimodal container transport. We summarize the status of Qingdao port from aspects of strengths, weaknesses, opportunities, and threats. As is shown in table1.

We can find the following problems of the sea-railway multimodal container transport in Qingdao port by using SWOT analysis.

(1) The infrastructure and the capacity of sea-railway are imperfect.

(2) There is a lack of coordination between departments in Qingdao port.

(3) The information is systematic and the capacity of tracking small goods is very low.

(4) The pricing mechanism needs to be improved.

(5) The market of the railway is a monopoly market and responds to the changes very slowly.

4. FORECAST OF SEA-RAILWAY MULTIMODAL CONTAINER TRANSPORT IN QINGDAO PORT

Whether the sea-railway multimodal container transport should be developed a lot depends on not only the existing advantages of them, but also the own strengths and weaknesses of Qingdao Port. Last but not least, it also depends on the trend of the sea-railway multimodal container transport in the future. How to make a scientific forecast of the sea-railway multimodal container transport and eliminate the uncertainty in the market, and explore the potential of the sea-railway multimodal container transport are the important questions that need to be studied.

4.1 Forecast data selection

This paper uses the throughput of goods and containers in Qingdao port from 2016 to 2015 to reasonably forecast the trend of the sea-railway multimodal container transport in Qingdao port. As is shown in Table 2.

4.2 Forecast of the sea-railway multimodal container transport in Qingdao Port based on the $GM(1,1)$

This paper uses matlab2014b to simulate the GM(1,1) model. Let the raw data of the throughput of goods and containers in Qingdao port from 2006 to 2015 as the original sequence, and then forecast the data in the following five years and estimate the average relative error. The results are shown in table 3 and table 4.

We can estimate the accuracy of the forecast model according to the residual error. If the level of accuracy is 1, then the relative error is 1%; if the accuracy is 2, then the relative error is 5%; if the accuracy is 3, then the relative error is 10%. According to the table 4-2 and 4-3, the relative errors are 2% and 2.25%, respectively, and the level of accuracy is 2. In fact, the relative errors are close to 1%, and we can consider that the results of the GM(1,1) model are reasonable.

4.3 Forecast of the sea-railway multimodal container transport in Qingdao Port based on the Markov modified model

$GM(1,1)$ model is an exponential function and has only one monotonicity. Therefore, $GM(1,1)$ model cannot estimate the changes in data. Hence, use Markov modified model to make up for this disadvantages and modify the results of the forecast.

First, divide the throughput of goods and containers into different groups according to the relative error of forecast. The relative errors of throughput of goods are divided into $E_1 \in (-5\%,-2\%)$, $E_2 \in (-2\%,1\%)$ and $E_3 \in (1\%,4\%)$. The relative errors of throughput of goods are divided into $E_1 \in (-7\%,-3\%)$, $E_2 \in (-3\%,-1\%)$ and $E_3 \in (1\%,5\%)$. According to the results in the tables, we can obtain state transition frequency matrix M of them correspondingly, and state transition probability matrix $P^{(m)}$.

The state transition frequency matrix of throughputs of goods is:

$$M_1 = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 1 & 2 \\ 1 & 1 & 2 \end{pmatrix}$$

Among them, M_{ij} denotes as frequency from i to j.

The state transition frequency matrix of throughputs is

$$P_1 = \begin{pmatrix} 0 & 1 & 0 \\ \frac{1}{4} & \frac{1}{4} & \frac{2}{4} \\ \frac{1}{4} & \frac{1}{4} & \frac{2}{4} \end{pmatrix} \quad P_1^{(2)} = \begin{pmatrix} \frac{1}{4} & \frac{1}{4} & \frac{1}{2} \\ \frac{3}{16} & \frac{7}{16} & \frac{3}{8} \\ \frac{3}{16} & \frac{7}{16} & \frac{3}{8} \end{pmatrix} \quad P_1^{(3)} = \begin{pmatrix} \frac{3}{16} & \frac{7}{16} & \frac{3}{8} \\ \frac{13}{64} & \frac{25}{64} & \frac{13}{32} \\ \frac{13}{64} & \frac{25}{64} & \frac{13}{32} \end{pmatrix}$$

$$P_1^{(4)} = \begin{pmatrix} \frac{13}{64} & \frac{25}{64} & \frac{13}{32} \\ \frac{51}{256} & \frac{103}{256} & \frac{51}{128} \\ \frac{51}{256} & \frac{103}{256} & \frac{51}{128} \end{pmatrix} \quad P_1^{(5)} = \begin{pmatrix} \frac{51}{256} & \frac{103}{256} & \frac{51}{128} \\ \frac{205}{1024} & \frac{409}{1024} & \frac{205}{512} \\ \frac{205}{1024} & \frac{409}{1024} & \frac{205}{512} \end{pmatrix}$$

$P^{(m)}$ Denotes as transferring steps, P_{ij}^{m} denotes as m steps from i to j

Because the state of the throughput of goods in 2015 is in E_2, then the initial vector $V_{2015} = \begin{pmatrix} 0 & 1 & 0 \end{pmatrix}$. We can determine the state from 2016 to 2020 by calculating the initial state quantity and transition matrix. Specifically, the throughput of goods in 2016 is in E_2; the throughput of goods in 2017 is in E_3; the throughput of goods in 2018 is in E_2; the throughput of goods in 2019 is in E_3; the throughput of goods in 2020 is in E_2.

The state transition frequency matrix of throughputs of containers is:

$$M_2 = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 2 & 2 \\ 0 & 2 & 1 \end{pmatrix}$$

Among them, M_{ij} denotes as frequency from i to j.

The state transition frequency matrix of throughputs is:

$$P_2 = \begin{pmatrix} 0 & 1 & 0 \\ \frac{1}{5} & \frac{2}{5} & \frac{2}{5} \\ \frac{1}{4} & \frac{1}{4} & \frac{2}{4} \end{pmatrix} \quad P_2^{(2)} = \begin{pmatrix} \frac{1}{5} & \frac{2}{5} & \frac{2}{5} \\ \frac{9}{50} & \frac{23}{50} & \frac{9}{25} \\ \frac{7}{40} & \frac{19}{40} & \frac{7}{20} \end{pmatrix} \quad P_2^{(3)} = \begin{pmatrix} \frac{9}{50} & \frac{23}{50} & \frac{9}{25} \\ \frac{91}{500} & \frac{227}{500} & \frac{91}{250} \\ \frac{73}{400} & \frac{181}{400} & \frac{73}{200} \end{pmatrix}$$

$$P_2^{(4)} = \begin{pmatrix} \frac{91}{500} & \frac{227}{500} & \frac{91}{250} \\ \frac{909}{5000} & \frac{756}{1663} & \frac{909}{2500} \\ \frac{727}{4000} & \frac{809}{1779} & \frac{727}{2000} \end{pmatrix} \quad P_2^{(5)} = \begin{pmatrix} \frac{909}{5000} & \frac{756}{1663} & \frac{909}{2500} \\ \frac{9091}{50000} & \frac{7574}{16663} & \frac{9091}{25000} \\ \frac{2425}{13337} & \frac{2019}{4442} & \frac{2423}{6663} \end{pmatrix}$$

$P^{(m)}$ Denotes as transferring steps, P_{ij}^{m} denotes as m steps from i to j

Because the state of the throughput of goods in 2015 is in E_2, then the initial vector $V_{2015} = \begin{pmatrix} 0 & 1 & 0 \end{pmatrix}$. We can determine the state from 2016 to 2020 by calculating the initial state quantity and transition matrix. Specifically, the throughput of containers in 2016 is in E_2; the throughput of containers in 2017 is in E_2; the throughput of containers in 2018 is in E_2; the throughput of containers in 2019 is in E_2; the throughput of containers in 2020 is in E_2.

Use Markov to modify the $GM(1,1)$ of throughputs of goods and containers, and let the median in each state as the relative error of predicted value, and then obtain the relative error between the actual value and predicted value modified by Markov model. Compare the relative errors of modified predicted value modified by Markov and those of $GM(1,1)$. The results are shown in table 5 and table 6.

According the table 5, the relative error of throughput of goods forecasted by $GM(1,1)$ is 2%, and decreases to 0.89% after modified by Markov model. Therefore, the accuracy of forecast increases to level1 from level 2.

According to table 6, the relative error of throughput of containers forecasted by $GM(1,1)$ is 2.25% and decreases to 1.6% after modified by Markov model. Although the accuracy of the forecast is still level 2, the accuracy increases by 0.85%.

It can be demonstrated that Gray-Markov model is superior to $GM(1,1)$. So we use Markov model to forecast the throughput of goods and containers in Qingdao port from 2016 to 2020. We can obtain the predicted value of Gray-Markov model by substituting the predicted value of $GM(1,1)$ and Markov modified relative errors. The results are shown in table7and table 8.

4.4 Forecasts analysis

It can be deduced that the Gray-Markov model is suitable to forecast the throughput of goods and containers in Qingdao Port. From the perspective of throughputs of goods, the predicted value increases by 11.08% in 2016, 11.18% in 2017, 4.64% in 2018, 11.18% in 2019, 4.64% in 2020. From the perspective of throughputs of containers, the predicted value increases by 8.43% each year from 2016 to 2020. We can find that the throughput of goods and containers will increase reasonably in the following yeas. Hence, developing the sea-railway multimodal container transports can meet the demands of the market.

Suggestions of the sea-railway multimodal container transport in Qingdao Port.

Based on above results, there are two problems existing in the sea-railway multimodal container transport in Qingdao port. One is existing in the economic and policy and the other is existing in the internal strengths.

Regarding the problems in the economic and policy, there are several following suggestions:

(1) Expand the economic hinterland of Qingdao Port

First, Qingdao port should accelerate the development of new markets and increase the competitiveness among other ports, such as Dalian port and so on. Second, Qingdao port should take advantage of its own location and increase contacts with overseas markets, increasing demands of the overseas market. Third, Qingdao should attempt to enter the inland markets and increase the market share. Finally, Qingdao port should cooperate with Lianyun port to become the leader among all ports in our country.

(2) Improve the network of transportation in Shandong peninsula and increase the efficiency of railway transportation

Shandong peninsula has not yet formed a comprehensive and efficient railway transportation network, seriously hampering the radiation effect of Qingdao port on inland regions. Also, old railways cannot adapt the rapid development of economy. So Qingdao port should improve the efficiency of transportation to match the rapid development of economy.

(3) Improve the coordination of sea and railway transportations

Qingdao port should set up specific agencies to coordinate maritime transport, railway transport and customs, and coordinates each agency to carry out multimodal transport.

(4) Take a more flexible and convenient tariff policy

Qingdao port should adjust the existing tariff mechanism and actively implement the differentiated pricing strategy. To be specific, Qingdao port can take differential and floating pricing strategy based on kinds of goods, distances and volumes.

(5) Take advantage of current policy and attempt to win support from new policy

Qingdao port should actively communicate with the local government and win the supports from policy as many as possible, including government subsidy, tax deduction and so on.

Regarding the problems in internal strengths, there are also several following suggestions.

(1) Strengthen the construction of infrastructure

Qingdao port can improve the basic level of sea-railway multimodal container transport and the conditions of railway transportation. Specifically, it should increase the capacity of railway transport and the capacity of disassembly of container transport.

(2) Increase the number of containers, especially the special containers

With the increase in throughputs of goods, Qingdao port should increase the number of containers to transport more goods. In addition, it should increase containers provided for specialties.

(3) Create an integrated information service platform for international trade

Qingdao port should take advantage of EDI platform in order to cooperate with traders, shipping companies. The large capacity of transporting goods needs a complete information system.

5. CONCLUSION

This paper uses Qingdao port as an example, and analyzes the status and problems of Qingdao port by SWOT. Then we forecast the trends of throughputs of goods and containers in Qingdao port by using $GM(1,1)$ and Markov model. According to the forecast, the throughputs of goods and containers in the following five years both increase. Finally, this paper provides several suggestions for the development of Qingdao port from the perspective of economic, environmental and Qingdao port.

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Appendix

Table 1 SWOT analysis

Strengths	Weaknesses	Opportunities	Threats
1. superior location; 2. well-developed in Qingdao; 3. comprehensive service and management system in port; 4. owns information network that connects the worldwide;	1. imperfect facilities in port and lack of related services; 2. lack related technology management talents; 3. compared with ports in Shanghai and Shenzhen, the economy develops slowly; 4. lack of capacity of transportation and inadequate infrastructure and equipment.	1. the volume of container is low and can be improved a lot; 2. the focus on international container transport transfers to Asia-Pacific regions; 3. Qingdao becomes the most important harbor city because of the support from policy; 4. the development of container transport is moving toward large-scale and deep-water.	1. several economical regions are shared by other ports and Qingdao port faces fierce competition; 2. fierce competitions from the worldwide, such as Korean, Japan and so on; 3. due to the close relationship with the global economy, Qingdao port is easily affected by the global economy.

Table 2 the throughput of goods and containers in Qingdao port from 2016 to 2015

Unit of goods throughput: ten thousand

Unit of containers throughput: TEU

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
goods	22365	26500	29998	31498	34999	37200	40699	45010	47710	48542
containers	767.97	945.99	1002.42	1026.24	1201.2	1302.01	1450.27	1552.68	1658.45	1732.47

Table 3 the forecast, residual value and relative error of the throughput of goods in Qingdao Port

Year	actual	forecast	residual value	relative error
2006	22365	22365	0	0.00%
2007	26500	27559	-1059	-4.00%
2008	29998	29727	271	0.90%
2009	31498	32065	-567	-1.80%
2010	34999	34587	412	1.18%
2011	37200	37307	-107	-0.29%
2012	40699	40241	458	1.13%
2013	45010	43406	1604	3.56%
2014	47710	46819	891	1.87%
2015	48542	50502	-1960	-4.04%
2016		54473		
2017		58757		
2018		63378		
2019		68363		
2020		73739		
		Average error		2%

Table 4 the forecast, residual value and relative error of the throughput of containers in Qingdao Port

year	actual	forecast	Residual value	Relative error
2006	767.97	767.97	0	0.00%
2007	945.99	933.66	12.33	1.30%
2008	1002.42	1012.37	-9.95	-0.99%
2009	1026.24	1097.7	-71.46	-6.96%
2010	1201.2	1190.23	10.97	0.91%
2011	1302.01	1290.56	11.45	0.88%
2012	1450.27	1399.34	50.93	3.51%
2013	1552.68	1517.3	35.38	2.28%
2014	1658.45	1645.2	13.25	0.80%
2015	1732.47	1783.88	-51.41	-2.97%
2016		1934.24		
2017		2097.29		
2018		2274.07		
2019		2465.76		
2020		2673.61		
		Average error		2.25

Table 5 comparisons of throughputs of goods between the Gray-Markov model and $GM(1,1)$

year	actual	forecast	Relative errors of $GM(1,1)$	states	Modified relative errors	Predicted value of Gray-Markov model	Relative errors of Gray-Markov model
2006	22365	22365	0.00%	E2	-0.50%	22253.73	0.50%
2007	26500	27559	-4.00%	E1	-3.50%	26627.05	-0.48%
2008	29998	29727	0.90%	E2	-0.50%	29579.10	1.40%
2009	31498	32065	-1.80%	E2	-0.50%	31905.47	-1.29%
2010	34999	34587	1.18%	E3	2.50%	35473.85	-1.36%
2011	37200	37307	-0.29%	E2	-0.50%	37121.39	0.21%
2012	40699	40241	1.13%	E3	2.50%	41272.82	-1.41%
2013	45010	43406	3.56%	E3	2.50%	44518.97	1.09%
2014	47710	46819	1.87%	E3	2.50%	48019.49	-0.65%
2015	48542	50502	-4.04%	E1	-3.50%	48794.20	-0.52%

Table 6 comparisons of throughputs of containers between the Gray-Markov model and $GM(1,1)$

year	actual	forecast	Relative errors of $GM(1,1)$	states	Modified relative errors	Predicted value of Gray-Markov model	Relative errors of Gray-Markov model
2006	767.97	767.97	0.00%	E2	-0.10%	767.20	0.10%
2007	945.99	933.66	1.30%	E3	3%	962.54	-1.75%
2008	1002.42	1012.37	-0.99%	E2	-0.10%	1011.36	-0.89%
2009	1026.24	1097.7	-6.96%	E1	-0.50%	1092.24	-6.43%
2010	1201.2	1190.23	0.91%	E2	-0.10%	1189.04	1.01%
2011	1302.01	1290.56	0.88%	E2	-0.10%	1289.27	0.98%
2012	1450.27	1399.34	3.51%	E3	3%	1442.62	0.53%
2013	1552.68	1517.3	2.28%	E3	3%	1564.23	-0.74%
2014	1658.45	1645.2	0.80%	E2	-0.10%	1643.56	0.90%
2015	1732.47	1783.88	-2.97%	E2	-0.10%	1782.10	-2.86%

Table 7 the predicted value of throughputs of goods from 2016 to 2020

year	value predicted by Gray model	state	Modified relative error	value predicted by Markov
2016	54473	E2	-0.50%	54201.99
2017	58757	E3	2.50%	60263.59
2018	63378	E2	-0.50%	63062.69
2019	68363	E3	2.50%	70115.90
2020	73739	E2	-0.50%	73372.14

Table 8 the predicted value of throughputs of containers from 2016 to 2020

year	Value predicted by Gray Model	state	Modified relative error	Value predicted by Markov
2016	1934.24	E2	-0.10%	1932.31
2017	2097.29	E2	-0.10%	2095.19
2018	2274.07	E2	-0.10%	2271.80
2019	2465.76	E2	-0.10%	2463.30
2020	2673.61	E2	-0.10%	2670.94