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Container Multimodal Transport Based On Railway-water Combined Transportation Coordination ：A Case Of China

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Container Multimodal Transport Based On Railway-water Combined Transportation Coordination: A Case Of China

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Abstract: Making great strides in social economy, demands for the material is growing, at the same time,it also stimulates the development of logistics.The railway-water combined transportation of our country is being into a golden opportunity, With the support of national policy and the improvement of railway transportation capacity,it's preparing for the development conditions of the railway-water combined transportation.What's the mixed, whether in traffic or on the quality of service about railway-water combined transportation, there is a big gap with developed countries.

This paper analyze the main problems in the development process of China's railway-water combined transportation, For solving these problems, the essay applies modern system theory, supply chain management and modern logistics theory, and coordination management, and other theoretical ideas,to construct coordination system and management system of railway-water combined transportation respectively to solve the problems that the development of railway-water combined transportation is limited from system angle.This article expounds the ability of the railway-water combined transportation system based on coordination, and illustrates the multi-path assignment Model from putting coordination theory into this system to optimize the system.

Keywords: railway-water combined transportation , synergy, Multi-path assignment model

1.I NTRODUCTION

Railway-water combined transportation has been carried out in China, but traffic volume propotion in ports with a slow growth is significantly low .Container throughput of mainland major ports in 2009 and 2010 are 122 million and 145 million TEUs, while among them, this throughput of railway-water combined transportation are just 1.224 million and 1.392 million TEUs which are equivalent to 1.00% and 1.18% （Table 1） of the total,lagging far behind the number of 20% in Europe,30% to 40% in the U.S. Highway transportation,waterway and railway accounted for about 78%, 20% and 1.5% of the amount of container collection and distribution of the national ports.

Experts does a large number of all-round, multi-angle studies revolving around the problems and solutions in railway-water combined transportation. Zhenyu Tang[1] accelerate the development status of the container seaports and railway containers of railway container, analyzes the main influencing factors, besides, made several recommendations to promote international container railway-water combined transportation in <Research on accelerating the Development of International Container Railway-water Combined Transportation. Dongxiao Liu[2] researched the theories about the application of the RFID technology in railway container center station .Jiqin Yang[3] analyzed collaborativly optimization to which the railway container transportation participating in the multimodal transport.Shoumin Peng, Yan Wang[4] expounded the operating proceduresunder to allocate and transprt empty containers and the supply and demand sources described among multimodal transport.Junwei Zhang[5] discussed elements and operation mechanism the global container transport network system in multimodal transportation.Yan Zeng , Peihua Zong[6] built multimodal transport co-development equation with order parameter of international

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container system capacity with synergetic theory.Junqing Shi[7] studied systematicly organization theory and method of seamless container transport .

Table 1． Situation of railway-water combined transportation among the Top 10 ports on China's container throughput in 2010

No.	Port	Container Throughput [Million TEU]	Railway-water combined transportation[Million TEU]	Proportion of ports' throughput[%]
1	Shanghai	2906.90	12.71	0.44
2	Shenzhen	2250.97	10.21	0.45
3	Ningbo	1314.40	6.82	0.52
4	Guangzhou	1255.00	2.67	0.21
5	Qingdao	1201.20	13.79	1.15
6	Tianjin	1008.00	15.43	1.53
7	Xiamen	582.00	3.80	0.65
8	Dalian	524.20	25.53	4.87
9	Lianyungang	387.00	19.30	4.99
10	Yingkou	333.80	28.94	8.67
	Total	11763.47	139.2	1.18

2. MAIN PROBLEMS OF RAILWAY-WATER COMBINED TRANSPOTATION

China's railway-water combined transportation has been moving forward with many problems nevertheless that hinder its development and a wide range of restrictions.

2.1 The uneven demand of railway-water combined transportation

China's economy belts distribution shape that the need of railway-water combined transportation is in few demand.China's major economic development zones are on the coast mostly that close to ports and so relatively speaking, it's better to be carried by road than railway.It's been thought the economic operation of the railway is more than 800 kilometers, without the coastal areas in it.

Mean time,how much the seaports rely on railway is different. There is a trend that all ports more and more rely on railway collecting and distributing ports ability.However, some certain constraints exist in China's overall economic environment including uneven and unbalanced transport facilities planning，so it is difficult to apply the same kind of mode.

2.2 Transportation capacity and quality needs to be improved

The insufficient railway transport capacity, especially the not high quality and the low volume of railway in ports' collecting and distributing restricte the development of railway-water combined transportation with high requirements.It's lack of effective interface between railway and waterway,besides,it's not well-connected between the railway and port on the integrated planning and construction issues of infrastructure.Besides, the international container railway-water combined transportation shipment arrangement is unbalanced in space,the information of container operation between port and rail is not unblocked,and these facts lead to a serious impacts directly on the facelift efficiency of international container railway-water combined transportation.

2.3 Development of other transport mode like Expressway.etc

In recent years, the declined cost of road transport and flexible price mechanism make highways account for a larger market share.After calculation, in the range of about 1200 km, road transport is competitive in price .

2.4 Large shortage of railway-water combined transport CTO

Because of the lack of CTOs who are able to comprehensivly coordinate all aspects of operation of the entire inter-modal system, and can really take full responsibility for multimodal transport, the advantages of multimodal transport has not been fully exploited.

3. SYNERGY SYSTEM CONSTRUCTION

3.1 Composition of coordination system

The railway-water combined transportation system synergy include two meanings: on the one hand it refers to the internal coordination of the container railway-water combined transportation system.Internal coordination is based on the synergies of the various subsystems which is coordination between each subsystem within the system in the total ratio, spatial layout, the level of technology, organization and management, technology policy.On the other hand it is mainly reflected in the coordination between system and outside world on the total demand and on space.

From the perspective of system science, railways, waterways, and even highways which establish there own complicated system constitute railway-water combined transportation system
system,and its complexity is mainly reflected in the diversity, interrelated dynamics and polyphyly of constituent elements.According to the views of Synergetics, the system can usually be divided into three levels: macro, meso and micro.The so-called macro refers to the whole system, meso is the various subsystems and micro refers to the basic component elements of the system.

Meso structure of the the container railway-water combined transportation collaboration system is composed by three parts of railway transportation, port transit, waterway transportation, as shown in Fig.1

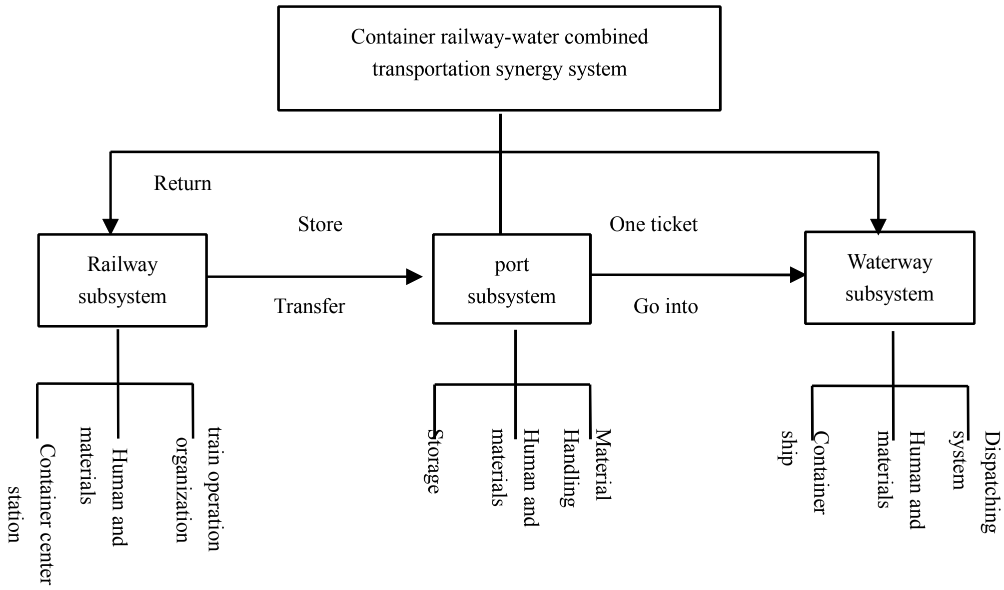

Fig.1 Container railway-water combined transportation synergy system structure

3.2 Optimization Model

The container network consist of container freight station, container ports and their transport routes connect them.What should be considered in container railway-water combined transportation system capacity coordination is to deal with the interaction and integration between the optimization of the layout of the nodes in the system and the network traffic flows.

Container network assignment problem is to solve the problem of container flow features between the container freight stations and container ports with measures of allocating the amount of container O-D trip distribution into the transport network.On the one hand, to achieve the purpose of the rational organization of container transport; On the other hand, make transportit lines more efficient in planned ways to to incrsease the transport capacity of the transport lines reasonablly.What's more,we need to consider two interactional aspects on the container transport network assignment problem.

◆ The allocation of container traffic in the transport network is result of the container users free behavior to choose, which is limited in integrative service level of multimodal transportation corridor to which the place container traffic begin belong.Container users take full account of all the factors involved in the entire transport process and evaluate the degree service meet their requirments,then choose a certain combination of the transport modes on their predicted routs to accomplish the whole process. This choice is often carried out from an overall perspective without the performance of segmented and partial cumulative characteristics.

Container transport network between the O-D is shown as Fig.2

◆

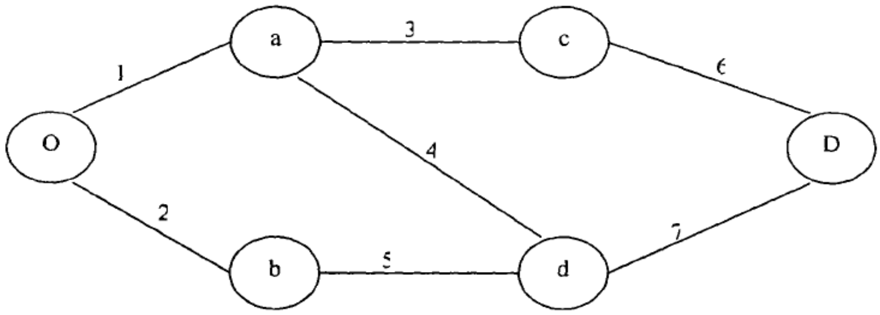

Fig.2 O-D Transport network diagram

Container users could select from the following three O-D container shipping lines:

① O → 1 → a → 3 → c → 6 → D

② O → 1 → a → 4 → d → 7 → D

③ O → 2 → b → 5 → d → 7 → D

The user not only examine the transportation demand satisfactory degree of the nodes a, b, c,d as well as the arc 2,3,4,5,6,7 when they select a line as their transport rout,but also combine the nodes and arcs to contrast the ① ② ③ as a whole to choose the most satisfactory transport route.The another measure is to investigate separately the extent to meet the transport needs of the transport line of the nodes and the arcs,and then accumulate two elements' satisfaction degrees to determine a certain route.However,these two ways are essential different.

◆ China's investment and construction as well as policy guidance on the nodes and arcs in the container transport network is based on taking into account the status quo that the extent container transport network meet the container users needs and the state development planning on regional economic and transport. In addition,in order to achieve the expected allocation of container traffic in the container transport network,It's been suggested to induce the users' choice behaviors through the planning and construction based on current situation. However, due to the choice of container transport routes is made from the analysis of the overall perspective of transport routes, if the investment in building and policy guidance on some node or arc of the container transport network of the state is able to achieve the desired purpose, depending on whether the investment and construction and the formulation of policy guidance insist on the point of view of the system, and comprehensivly survey the various factors affecting the transport routes.

3.3 Multi-path assignment model

According to the feature of the container transport network assignment, multi-path assignment model is selected to solve the container traffic allocation problem in the transport network[8].

The network users always want to choose the most appropriate path, known as the shortest path factors according to this modal.Nevertheless, because of the randomness of the traffic conditions and complexity of the network, users are so basically impossible to have complete information on choosing the path that each user choose the path with a kind of uncertainty known as randomness.So users will conside the shortest path factors and random factors allsidedly.According to the random assignment model proposed by Dial in 1971:

$$f_{ij}^r = \frac{q_{ij} h_{ij}^r}{\sum_r h_{ij}^r} \tag{1}$$

In order to compare with each other in reasonable paths， introduct the generalized cost functions and computation formula for calculating the flow of the r-th reasonable path between point i to j :

$$f_{ij}^r = \frac{q_{ij} \exp(-\theta C_{ij}^r)}{\sum_r \exp(-\theta C_{ij}^r)} \tag{2}$$

f_{ij}^r - the flow of the rth reasonable path between point i to j ;

q_{ij} -the traffic from point i to point j;

C_{ij}^r -the generalized cost of the r-th reasonable path from point i to j;

θ - coefficient controlling traffic distribution between the paths

Current random assignment model is to combine Dial random assignment model and generalized cost flow model.And the key to calculate f_{ij}^r with (2) model is to determine θ .Therefore, the introduction of entropy principle to determine the θ is in needs.

The entropy is a measure of the degree of a system ordering.According to the entropy principle, independent system is always change from orderly to disorderly direction which is the process of entropy increasing.In terms of Wardrop criteria:no matter from the point view of the network system or the network user's,flow distribution in the network, is a process of entropy increase based on cost, and follow the following constraints:

$$\sum_r q_{ij} = D_j \tag{3}$$

$$\sum_r q_{ij} = O_i \tag{4}$$

Therefore, the final allocation result is a result of the maximum entropy based on the constraint of (3) and

(4).

For the purpose of building a entropy assignment criteria according to entropy distribution principal,assume the O-D matrix of network is known,and p_{ij}^{r} stand for the flow distribution probability of the r-th rational path between point i to j in network.Then define each combination of all p_{ij}^{r} in the network as a "state",thus, according to the theory of permutations and combinations, deduce entropy maximum principle:

$$W(p_{ij}^{r}) = \frac{(\sum_{r} p_{ij}^{r})!}{\prod_{r} p_{ij}^{r}!} \tag{5}$$

$W(p_{ij}^{r})$ is occurrence opportunities value of p_{ij}^{r}.Simplify (5) by using approximate formulas $\ln x! = x\ln x - x$, and define the network system's entropy as S(p_{ij}^{r}), let

$$S(p_{ij}^{r}) = \ln W(p_{ij}^{r}) = (\sum_{r} p_{ij}^{r}) \ln (\sum_{r} p_{ij}^{r}) - \sum_{r} p_{ij}^{r} - \sum_{r} (p_{ij}^{r} \ln p_{ij}^{r} - p_{ij}^{r}) \tag{6}$$

Let $\sum_{r} p_{ij}^{r}$ to be a constant so the formula begging maximum of S(p_{ij}^{r}), which is the entropy formula of network traffic allocation .

$$\max S = -\sum_{r} (p_{ij}^{r} \ln p_{ij}^{r} - p_{ij}^{r}) \tag{7}$$

Fig.3 Multipath flow distribution diagram

According to the figure, there are n reasonable paths from i to j of the flow, traffic distributed to each of them is f_{ij}^{r} ,flow q_{ij} from point i to j is:

$$q_{ij} = \sum_{r} f_{ij}^{r} \tag{8}$$

The probability p_{ij} to select the r-th path for network users is :

$$p_{ij}^{r} = \frac{f_{ij}^{r}}{q_{ij}^{r}} \tag{9}$$

Network users observed universally minimum cost principle when they choose the path:

$$\min C = \sum_{r} p_{ij}^{r} C_{ij}^{r} \tag{10}$$

Make normalization processing for the formula (2), can be obtained:

$$\theta = -\frac{\ln p_{ij}^{r}}{C_{ij}^{r}} \tag{11}$$

Researching the relationship between the minimum cost and θ from the point of view of the network, define a factor:

$$k = -\frac{\sum_{r}(p_{ij}^{r}\ln p_{ij}^{r} - p_{ij}^{r})}{\sum_{r} p_{ij}^{r} C_{ij}^{r}} \tag{12}$$

k has maximum theoretically, moreover, p_{ij}^{r} satisfing the max.k must be the optimum probability of value assignment in network.And thus seeking the first partial derivative to (12), and let it be θ:

$$\frac{\partial k}{\partial p_{ij}^{r}} = -\frac{-\ln p_{ij}^{r}(\sum_{r} p_{ij}^{r} C_{ij}^{r}) + C_{ij}^{r}\sum_{r}(p_{ij}^{r}\ln p_{ij}^{r} - p_{ij}^{r})}{(\sum_{r} p_{ij}^{r} C_{ij}^{r})^{2}} = 0$$

$$\frac{\ln p_{ij}^{r}}{C_{ij}^{r}} = -\frac{\sum_{r}(p_{ij}^{r}\ln p_{ij}^{r} - p_{ij}^{r})}{\sum_{r} p_{ij}^{r} C_{ij}^{r}} \tag{13}$$

Seeking the second derivative of (13):

$$-\frac{(\sum_{r} p_{ij}^{r} C_{ij}^{r}) / p_{ij}^{r}}{(\sum_{r} p_{ij}^{r} C_{ij}^{r})^{2}} < 0$$

Resultingly, the model reveal that network flow assignment is essentially the unification of the minimum cost under the flow control and the maximum probability.

4.CONCLUSION

This article regard railway-water combined transportation network and IT system as the cornerstone to build railway-water combined transportation synergy system.Furthermore, the paper discusses the allocation of container railway-water combined transportation system's capability and establish a network flow distribution model with the collaborative theory to improve capacity of the railway-water combined transportation system.

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