Using Markov Process for Passenger Structure Prediction within Comprehensive Transportation Channel

Dong Wang and Xiaonian Sun
China Academy of Transportation Sciences/ Transportation Technical Advisory Center, Beijing China
Email: 18811221198@163.com

Yanhong Li
Beijing Jiao Tong University/ School of Traffic and Transportation, Beijing China
lisa813328@163.com

***Abstract*—Comprehensive transportation Channel is the backbone of the regional transport system. The Channel structure configuration is a direct means of adjusting channel development state to meet the needs of traveler. By using fundamental analysis of the affecting factors and mechanism of passenger structure evolution within comprehensive transportation Channel, this paper presents a model on the basis of Markov chain theory to predict passenger structure evolution. We verified the quality and accuracy of the parameters in this paper, and implemented this model successfully in Beijing-Shanghai Channel. This application indicated that the integration model was effective and efficient in dynamic traffic demand forecasting. This study makes crucial contributions to the theory of comprehensive transportation system.**

***Index Terms*—Comprehensive Transportation Channel, Passenger structure, Prediction, Markov process, Least square method, Orthogonal test**

I. Introduction

Comprehensive transportation Channel is a kind of multiple levels and traffic modes integrated transport system which connects main distributing points of passenger and freight across the region, and takes large scale and stable traffic flow among different distributing points. The prediction of passenger structure evolution investigates the evolution trend and direction of the composition of various traffic modes inside transport industry.

Reference [1] built the game model for traffic custom evolution of urban resident groups under the condition of incomplete information and made a study of the structure evolution trend of urban public transport system, which was based on the accumulated experience and inherent expectations generated while urban resident groups choose their travel mode of public transport. Reference [2] built the entropy calculation model for road transport system in metropolitan circles and made a study of the structure evolution direction for the transport system, which was based on the theory of dissipative structure. Reference [3] analyzed the evolution rules and trends of passenger structure for China's transport Channel in theory. Reference [4] proposed a network-based model to evaluate the market share for various competitive traffic modes within regional transport Channel. Reference [5] and reference [6] made the studies of models and methods to determine the market share respectively for high-speed railway within transport Channel, and made some case studies.

What we can see from the above mentioned: those studies either focused on the evolution trend of passenger structure in urban public transport or metropolitan circles, or focused on reasonable allocation and optimization of passenger structure within comprehensive transportation Channel, or made a qualitative analysis for the evolution direction and trend of passenger structure within comprehensive transportation Channel. There are fewer studies focused on the prediction of passenger structure evolution within comprehensive transportation Channel. This paper makes a prediction of passenger structure evolution trend based on Markov process within comprehensive transportation Channel.

II. Evolution Mechanism for Passenger Structure within Comprehensive Transportation Channel

A. Main Factors That Affecting Passenger Structure

A certain level of socio-economic development requires not only the matching transport capacity, but also proper distribution of transport capacity between different transport modes. With the social and economic development, passenger structure has always been changing. The main factors affecting the evolution of passenger structure are as follows:

1) Economic development

Studies have shown that traffic development level and its structure changes are relevant closely to the level and stage of economic development with a certain rules. In principle, the level of economic development determines people's consumption level, patterns and attitudes. When industry structure adjustments, then traffic structure

doi:10.4304/jcp.8.4.1072-1077

changes accordingly. Under the condition of economy development lagging, traffic structure gives priority to freight, most transport categories are big size items with lower added value, and the primary mission of passenger transport is to meet travel demand. At this point transport mode is dominated by traditional mode. Along with economic developing, people's income level improving and consumption attitudes changing, the emerging modern transport mode has been popular. Accordingly, economic development is a main factor resulting in traffic structure changing.

2) Sci-tech progress

Sci-tech progress supports and promotes transportation industry forward. With the progress of technology and the emergence of new vehicles, this inevitably leads to changes in transportation. From the perspective of integrated transport system, transportation trends is to transform the coexistence of multiple transport modes from single mode, and forms high efficiency, reasonable and stable traffic structure through advantage complementary and division of labor. From this point, the changes of traffic structure directly reflect technology progress.

3) Competition between different transport modes

Different modes of transport have their own technical and economic characteristics, and that determines the objective basis for the coexist of various transport modes in traffic structure. The growth of transport capacity is usually jumping growth, and it is impossible to accord with relevant transport demand, so there is at least one transport mode and its supply capacity cannot run in full play for the most suitable transport demand, while a certain of transport demand need to be met by two or more transport modes. And it will be forced to meet the less suitable transport demand by the way of 'supply replacement'. In fact, 'supply replacement' of any transport mode first appears in the common supply field, and that will influence the supplies of other transport mode, then result in competition. There is always the competition relationship between various transport modes in reality, but the competition intension is different, and different competition results generate different traffic structure.

B. *Evolution Mechanism of Passenger Structure*

The evolution of passenger system within comprehensive transportation Channel is combined with economic development along the Channel and there is a complex and two-way mechanism between these two items. The complexity reflects not only how various social and economic factors impact passenger system development, but also how passenger system boosts economic growth along the Channel. In addition, the mechanism can be regarded as the same type in theory, but there is difference in practice due to different environment and time, and that adds the complexity of the relationship between passenger system and economy along the Channel in further. The complex and two-way mechanism between passenger system and economic environment along the Channel will directly impact the evolution of passenger structure. From figure1, we can see that diversifying passenger demand raised by social and economic environment along the Channel is the root cause for the existence of passenger system. Different technical and economic characteristics lead to different adaptability for various transport demand while they meet the demand. According to the theory of consumer equilibrium, different transport demand will always seek the optimal transport mode, and then form a certain transport structure. The shaped transport structure will change with the changes of quality and quantity of passenger demand raised by social and economic environment along the Channel. The evolution of social and economic environment along the Channel follows a certain rules, so there are some common trends for the change of passenger structure. Meanwhile, transport mode is restricted by various objective conditions of nature, geography, policy and so on, while it meets passenger demand along the Channel, then that makes the evolution of passenger structure different.

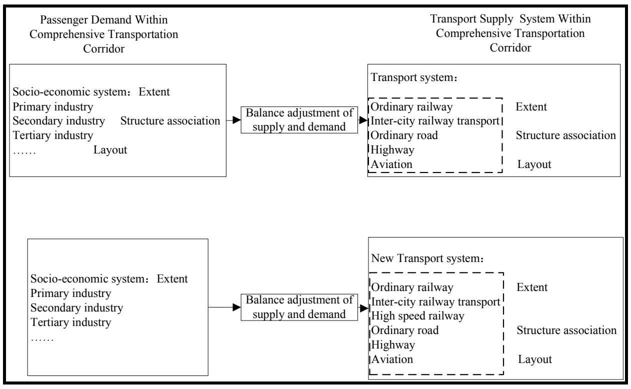

Figure 1. The Evolution Mechanism of Transport Structure.

III. BASIC ASSUMPTIONS AND SYMBOL DEFINITIONS

A. *Symbol Definitions*

i ——No i traffic mode,(i = 1…5)

j ——No j traffic mode,(j = 1…5)

t ——Period symbol

n Iteration number

$X^{(0)}$ The initial state

$X^{(n)}$ No n iteration result

$X^{(n+1)}$ No $n+1$ iteration result

p_{ij} One step transition probability

$P^{(n+1)}$ State transition probability

$f_i(t)$ Proportion of transport capacity structure of No i mode in t period

$\Delta f_{ij}(t)$ The proportion of transport capacity structure transferred from No i to No j mode in the period from t to $t+1$

G_{ij} Proportion factor, and will determine the size of transfer capacity $\Delta f_{ij}(t)$ over time

Δ_s	A positive constant determined by $G_{ij}^{(0)}$ value and satisfaction of initial estimate value.
K	Level of orthogonal test
m	Factor of orthogonal test
N	Number of samples
S	Simulation times
$G_{ij}^{(S)}$	The valve at a certain level when G_{ij} runs No S simulation.
$\bar{R}_s$	Objective function
ρ	Sample data length in the period of non-adaptation.

B. Basic Assumptions

$$f_1(t)+f_2(t)+\cdots+f_m(t)=1 \quad (1)$$

$$f_i(t)=\sum_{j=1}^{m}\Delta f_{ij}(t) \qquad i=1,2,\cdots\cdots,m \quad (2)$$

$$f_i(t+1)=\sum_{j=1}^{m}\Delta f_{ji}(t) \quad i=1,2,\cdots\cdots,m \quad (3)$$

Expression (1) means that passenger demand within comprehensive transportation Channel is shared and done together by all modes of transport. Assume the proportions of the transport capacity of all transport modes accounting for 1.

Expression (2) states: transport capacity structure proportion $f_i(t)$ of No i mode in period t will be transferred to the modes from No i to No m by certain probability from period t to $t+1$.

Expression (3) states: transport capacity structure proportion of No i mode in period $t+1$ will be transferred from all modes from No i to No m .

As the inertia of the evolution of transport structure, so assume that transport capacity proportion of No i mode in period t is not concerned with transport capacity proportion of other modes in the period, and it is only concerned with the proportion $f_j(t+1)(j=1,2,\cdots,m)$ of transport capacity structure of all modes in the previous period. And assume that from period t to $t+1$, the proportion $\Delta f_{ij}(t)$ of transport capacity structure of No j mode got from No i mode has a certain of proportion relationship with the proportions $f_i(t)$ and $f_j(t)$ of transport capacity structure of No i and j modes in period t : $\Delta f_{ij} \propto f_i(t)\cdot f_j(t)$, i.e.:

$$\Delta f_{ij}(t)=G_{ij}\cdot f_i(t)\cdot f_j(t) \quad (4)$$

IV. PREDICTION MODEL BASED ONMARKOV PROCESS

Markov process is a random process without aftereffect, and the prediction expression is as follows:

$$X^{(n+1)}=X^{(0)}\cdot P^{(n+1)}. \quad (5)$$

Or expressed as:

$$X(n+1)=X(n)\begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1N} \\ p_{21} & p_{22} & \cdots & p_{2N} \\ \vdots & \vdots & \vdots & \vdots \\ p_{N1} & p_{N2} & \cdots & p_{NN} \end{bmatrix} \quad (6)$$

Markov model has shown that No operation result only depends on No result and state transition probability. No operation result only depends on No result and state transition probability, the whole transition process is Markov chain. Use Markov chain to predict future trend for random event, is the same as use transition probability matrix of random event under various states to calculate. This prediction method has the advantage of only required recent data, without a lot of historical data. And Markov analysis model is a dynamic model, which can be used both for short-term model and long-term predication. The disadvantage is that it is necessary to make the actual investigation while obtaining the required data for determining transition probability matrix.

Under Markov theory, when it meets the condition after multi-step state transition, the Markov chain will gradually stabilize, and this state has nothing to do with the initial state. From a long-term perspective, this nature means that the share of transport structure of various transport modes will not change greatly as time goes by, and can reach a relative stable state. The examples can be found in the evolution of transport structure in the developed countries, for example, the structure share of U.S. freight volume has remained small changes since 1980s. The transport structure with basic stability is called transport equilibrium structure which reflects long-term general trend without impact from recent volatility. Accordingly, refer to the evolution of transport mode in developed countries and for the foregoing evolution rules and trends of China's transport structure, there must be a Markov chain that can make our transport structure to become more mature and stable in the future.

The dynamic evolutions process of many economic systems can be abstracted as state transition process. We can use Markov theory to make the study of dynamic transition track of the evolution of transport system structure. Transition probability matrix is the key to predict based on Markov chain theory. For many practical problems, we are unable to get transition probability matrix by the way of market survey. According to the characteristics of transport structure change, and using the method of optimization and simulation to approximate the actual state, this paper takes Markov chain process as the theoretical basis, then proposes multi-product alternative prediction model to predict transport structure.

Based on above basic assumptions, substitute above equations, and then we can get the function expression of prediction model as follows:

$$f_i(t)=\sum_{j=1}^{m} G_{ij}\cdot f_i(t)\cdot f_j(t)\ \ i=1,2,\cdots\cdots,m. \quad (7)$$

$$f_i(t+1)=\sum_{j=1}^{m} G_{ji}\cdot f_j(t)\cdot f_i(t)\ \ i=1,2,\cdots\cdots,m \quad (8)$$

Make above two expressions divided by $f_i(t)$, and then we can get the model expression of transport structure trend as follows:

$$\begin{cases}\sum_{j=1}^{m} G_{ij}\cdot f_i(t)=1\\ \sum_{j=1}^{m} G_{ji}\cdot f_i(t)=f_i(t+1)/f_i(t)\end{cases}. \quad (9)$$

Therefore, if it meets certain accuracy, it can be used to predict transition matrix. The above expression also can be described as:

$$(f_1(t+1)/f_1(t),\, f_2(t+1)/f_2(t),\cdots,\, f_m(t+1)/f_m(t))$$
$$=(f_1(t),\, f_2(t),\cdots,\, f_m(t))\cdot\begin{bmatrix}G_{11} & G_{12} & \cdots & G_{1m}\\ G_{21} & G_{22} & \cdots & G_{2m}\\ \vdots & \vdots & \vdots & \vdots\\ G_{m1} & G_{m2} & \cdots & G_{mm}\end{bmatrix}$$

(10)

V. Parameter Estimation

Step1:Use least square method to estimate the initial estimate of parameter G_{ij} in expression (9), and recorded as $G_{ij}^{(0)}$.

Step2:Calculate return error, if it meets the accuracy, make a prediction, and else go on.

Step3:Take G_{ij} as simulation test factor (total $m\times m$) in the orthogonal test, and take $G_{ij}^{(0)}$ as basic value to give initial level valve corresponding to each G_{ij}. For easy calculation, usually take three initial levels: $G_{ij}^{(0)}-\Delta$, $G_{ij}^{(0)}$, $G_{ij}^{(0)}+\Delta$, in which, Δ_s is a positive constant determined by $G_{ij}^{(0)}$ value and satisfaction of initial estimate value.

Step4:Select orthogonal table and take G_{ij} to run an orthogonal test of K level of factor $m\times m$, in the simulation process of orthogonal test, the selected objective function is:

$$\bar{R}_s=\frac{1}{N}\sum_{t=1}^{N}\sum_{j=1}^{m}\left\{\left[1-\sum_{j=1}^{m}G_{ij}^{(S)}f_j(t)\right]^2+\left[f_i(t+1)\Big/f_i(t)-\sum_{j=1}^{m}G_{ji}^{(S)}f_j(t)\right]^2\right\}$$

(11)

Step5:Determine whether the simulation of orthogonal test proceeds according to simulation results and the satisfaction of relative target value and error to get optimal estimate value of parameter. If necessary, replace $G_{ij}^{(S-1)}$ with new value $G_{ij}^{(S)}$, and calibrate Δ_s to Δ_{s+1}, then go to Step 2, else the test is completed.

To make that model can predict in a long term in practice, the parameters of this model need to be calibrated. The basic calibration method is: in orthogonal test, under the condition of making the model properly fitting to historical data, in the process of man-machine dialogue determined by the direction and magnitude of calibration of parameter factor G_{ij}, and integrates qualitative analysis results, and run simulation calibration again and again. Finally, we can select parameter calibration program which not only makes the model with good fitting of recent historical data, but also can be accepted by the qualitative results.

In the process of actual parameter estimation, for improving the ability of the model adapting to recent data and the accuracy of model prediction, and adjust the objective function as follows:

$$\bar{R}_s=\frac{1}{N-\rho}\sum_{t=\rho}^{N}\sum_{j=1}^{m}\left\{\left[1-\sum_{j=1}^{m}G_{ij}^{(S)}f_j(t)\right]^2+\left[f_i(t+1)\Big/f_i(t)-\sum_{j=1}^{m}G_{ji}^{(S)}f_j(t)\right]^2\right\}$$

(12)

VI. Empirical Study of Beijing-Shanghai Channel

A. Data Collection of Beijing-Shanghai Channel

Summary of passenger capacity of Beijing-Shanghai Channel in historical years, see Table Ⅰ.

B. Initial Transfer Matrix Calculation and Model Accuracy Test

First calculate initial transfer matrix of passenger capacity of the four transport modes as railway, highway, waterway and civil aviation. This paper builds multiple linear regression models and uses least square method to deduce estimation expression:

$$G^{(0)}=(X^TX)^{-1}X^TY. \quad (13)$$

In Which,

$$X=\begin{bmatrix}f_1(1990) & f_2(1990) & f_3(1990) & f_4(1990)\\ f_1(1991) & f_2(1991) & f_3(1991) & f_4(1991)\\ \cdots & \cdots & \cdots & \cdots\\ f_1(2008) & f_2(2008) & f_3(2008) & f_4(2008)\end{bmatrix}=\begin{bmatrix}15.0 & 82.3 & 2.6 & 0.12\\ 16.2 & 81.3 & 2.4 & 0.14\\ \cdots & \cdots & \cdots & \cdots\\ 5.42 & 94.19 & 0.39 & 1.33\end{bmatrix}$$

$$Y=\begin{bmatrix}f_1(1991) & f_2(1991) & f_3(1991) & f_4(1991)\\ f_1(1992) & f_2(1992) & f_3(1992) & f_4(1992)\\ \cdots & \cdots & \cdots & \cdots\\ f_1(2009) & f_2(2009) & f_3(2009) & f_4(2009)\end{bmatrix}=\begin{bmatrix}16.2 & 81.3 & 2.4 & 0.14\\ 13.7 & 83.7 & 2.3 & 0.21\\ \cdots & \cdots & \cdots & \cdots\\ 5.73 & 93.52 & 0.74 & 0.74\end{bmatrix}$$

Use Matlab software to deduce initial transfer matrix, and the estimation expression is as follows:

$$G^{(0)}=\begin{bmatrix}G_{11}^{(0)} & G_{12}^{(0)} & G_{13}^{(0)} & G_{14}^{(0)}\\ G_{21}^{(0)} & G_{22}^{(0)} & G_{23}^{(0)} & G_{24}^{(0)}\\ G_{31}^{(0)} & G_{32}^{(0)} & G_{33}^{(0)} & G_{34}^{(0)}\\ G_{41}^{(0)} & G_{42}^{(0)} & G_{43}^{(0)} & G_{44}^{(0)}\end{bmatrix}=\begin{bmatrix}0.2871 & 0.7539 & 0.0227 & -0.0340\\ 0.0221 & 0.9642 & -0.0002 & 0.0060\\ 3.5937 & -3.3068 & 0.7419 & 0.0283\\ 0.3417 & 0.6088 & -0.0259 & 0.7438\end{bmatrix}$$

TABLE I.
PASSENGER VOLUME AT THE HISTORY YEAR OF BEIJING-SHANGHAI CHANNEL UNIT: TEN THOUSAND PERSONS

Year	Beijing-Shanghai Channel										National passenger volume	Ratio of Beijing-Shanghai accounts for China
	Sum		*Highway*		*Railway*		*Water Way*		*Civil Aviation*			
	Passenger volume	*Proportion*	*Passenger volume*	*Proportion*	*Passenger volume*	*Proportion*	*Passenger volume*	*Proportion*	*Passenger volume*	*Proportion*		
1985	130945	100.0%	99454	76.0%	25754	19.7%	5586	4.3%	151.1	0.12%	620206	21.1%
1990	156471	100.0%	128759	82.3%	23435	15.0%	4085	2.6%	192.1	0.12%	772682	20.3%
1991	165005	100.0%	134083	81.3%	26719	16.2%	3965	2.4%	238.2	0.14%	806048	20.5%
1992	176617	100.0%	147880	83.7%	24224	13.7%	4144	2.3%	369	0.21%	860855	20.5%
1993	179494	100.0%	150314	83.7%	25657	14.3%	3052	1.7%	471.2	0.26%	996634	18.0%
1994	191300	100.0%	162193	84.8%	25684	13.4%	2857	1.5%	565.5	0.30%	1092883	17.5%
1995	233783	100.0%	204426	87.4%	25710	11.0%	2932	1.3%	715	0.31%	1172596	19.9%
1996	243537	100.0%	216862	89.0%	23056	9.5%	2869	1.2%	749.6	0.31%	1244722	19.6%
1997	251774	100.0%	224955	89.3%	23395	9.3%	2675	1.1%	749	0.30%	1325364	19.0%
1998	286447	100.0%	258519	90.3%	24147	8.4%	2743	1.0%	1037.8	0.36%	1377252	20.8%
1999	307501	100.0%	278090	90.4%	24705	8.0%	2833	0.9%	1872.6	0.61%	1394413	22.1%
2000	329645	100.0%	298857	90.7%	25659	7.8%	2737	0.8%	2391.5	0.73%	1478573	22.3%
2001	347659	100.0%	316432	91.0%	26046	7.5%	2412	0.7%	2768.5	0.80%	1534122	22.7%
2002	374705	100.0%	341129	91.0%	27267	7.3%	2855	0.8%	3454	0.92%	1608150	23.3%
2003	368778	100.0%	338511	91.8%	24880	6.7%	2498	0.7%	2889	0.8%	1587497	23.2%
2004	427437	100.0%	390468	91.35%	29649	6.94%	2830	0.66%	4490	1.05%	1767453	24.18%
2005	424367	100.0%	383484	90.37%	31390	7.40%	2843	0.67%	6650	1.57%	1847018	22.98%
2006	456359	100.0%	418695	91.75%	34683	7.60%	2981	0.65%	4633	1.18%	2024158	22.55%
2007	519150	100.0%	478810	92.23%	36946	7.12%	3394	0.65%	4953	1.25%	2227761	23.30%
2008	755357	100.0%	711488	94.19%	40926	5.42%	2943	0.39%	5273	1.33%	2867892	26.34%
2009	753549	100.00%	704758	93.52%	43182	5.73%	5609	0.74%	5593	0.74%	2976898	25.31%

Note: Data Source: China Statistics Abstract, China Transportation Yearbook.

TABLE II.
POST-PREDICTION AND RETURN ERROR FOR SHARING RATIO OF PASSENGER CAPACITY OF ALL MODES OF TRANSPORT

Year	Rail Way			Highway			Water Way			Civil Aviation		
	Predict Value	*Real Value*	*Relative error*	*Predict Value*	*Real Value*	*Relative error*	*Predict Value*	*Real Value*	*Relative error*	*Predict Value*	*Real Value*	*Relative error*
2000	7.73	7.80	-0.90	90.59	90.70	-0.12	0.81	0.80	1.25	0.75	0.73	2.74
2001	7.36	7.50	-1.87	91.13	91.00	0.14	0.73	0.70	4.29	0.84	0.80	5.00
2002	6.95	7.30	-4.79	91.57	91.00	0.63	0.75	0.80	-6.25	0.9	0.92	-2.17
2003	7.29	6.70	8.81	91.16	91.80	-0.70	0.71	0.70	1.43	0.86	0.80	7.50
2004	6.74	6.94	-2.88	91.74	91.35	0.43	0.63	0.66	-4.55	0.95	1.05	-9.52
2005	6.74	7.40	-8.92	91.77	90.37	1.55	0.62	0.67	-7.46	1.51	1.57	-3.82
2006	7.06	7.60	-7.11	91.46	91.75	-0.32	0.6	0.65	-7.69	1.27	1.18	7.63
2007	6.95	7.12	-2.39	92.77	92.23	0.59	0.6	0.65	-7.69	1.19	1.25	-4.80
2008	5.94	5.42	9.59	92.91	94.19	-1.36	0.4	0.39	2.56	1.26	1.33	-5.26
2009	5.56	5.73	-2.97	93.49	93.52	-0.03	0.53	0.74	-2.70	1.07	0.74	8.11

Take relative return error limit as 10%, then above prediction meets the accuracy requirements, so we can use this matrix directly to predict.

C. Predictions

Use expression (10) to predict passenger turnover for Beijing-Shanghai Channel in the next few years, and see the prediction results with and without high speed highway in Table Ⅲ and Ⅳ.

TABLE III.
SHARE RATIO PREDICTION OF PASSENGER CAPACITY IN BEIJING-SHANGHAI CHANNEL WITHOUT HIGH SPEED RAILWAY (%)

Year	Railway	Highway	Water Way	Civil Aviation
2010	5.30	92.99	0.32	1.38
2011	5.20	93.09	0.30	1.41
2012	5.10	93.19	0.28	1.43
2013	5.01	93.28	0.26	1.44
2014	4.94	93.35	0.25	1.47
2015	4.87	93.41	0.24	1.48
2020	4.63	93.64	0.20	1.54

TABLE IV.
SHARE RATIO PREDICTION OF PASSENGER CAPACITY IN BEIJING-SHANGHAI CHANNEL WITH HIGH SPEED RAILWAY (%)

Year	Highway	Civil Aviation	Existed Railway	Expressed Railway	Inter-city Railway
2012	15.21	4.60	9.11	40.67	30.41
2015	14.49	4.24	7.35	40.80	33.12

VII. ANALYSIS OF EVOLUTION TEND FOR PASSENGER STRUCTURE IN BEIJING-SHANGHAI CHANNEL

From the predictions in Table Ⅲ and Ⅳ, we can see that passenger structure of Beijing-Shanghai Channel has the following evolution trends:

A. In the Case without High Speed Railway(before 2011)

Passenger market within Beijing-Shanghai Channel is highway market. Most passengers have been transported by highway which accounts for above 90%, while railway and civil aviation for less than 10%, waterway almost for nothing under the established supply structure in Beijing-Shanghai Channel. On the one side, an illusion has appeared that supply capacity is much more than demand within comprehensive transportation Channel and it seems to have met the growing passenger demand. On the other side, the situation of tight transport capacity has not been eased essentially, and there are large number of passengers forced to stay home or take other measures because transportation service cannot meet the demand of high quality, high efficiency and high service level.

B. In the Case with High Speed Railway (after 2011)

Passenger market within Beijing-Shanghai Channel has become high speed railway and inter-city railway markets. Both high speed railway and inter-city railway win most of passenger market share, which are up to above 70%. Highway accounts for around 10%, civil aviation for around 5%, existed railway for around 5%. In other words, passenger structure within the Channel has changed completely. Moreover, with social and economic development, people’s living standards and time value concept improving, passenger share for high speed and inter-city railways still have growth space. It can be expected that passenger market for Beijing-Shanghai Channel in future will take shape of integrated transport system which orients high speed highway and inter-city highway with the supplement of highway and civil aviation, and various traffic modes complement and coordinate each other.

VIII. CONCLUSION

This paper first makes an analysis and study for the affecting factors and mechanism of passenger structure evolution within comprehensive transportation Channel. Then it builds a passenger structure evolution model based on Markov process, and calibrates the model parameters. Finally it takes Beijing-Shanghai Channel to make an empirical study.

However, it is an important assumption for the prediction of Markov process is that all of current basic conditions remain unchanged. But anything is more complex than people expects, it will be a main direction for author’s further research how to predict passenger structure evolution trend while external related environments such as society, economy and policy change greatly within comprehensive transportation Channel.

ACKNOWLEDGMENT

The authors wish to thank the anonymous referees and the editor for their comments and suggestions. The research of Dong Wang, Yanhong Li and Xiaonian Sun has been supported in part by Technology Project of Guangdong Transportation Department under Grant No 2011-02-071.

REFERENCES

[1] Xu Yongneng, Research on evolution mechanism and optimization method for system structure of metropolitan public passenger transport [D]. Nanjing: Southeast University, PhD thesis, 2006. pp: 118-119.

[2] Nie Wei, Research on road network optimization in metropolitan circles and its evaluation [D]. Beijing: Beijing Jiaotong University, PhD thesis, 2007, pp: 43-54.

[3] Fan Yanlong, Research on Passenger Structure in China’s transport Channel [D]. Xi’an: Chang'an University, Master thesis, 2004, pp:32-33.

[4] Lejoon Chang.A network-based model for market share estimation among competing transportation modes in a regional Channel [D].University of Maryland, Ph.D, 2001.

[5] Hensher,D.A.A practical approach to identifying the market potential for High-Speed rail:A Case study in the Sydney-Canberra Channel[J].Transportation Research A,Vol.31(6), 1997.

[6] Hsu,C-I.,Chung,V-M.A model for market share distribution between High-Speed ans conventional rail services in a transportation Channel[J].The Annals of Regional science, Vol.31(2).

[7] The Third Railway Survey And Design Institute, The Fourth Railway Survey And Design Institute, Beijing National Railway Research & Design Institute of Signal & Communication, China Railway Electrification Survey Design & Research Institute, China Railway Major Bridge Reconnaissance & Design Institute. New railway: Research on the feasibility of Beijing-Shanghai high speed railway (revised version), title 1, general instruction [R]. Tianjin: The Third Railway Survey and Design Institute, Oct. 2006.9