УДК 654.6.4

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# ANALYSIS OF TRAVEL BEHAVIOR CHARACTERISTICS OF GUANGZHOU − ZHUHAI INTERCITY PASSENGERS BASED ON SURVEY

Conducts a questionnaire survey on passengers traveling between Guangzhou and Zhuhai cities, analyzes the characteristics of intercity travel behavior of passengers, and combines utility functions and Logit models to study the sharing rate of travel modes under different ticket prices. The aim is to provide a basis for coordinating the intercity passenger transportation market and formulating ticket prices.

In recent years, intercity railways have occupied a place in intercity travel due to their advantages of safety, comfort, speed, economy, and convenience. Studying the travel characteristics of intercity passengers is of great significance for optimizing intercity train operation plans and improving passenger service quality. Scholars at home and abroad have conducted extensive research on passenger travel choices, starting from Deserpa [1] constructing a travel consumer behavior model and studying the contribution of microeconomic theory to saving travel time, to Luce proposing the Logit model, McFadden [2] and Ben Akiva [3] gradually improving and perfecting the Logit model, taking into account factors such as travel purpose, travel cost, and travel time, Study the travel mode choice behavior of intercity travelers [4]. Scholars such as Feng Yan [5], Xiang Hongyan [6], and Hao Xiaoni [7] applied a random coefficient Logit model to analyze the intercity transportation travel choice behavior of passengers. Li Wanwen [8] and Zheng Xuelin [9] analyze the preference patterns of passengers for intercity travel choices and compare the marginal utility values of various influencing factors.

1 Analysis of the connotation and characteristics of intercity travel.

1.1 The definition of intercity travel.

This article defines intercity travel as the entire process of intercity passengers traveling from one city to adjacent cities by taking a certain intercity transportation to achieve a certain travel purpose [10].

1.2 The influencing factors of intercity passenger travel mode choice behavior.

1.2.1 Characteristics of intercity travelers.

This article mainly analyzes passenger travel mode choice behavior from the characteristics of transportation facilities, intercity travelers, intercity travel characteristics, and other macro influencing factors.

1.2.2 Characteristics of intercity travel.

Each individual traveling will choose a different mode of transportation due to differences in gender, age, occupation, income, and other factors. The characteristics of intercity travel mainly include factors such as travel distance, travel purpose, travel time, travel cost, etc.

1.2.3 Characteristics of intercity transportation facilities.

The characteristics of intercity transportation facilities mainly include safety, speed, convenience, economy, comfort, punctuality, and other characteristics [11]. Due to different characteristics, there are also differences in the choice of transportation modes among intercity travelers. Summary of Characteristics of Transportation Facilities as shown in Table 1.

*Table 1* − **Transportation Facility Properties**

| Transportation facility attributes | Meaning of indicators |
|---|---|
| Security | Operation, personal and property safety protection |
| Fastness | Running speed, transfer time, waiting time |
| Convenience | Transfer, ticket purchase, station entry convenience, and departure frequency |
| Economy | Ticket prices and transfer fees |
| Punctuality | Timeliness of departure and arrival |
| Comfort | Waiting environment, occupancy rate, carriage environment, and degree of carriage congestion |

2 The behavioral model for intercity passenger travel mode selection.

2.1 Investigation and analysis of passenger travel between Guangzhou and Zhuhai cities.

In order to more accurately reflect the travel characteristics of passengers between Guangzhou and Zhuhai, and to make the data more authentic and effective, this article conducted a survey on passengers between Guangzhou and Zhuhai. The survey was conducted at Guangzhou South Station, Guangzhou Passenger Bus Station, Zhuhai Station, etc., with 480 respondents and 453 valid questionnaires. The content of this survey questionnaire mainly includes:

− characteristic information of intercity travelers: gender, age, occupation, and income;

− travel demand information for intercity travelers: travel purpose, travel time, travel frequency, and transportation mode chosen for travel;

− information on the choice of transportation modes for intercity travelers: factors influencing the choice of transportation modes.

The survey content of Guangzhou − Zhuhai intercity passenger travel is shown in Figure 1.

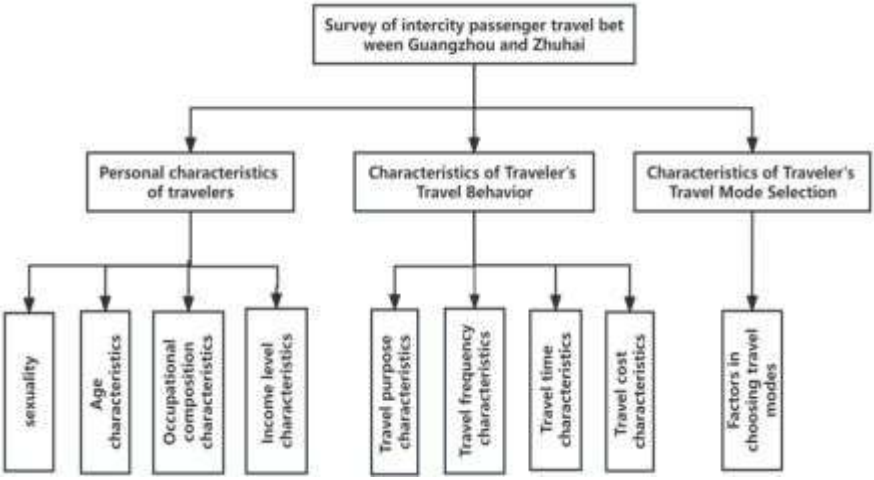


Figure 1 – The survey content of Guangzhou − Zhuhai intercity passenger travel

Through data processing using SPSS software, it was found that the top three preferred factors for intercity travelers to choose their travel modes were safety (35,2 %), convenience (22,8 %), and punctuality (15,7 %). The preferred transportation modes from highest to lowest were intercity railways (56,4 %), intercity buses (19,8 %), trains (12,4 %), private cars, taxis, and others (11,4 %) (Tables 2, 3).

*Table 2* − **Preferred factors for intercity travel mode selection**

| Factor | Economy | Fastness | Comfort | Security | Punctuality | Convenience |
|---|---|---|---|---|---|---|
| Ratio, % | 6,2 | 9,2 | 11,4 | 36,2 | 15,5 | 21,5 |

*Table 3* − **Priority transportation modes for intercity travelers**

| Transportation mode | Intercity bus | Intercity railway | Train | Other |
|---|---|---|---|---|
| Ratio, % | 15,7 | 59,5 | 10,4 | 14,4 |

2.2 Application of Utility Theory in Intercity Travel.

In intercity travel, utility refers to the satisfaction obtained by travelers after considering various factors such as cost, time cost, convenience, and comfort, and deciding to choose a certain mode of transportation. From the psychological perspective of intercity travelers, analyze various intercity travel plans, and each plan has a utility value. The magnitude of utility value represents the amount of benefits that travelers receive from choosing a certain travel plan.

The utility function relationship can be represented by following equation.

$$U_{in} = U_{in}(X_{in}), \quad (1)$$

where $U_{in}$ − the utility brought by passenger's choice of travel mode *i*; $X_{in}$ − the comprehensive characteristic variable when selecting transportation mode *i*.

The behavioral analysis model of intercity passenger travel mode selection can be understood as a multi option selection problem. Analyze the travel mode selection behavior of intercity passengers from a probabilistic perspective, and analyze the impact of various influencing factors on the probability of transportation mode selection. The probability of passenger *n* choosing Class *I* transportation plan can be expressed as

$$P_{in} = Prob(U_{in} > \max U_{jn},\ i \neq j,\ i, j \rightarrow A_n), \tag{2}$$

where $A_n$− set of transportation methods available for passenger *n to* choose from; $U_{in}$ − the utility of passenger *n* choosing the *i*-th mode of transportation; $U_{jn}$ − the utility of passenger *n* choosing the *j*-th mode of transportation; $U_{in}$ − the utility function when passenger *n* chooses the *i*-th mode of transportation.

Due to errors in the judgment of passengers for each mode of transportation, as well as different subjective preferences of passengers, the utility function is divided into two parts: a fixed term and a random term, expressed as

$$U_{in}=V_{in} + \varepsilon_{in}, \tag{3}$$

where $V_{in}$− the fixed term calculated for the observable characteristic variable; $\varepsilon_{in}$ − random term caused by errors or unobservable influencing factors.

2.3 Model for intercity passenger travel mode selection.

According to the intercity travel mode between Guangzhou and Zhuhai, a binomial Logit model is used for prediction. By establishing utility value functions for each intercity transportation mode, the sharing rate of each transportation mode is predicted, and the utility value of each transportation mode is determined by the facility characteristics of the transportation mode [12]. The main influencing factors selected for the Logit model include economy, speed, comfort, safety, and convenience, and it is assumed that each influencing factor is independent of each other. Multiple Logit models are selected to predict the sharing rate.

The utility function relationship used is as follows:

$$U_{in} = w_1E_i + w_2T_i + w_3C_i + w_4S_i + w_5R_i, \tag{4}$$

where $U_{in}$ − the utility value of the *i*-th transportation method chosen by the *n*-th type of passengers; $w_i$ − weight coefficient of influencing factors; $E_i$ ,$T_i$ ,$C_i$, $S_i$, $R_i$ − characteristic values of the *i-th* mode of transportation.

The Guangzhou − Zhuhai intercity transportation channel includes two modes of transportation: railways and highways, including ordinary railways, intercity railways, intercity buses, and cars. For the convenience of studying the passenger volume sharing rate within the Guangzhou − Zhuhai Intercity Railway, the following restrictions are made: due to the extremely low frequency and passenger flow of ordinary railways between Guangzhou and Zhuhai, only the Guangzhou – Zhuhai Intercity Railway is analyzed in railway transportation, and no research is

conducted on ordinary railways. In road transportation, research is only conducted on operating vehicles, namely intercity buses, and private cars are no longer studied.

3 Results.

3.1 Solving the Utility Function Model.

By analyzing the characteristics of each facility, determine the characteristic values of each influencing factor.

3.1.1 Security.

When calibrating the characteristic values of safety, the average mortality rate per unit of passenger turnover is used as a quantitative indicator of safety. According to existing survey data in China, the safety indicators for high-speed trains and buses are 0,018 people/100 million person kilometers and 18 people/100 million person kilometers, respectively.

3.1.2 Fastness.

According to the current transportation conditions in Zhuhai, the transportation time for each mode of transportation within the city is approximately 0,5 hours. The average operating time for the Guangzhou − Zhuhai Intercity Railway is 0,88 hours, and the average operating time for buses on highways is 2,5 hours. Therefore, the total time for the intercity railway and bus between Zhuhai and Guangzhou is 1,38 hours and 3 hours, respectively.

3.1.3 Convenience.

In the Guangzhou − Zhuhai intercity transportation channel, the frequency of urban rail departures is about 3,2 times/h, and the frequency of bus departures is about 2 times/h. The average waiting time for intercity passengers is taken as half of the departure time interval. Therefore, the total time required for the Guangzhou − Zhuhai intercity rail and bus services is 0,468 hours and 0,6 hours, respectively.

3.1.4 Economy.

When calibrating the characteristic values of economy, the fare of transportation modes is used as the economic indicator. The average ticket price for intercity buses from Zhuhai to Guangzhou is 43,5 yuan; The first class ticket price for intercity railway is 90 yuan, and the second class ticket price is 70 yuan.

Based on the analysis of survey data, considering that intercity passengers tend to choose relatively economical second-class seats on the Guangzhou − Zhuhai Urban Railway in most cases, this article selects the ticket price of second-class seats as the economic measure.

3.1.5 Comfort.

The measurement standards for passenger comfort of transportation vehicles include indicators such as the smoothness of transportation facility operation, riding environment, cabin congestion, and facility service quality. Quantify the per capita space occupied by vehicles and the vibration acceleration during operation as measurement indicators, and then scale these quantification indicators to form a comfort index $C_i$:

$$C_i = C_{space}^i + \frac{1}{C_a^i}, \quad (5)$$

where $C^i_{space}$ − the quantified value of the space occupied by each person of the *i*-th type of transportation vehicle; $C_a{}^i$ − the quantified value of the average vibration acceleration during the operation of the *i*-th type of carrier.

According to the study on the main technical and economic issues of high-speed railway passenger dedicated lines in China, the per capita occupancy space of high-speed trains and cars is 3,6 and 1,5, respectively, and the peak vibration acceleration is 1,5 and 3,6. According to formula 6, the comprehensive comfort indicators for urban rail and buses are 4,27 and 1,78, respectively.

In order to facilitate the comparison of the indicators of the influencing factors between the two transportation modes, the indicator values of the service attributes of each transportation facility are dimensionless in the following way, as shown in formulas 6 (Positive indicator) and 7 (Negative indicator).

$$X_i^* = \frac{X_i}{\max X_i}; \quad (6)$$

$$X_i^* = \frac{X_i}{\min X_i}, \quad (7)$$

where $X_i$ − the measurement of each influencing factor; $X^*{}_i$ − the characteristic values obtained through dimensionless transformation of various influencing factors.

The converted results, namely the characteristic values of each influencing factor in the utility function, are shown in Table 4.

*Table 4* − **Eigenvalues of various influencing factors of utility function**

| Transportation method | Security | Fastness | Convenience (negative indicator) | Economy (negative indicator) | Comfort |
|---|---|---|---|---|---|
| Intercity railway | 1,000 | 1,000 | 0,591 | 1,000 | 1,000 |
| Bus | 0,390 | 0,504 | 1,000 | 0,875 | 0,417 |

(Note − According to the «Research on the Passenger Transport Structure of Transportation Channels in China»[13], the safety index is first transformed into data of "people/billions of person kilometers", then transformed using natural logarithm method, and finally processed using formulas.)

By using SPSS software to analyze and process the data obtained from the survey questionnaire, the proportion of travelers with different income levels in the total sample data can be obtained. Meanwhile, the weighted average method is used to determine the weight coefficients of each influencing factor in the utility function. The weight coefficient represents the contribution of the influencing factors of each transportation mode to the utility value:

$$\tilde{\omega} = q_1\omega_{1i} + q_2\omega_{2i} + ... + q_n\omega_{ni},$$

where $\tilde{\omega}$ − the weight values of each influencing factor; $q_i$ − type $i$ the percentage of intercity travelers with the nth income level in the total number; $\omega_{ni}$ − the weight value of intercity travelers with the $n$-th income level on the characteristics of transportation modes.

Thus, the degree to which intercity travelers with different income levels attach importance to the various characteristics of transportation facilities, as well as the weight coefficients of various influencing factors in the utility function, can be obtained. See Tables 5 and 6 respectively.

*Table 5* − **Weight coefficients of influencing factors for travelers with different income levels**

| Passenger type | Security | Fastness | Convenience | Economy | Comfort |
|---|---|---|---|---|---|
| Below3000 yuan (26,7 %) | 0,16 | 0,24 | 0,14 | 0,35 | 0,11 |
| 3000−4500 yuan (24,2 %) | 0,18 | 0,18 | 0,22 | 0,27 | 0,15 |
| 4500−6000 yuan (22,8 %) | 0,12 | 0,23 | 0,25 | 0,28 | 0,12 |
| 6000−7500 yuan (12,9 %) | 0,18 | 0,21 | 0,22 | 0,18 | 0,21 |
| Over 7500 yuan (12,4 %) | 0,18 | 0,27 | 0,18 | 0,15 | 0,21 |

*Table 6* − **Weight coefficients of various influencing factors in the utility function**

| Influence factor | Security | Fastness | Convenience | Economy | Comfort |
|---|---|---|---|---|---|
| Weight coefficient | 0,14 | 0,23 | 0,22 | 0,25 | 0,16 |

3.2 Calculation of intercity passenger flow sharing rate.

Calculate the utility value of intercity railways and buses using formula 5, as follows. The utility value of the Guangzhou − Zhuhai Intercity Railway is:

$$0{,}14 \cdot 1 + 0{,}23 \cdot 1 + 0{,}22 \cdot 0{,}591 + 0{,}25 \cdot 1 + 0{,}16 \cdot 1 = 0{,}910.$$

The utility value of intercity buses is:

$$0{,}14 \cdot 0{,}39 + 0{,}23 \cdot 0{,}504 + 0{,}22 \cdot 1 + 0{,}25 \cdot 0{,}875 + 0{,}16 \cdot 0{,}417 = 0{,}676.$$

The passenger volume sharing rate of intercity railways and expressways within the Guangzhou − Zhuhai intercity transportation channel is calculated as follows calculation of urban rail sharing rate:

$$p_1 = \frac{\exp(0{,}910)}{\exp(0{,}910) + \exp(0{,}676)} = 57{,}37\ \%.$$

Calculation of highway sharing rate: $p_2 = 1 - p_1 = 42{,}63$ %.

Comparing the current intercity passenger flow sharing rate and predicted sharing rate obtained from the survey, we can identify the gap between the two, providing support for coordinating the passenger transportation market and improving the passenger transportation structure. Based on actual survey data and predicted results, the comparison between the two is shown in Table 7.

*Table 7* − **Comparison of Guangzhou − Zhuhai Intercity Passenger Transport Structure**

| Transportation method | Intercity railway | Expressway |
|---|---|---|
| Actual survey value, % | 59,50 | 30,10 |
| Model predicted value, % | 57,37 | 42,63 |

Through comparison, it can be seen that intercity railways are accepted and prioritized by most intercity passengers. The cancellation of intercity buses has a certain impact on the travel mode choices of passengers. In actual investigations, some intercity travelers are affected by the suspension of intercity buses. But overall, the prediction of passenger flow sharing rate on intercity railways has a certain degree of accuracy.

3.3 Calculation of Guangzhou Zhuhai City Railway Share Rate under Different Ticket Prices.

The changes in indicators such as operating speed and comfort of transportation modes require a significant amount of technology and material investment. Therefore, based on the above situation, assuming that the other characteristics of each mode of transportation remain unchanged, only considering changes in ticket prices, calculate and analyze the changes in the sharing rate of the Guangzhou − Zhuhai intercity railway under different ticket price conditions. Considering the policies and costs of the two modes of transportation, the fluctuation range of ticket prices for the Guangzhou − Zhuhai Intercity Railway is set to be 10 % lower and 30 % higher, while the ticket prices for the expressway are set to be 10 % higher and 10 % lower respectively. From the above conditions, it can be inferred that, the passenger sharing rate of the Guangzhou − Zhuhai Intercity Railway under different ticket prices is shown in Table 8.

*Table 8* − **The passenger sharing rate of the Guangzhou − Zhuhai Intercity Railway under different ticket prices, yuan**

| Intercity Railway ticket price | Highway ticket price | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 39,2 | 41,2 | 43,5 | 45,7 | 47,9 | 50,0 | 52,2 | 54,4 | 56,6 |
| 63,0 | 0,5723 | 0,5692 | 0,5660 | 0,5640 | 0,5601 | 0,5574 | 0,5551 | 0,5529 | 0,5509 |
| 66,5 | 0,5751 | 0,5733 | 0,5725 | 0,5665 | 0,5635 | 0,5606 | 0,5581 | 0,5559 | 0,5536 |
| 70,0 | 0,5778 | 0,5751 | 0,5737 | 0,5695 | 0,5668 | 0,5638 | 0,5613 | 0,5588 | 0,5566 |
| 73,5 | 0,5802 | 0,5776 | 0,5749 | 0,5723 | 0,5695 | 0,5670 | 0,5643 | 0,5618 | 0,5593 |
| 77,0 | 0,5825 | 0,5798 | 0,5773 | 0,5749 | 0,5723 | 0,5797 | 0,5672 | 0,5638 | 0,5621 |

According to Table 8, when the ticket price of intercity buses is fixed, the lower the ticket price of urban rail, the higher the passenger flow sharing rate of urban rail; On the contrary, as the ticket price of urban rail increases, the passenger flow sharing rate of urban rail decreases. Overall, ticket prices have a certain impact on the passenger flow sharing rate. With the increase in intercity railway ticket prices, intercity travelers will also have fewer choices for this mode of

transportation. Therefore, it is necessary to establish reasonable ticket prices and coordinate the intercity passenger transportation system. By calculating and predicting the passenger flow sharing rate of urban rail under different ticket prices, it can provide strong basis for the fare formulation and facility improvement of transportation operation departments.

4 Suggestions for the operation plan of the 4 trains.

By analyzing the travel behavior characteristics of passengers between Guangzhou and Zhuhai, as well as predicting the passenger flow sharing rate, feasible suggestions are provided for train operation, and more convenient and high-quality services are also provided for the travel of passengers between Guangzhou and Zhuhai.

In terms of travel time slots, the travel time slots for passengers are not fixed, and the distribution of travel time slots is not entirely the same. According to the investigation and analysis, railway operation departments should increase the frequency of train departures during peak passenger travel hours, and increase the number of train departures during weekends or holidays to alleviate the tense peak passenger flow.

In terms of balancing train occupancy, the comfort of residents is closely related to the occupancy rate of the train. A high occupancy rate can lead to a decrease in passenger comfort; A low occupancy rate can lead to wastage of operating costs. Therefore, the operations department should consider comprehensively and strive to find a balance between the two.

REFERENCES

1 *Deserpa, A.* Microeconomic theory and the evaluation of travel time: Some clarification / A. Deserpa // Regional and Urban Economics. − 1973 (4). – P. 401−410.

2 *McFadden, D.* A Method of Simulated Moments for Estimation of Discrete Response Models Without Numerical Integration / D. McFadden // Econometrica, 1989(5). – P. 995−1026.

3 *Ben-Akiva.* Discrete Choice Analysis: The Theory and Application to Travel Demand / Ben-Akiva, R. L. McFadden. The MIT Press, Cambridge Massachusetts, 1987. – P. 21−24.

4 *Espino, R.* Understanding Suburban Travel Demand: Flexible Modeling With Revealed and Stated Choice Data / R. Espino, J. Ortuzar, C. Roman // Transportation Research Part A Policy & Practice. − 2007(10). – P. 899−912.

5 *Feng, Yan.* Research on the Calculation of Passenger Volume Sharing Rate in Intercity Transportation Channels Based on Logit Model / Yan Feng, Li Dewei // Railway Transportation and Economy. − 2016 (4). – P. 47−51.

6 *Hongyan, Xiang.* Modeling the behavior of intercity short distance travel mode selection within urban agglomerations / Xiang Hongyan, Ren Xiaocong, Chen Jian // Journal of Chongqing Jiaotong University, 2016 (3). – P. 129−133.

7 *Xuelin, Zheng.* Analysis of Factors Influencing Residents' Transportation Mode Choice Behavior / Zheng Xuelin, Gan Hongcheng // Journal of Shanghai University of Technology. − 2013 (6). – P. 563−566.

8 *Hao, Xiaoni.* A study on the behavior of intercity travel mode selection in urban agglomerations based on the random coefficient Logit model / Xiaoni Hao, Wenhan Shi, Jianrong Liu // Traffic Information and Safety. − 2022 (5). – P. 139−146.

9 *Li, Wan-wen.* The influencing factors of travel mode choice in intercity tourism / Wan-wen Li, Yi-chi Liu // Integrated Transport. − 2022(10). – P. 24−29.

10 *Fuli, Chen.* Study on the characteristics of intercity travel behavior in urban agglomerations / Chen Fuli. Xi'an. − Chang'an University, 2010. – P. 6−15.

11 *Li, Honghui.* Analysis of Transportation Mode Choice Behavior of Residents in the Beijing Tianjin Hebei Urban Agglomeration for Intercity Travel / Honghui Li. Beijing. − Beijing Jiaotong University, 2020. – P. 5−12.

12 *Shao, Chunfu.* Principles of Urban Planning / Chunfu Shao. – Beijing : China Railway Press, 2014. – P. 182−196.

13 *Fan, Yanlong.* Research on the Passenger Transport Structure of Transportation Channels in China / Y. Fan. − Chang'an University, 2005. – P. 12−16.

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**ХАРАКТЕРИСТИКИ ПАССАЖИРОПОТОКА ЖЕЛЕЗНОЙ ДОРОГИ ГУАНЧЖОУ – ЧЖУХАЙ НА ОСНОВЕ АНАЛИЗА ЗАПРОСОВ ПАССАЖИРОВ**

Представлены результаты анкетного опроса пассажиров железнодорожного транспорта, курсирующего по маршруту Гуанчжоу − Чжухай с оценкой характеристик качества пассажирских перевозок на основании анализа сервисных функций Logit-модели, что позволяет изучить спрос на транспортные услуги при различных ценовых диапазонах по стоимости билета и тем самым найти наиболее эффективные и экономически целесообразные решения по обслуживанию пассажиров.

Получено 29.11.2023

**ISSN 2664-5025. Проблемы перспективного развития железнодорожных станций и узлов. Вып. 5. Гомель, 2023**

УДК 656.225.073:656.064

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**ПРИНЦИПИАЛЬНЫЕ ОСНОВЫ ТЕХНОЛОГИИ ПЕРЕРАБОТКИ МАССОВОГО КОНТЕЙНЕРОПОТОКА НА ТЕРМИНАЛЬНО-СОРТИРОВОЧНОМ КОМПЛЕКСЕ**

Рассматривается один из аспектов потенциальной трансформации технологии перевозочного процесса при потенциальной массовой контейнеризации грузопотока – изменение технологии переработки вагонов на технических станциях. Показано, что в