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ИССЛЕДОВАНИЕ ВЛИЯНИЯ РАЗМЕРА СУДНА И ДАЛЬНОСТИ МОРСКОЙ ПЕРЕВОЗКИ НА ВОЗМОЖНОЕ УМЕНЬШЕНИЕ ЭФФЕКТИВНОСТИ РЕЙСА

Сформулировано выражение отклонения показателя эффективности выполнения судном рейса (тайм-чартерного эквивалента) как функции от характеристик судна (грузоподъемности) и рейса (дальности перевозки). Сделаны выводы о влиянии размера судна и дальности перевозки на возможные отклонения эффективности рейса. Полученные результаты позволяют осуществлять практическую оценку возможных отклонений эффективности рейса под влиянием факторов риска.

Ключевые слова: регрессионная зависимость, отклонение, тайм-чартерный эквивалент, дальность перевозки, грузоподъемность, вероятность.

__Vyshnevska Olha,__ Senior Lecturer, Department of Marine Transportation, Odessa National Maritime University, Ukraine, e-mail: vishn.ol.24@mail.ru, ORCID: http://orcid.org/0000-0003-1021-3176

__Vishnevsky Dmitry,__ PhD, Assistant, Department of Marine Transportation, Odessa National Maritime University, Ukraine, e-mail: system013@mail.ru, ORCID: http://orcid.org/0000-0002-1270-713X

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Dolya C.

MODELING OF PASSENGER TRANSPORT CORRESPONDENCE BETWEEN REGIONAL CENTERS IN UKRAINE

Досліджено процес надання послуг з перевезення пасажирів на міжобласних маршрутах загального користування. За отриманими даними фактичних кореспонденцій було проведеного дослідження можливості застосування відомих методів щодо розрахунку пасажирських транспортних кореспонденцій. Винайдено параметри складових, при яких застосування розглянутих методів є можливим в рамках дослідженої системи.

Ключові слова: *транспортна система, гравітаційна модель, пасажирські транспортні кореспонденції, міжміські перевезення.*

1. Introduction

Modern transport systems need to make informed decisions about their development, change and adaptation to the operational environment of these systems. Operational environment of the transport system is man-made, artificially created to meet the needs of humanity with the carriage of passengers or goods. To achieve the state in which transport system has the ability to satisfy the needs of transportation, we must carefully decide on the change of the elements of transport system.

All elements of the transport systems are required to be revised and adapted to modern conditions. It should be noted that the transport systems have the elements, which production is costly time, financial and human resources. Place of passenger transport systems in the development of society can't be overemphasized. Therefore, the decisions to reform elements of the transport system have taken relying on calculations made in terms of modernity.

Passenger is the basis for all calculations in organization of passenger transportation. It is well-known that schedule, the number and type of vehicles, vehicle traffic scheme are depend on the volume and characteristics of passenger transportation. Traffic volumes cause cash flow of the company. The importance of establishing traffic volumes for passenger transport system is significant.

2. The object of research and its technological audit

The object of research is the modern intercity passenger transport system in Ukraine. Intercity passenger transport correspondence, which is formed in the current system, is considered in this research.

One of the problem areas is to study actual sustainable intercity correspondence, which is in obtaining still not defined corrective coefficients for calculation of potential intercity correspondence. The knowledge provides an opportunity in the use of this method of correspondence calculations between cities towards the passenger transportation market in Ukraine.

3. The aim and objectives of research

The aim of research is modeling of transport intercity passenger correspondence by formalizing adequate gravity function. Determination of features of gravity function will lead to the possibility of intercity passenger correspondence calculation within the studied system.

To achieve this aim the following problems are solved:

1. Experimental determination of passenger transport correspondence between cities with different number of inhabitants.
2. Comparison of the theoretical and experimental data.

4. Research of existing solutions of the problem

The issue of intercity transport correspondence calculation is in that the patterns of passenger transport system parameters are still not studied at a sufficient level.

The authors of [1] propose dependence (1) to calculate intercity passenger correspondence. To establish an intercity correspondence in [1] the use of classical gravity model is proposed:

$$H_{ij} = d_{ij} H_{di} N_{aj}, \quad (1)$$

where H_{ij} – potential correspondence between cities i and j, respectively; H_{di} – the number of departures from city i; N_{aj} – the number of arrivals to city j; d_{ij} – gravity function from city i to city j.

The disadvantage of this method is taking into account only the distance between cities i and j as a resistance factor of correspondence.

The researchers [2] propose a different method of calculating the potential departures between cities i and j:

$$H_{ij} = \frac{P_i P_j}{L_{ij}^2}, \quad (2)$$

where L_{ij} – the distance between cities i and j; P_i and P_i – the number of inhabitants of cities i and j, respectively.

In this case, the authors don't take into account the peculiarities of departure and arrival points.

The authors of [3] propose a different method of H_{ij} calculation – potential intercity correspondence that is in the equation (3).

$$H_{ij} = S_{ij} d_{ij}, \quad (3)$$

where S_{ij} – potential departure from city i to city j.

The authors of [3] are not considered components of gravity function.

Other researchers [4] propose to use dependence (4) to calculate potential correspondence between cities i and j.

$$H_{ij} = \frac{{}_{di}N_{aj} f(d_{ij})}{\sum_k A_k f(d_{ik})}, \quad (4)$$

where d_{ik} – complex gravity function from point i to point j; A_c – calibration coefficient.

In this case, the authors propose to consider the correspondence resistance factor as a complex function. Definition or components of this function aren't offered.

The authors [5] consider the issues of intercity correspondence distribution for working and entertainment streams and double-limited gravity model is proposed. It makes accounting of working and entertaining correspondence. In this case, the next dependence is proposed to calculate an intercity correspondence:

$$H_{ij} = \frac{{}_{di}N_{aj} f(d_{ij}) X_i Y_i}{\sum_k A_k f(d_{ik})}. \quad (5)$$

At the same time, the authors of [6] propose the introduction of dependences (6), (7) for calculating X_i and Y_j, which are as follows:

$$X_i = \frac{1}{\sum_j H_j Y_j f(d_{ij})}, \quad (6)$$

$$Y_i = \frac{1}{\sum_j H_{di} X_i f(d_{ij})}. \quad (7)$$

Taking into account the proposed authors' approach, the problems of the difference between the gravity function from the point i to the point j and complex gravity function from the point i to the point j isn't revealed. Like their predecessors, dependence has the components, definition of which requires the use of empirical methods. In addition, the number of defining factors is more in proposed method. This leads to uncertainty.

The authors of [7] in the works propose survey of existing intercity correspondence to calculate calibration coefficients that were introduced in the dependence.

Research is not focused only on the issue of establishing methods for calculation of potential intercity correspondence. Thus, the authors [5] propose method of calculation and distribution of correspondence among the proposed means of transportation – railway and bus. According to the authors [5], to establish the distribution of potential intercity passenger correspondence it is appropriate to use the following dependence:

$$P_k = \frac{e^{Uk}}{\sum_z e^{Uk}}, \quad (8)$$

where P_k – the proportion of tours in the mode k; U_k – utility of the mode k; Z – efficiency index of all modes; e – 2,718281.

Also in [7] the means of definition of U_k and Z are proposed. According to their assumptions, calculation of utility of the mode k (U_k) and efficiency index of all modes (Z) can be calculated by the following equations:

$$U_k = a_k + a_1 t + a_2 c + ..., \quad (9)$$

where a – empirical constants; t, c – factors of correspondence resistance (time, cost, etc.).

$$Z = \frac{\varphi_n Ln \sum_k e^{Zk}}{\varphi_n + \mu_n}, \quad (10)$$

where Z_k – utility of the one level lower mode; φ_n, μ_n – constants for flows of appropriate level.

The authors of [8] provide inspections of existing intercity passenger correspondence to define the actual empirical constants, resistance factors, balancing coefficients and other calibration constants.

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It may be noted that the authors of [9, 10] also propose inspections of available passenger correspondence to establish the actual values in proposed equations.

5. Methods of research

To establish actual intercity passenger traffic in Ukraine we choose another way that consists in obtaining of relevant quantitative indicators from accounting materials of passenger services. These documents and materials include information of railway ticket sails system of JSC «Ukrzaliznytsia» (Ukraine) [11]. Road transport in the system of intercity passenger transportation provides a passenger service at the stations.

Fig. 1 shows a proposed model of transport network of Ukraine on the basis of interregional routes. Regional centers are adopted as the transport hubs in the proposed model, and the curves are the roads, which provided intercity correspondence.

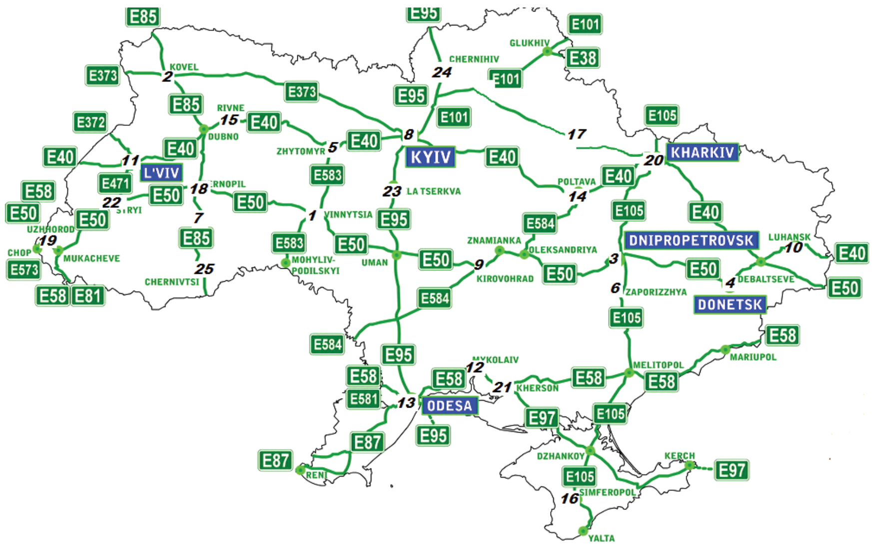

Fig. 1. Model of transport network of Ukraine on the basis of interregional routes

The proposed model (Fig. 1) allows to obtain quantitative distances between regional centers and the number of regional centers. This makes it possible to calculate a matrix of the shortest distances.

Dependence (1) is chosen as dependence for calculating intercity passenger correspondence from point i to point j. In this case, it is proposed to calculate an intercity correspondence gravity function by the following dependence:

$$d_{ij} = \frac{a}{L_{ij}^{x}}, \qquad (11)$$

where a – empirical constant; L_{ij} – the distance between cities i and j; x – calibration coefficient.

Taking into account the dependence (5), equation (1) has the following form:

$$H_{ij} = \left(\frac{a}{L_{ni}^{x}}\right) H_{di} N_{aj}, \qquad (12)$$

where L_{ij} – the distance between cities i and j; x – calibration coefficient.

For calculation of potential intercity correspondence in accordance with (1), the next values of empirical constants are selected – a: 1; 5, 35, 65, 95, 125 and 155. The value of the calibration coefficient x in the calculations: –0,8; 1; 1,2; 1,4; 1,6; 1,8; 1,9 and 2,5.

Potential correspondence between cities i and j for all possible combinations between a and x is calculated according to the selected values of empirical constant and calibration coefficient.

The obtained values H_{ij} – potential correspondence between city i and city j are summarized in Table 1.

Compliance and evaluation of estimated potential correspondence H'_{ij} between cities i and j to the actual value of passenger correspondence is obtained in accordance with the results of research conducted using dependence (13). The value ε is a deviation of resulting calculated quantitative indicator from the actual (in percentage form) and it provides to analyze the quality of the combination of the value of empirical constant – a and value of calibration coefficient – x.

$$\varepsilon = \frac{\left|H_{ij} - H'_{ij}\right|}{H_{ij}}. \qquad (13)$$

The calculation results for the dependence (13) are summarized in Table 2.

This value ε_{av} shows the average deviation of resulting calculated quantitative indicators from the actual (in percentage form) in the application of a combination of value of empirical constant – a and value of calibration coefficient – x.

Table 1

Calculated values of potential intercity correspondence

№	№ of transport node i	№ of transport node j	H'_{ij} at a=1, x=1,0, hundred days	H'_{ij} at a=1, x=1,4, hundred days	…	H'_{ij} at a=155, x=1,6, hundred days	H'_{ij} at a=155, x=1,8, hundred days	H'_{ij} at a=155, x=1,9, hundred days	H'_{ij} at a=155, x=2,5, hundred days
1	8	22	19,31	17,77	…	16,83	15,79	15,23	11,57
2	8	15	71,07	66,98	…	63,99	60,46	58,52	45,52
…	…	…	…	…	…	…	…	…	…
27	22	14	134,60	4,04	…	11,15	9,34	8,53	4,86
28	22	8	11,83	136,01	…	132,81	135,32	136,55	143,47

Table 2

Deviation of the calculated values of potential intercity correspondence from actually received according to the results of research (in percentage form)

№	№ of transport node i	№ of transport node j	ε at a=1 x=–0,8	ε at a=1 x=1,4	…	ε at a=155, x=1,6	ε at a=155, x=1,8	ε at a=155, x=1,9	ε at a=155, x=2,5
1	8	22	0,26	0,09	…	0,03	0,03	0,07	0,29
2	8	15	0,04	0,04	…	0,00	0,06	0,09	0,29
…	…	…	…	…	…	…	…	…	…
27	22	14	0,33	0,02	…	0,02	0,02	0,03	0,05
28	22	8	2,23	0,30	…	132,81	135,32	136,55	143,47
ε_{av}			2,0	0,24	…	0,11	0,10	0,15	0,41

6. Research results

The results of calculations from the Table 2 provide an opportunity to empirically define the parameter of gravity function at which the estimated values of potential correspondence are near to the actual. The process of intercity passenger transportation process by the public routes has a passenger correspondence that can be calculated using the gravity model (12). According to the deviation parameters of calculated values of potential intercity correspondence from actually obtained as the results of research it is determined that the calibration coefficient x in investigated transport system for the corresponding calculations must take values from 1,6 to 1,8.

And, according to calculated data, it can be concluded that ε_{av} isn't depend on a quantitative indicator a. This statement is also confirmed by illustrated surface of distribution function ε_{av}. As a result of this work it could be argued that the calculation function of the potential correspondence between cities i and j takes the following form:

$$H_{ij} = \left(\frac{1}{L_{ni}^{x}}\right) H_{di} N_{aj}. \tag{14}$$

It is necessary to determine that the survey isn't covered passengers, who realize the need for correspondence on personal transport and air transport. A necessity to clarify d_{ij} gravity function between cities i and j, taking into account the economic state of society, is identified as a result of discussion. So, it is necessary to conduct a study, taking into account the distance and fare in comparison with incomes as resistance factor. Also, there is a reason for additional research and their further processing for obtaining the prediction function with a higher quality of calculations. The research doesn't contain information about the speed, time and fare.

These results can be used for calculation of intercity passenger correspondence in Ukraine. Despite everything, obtained results are important for understanding the current processes in the field of transport. It should be noted that selected correspondence resistance factor, L, can be taken as highly correlated with the time and fare of travel. This leads to a consideration of these factors in the resulting model of d_{ij} gravity function between cities i and j. The achievements in the results of research include the possibility to use chosen gravity model for intercity passenger transport market in Ukraine.

7. SWOT analysis of research results

Strengths. One of the strengths of this research is an evidence of the possibility to use a gravity model for intercity passenger transport system in Ukraine. New information is received for the study of still not defined corrective coefficients for calculation of potential intercity correspondence. They are customized for each transport system. The modern scientific achievements are evidenced in support of this assertion. They are outlined in the considered literature. These circumstances define an impossibility to use gravity models in practice for calculation of the performance of the system without preliminary calculation of above-mentioned coefficients. Use of this data regarding the optimal values of the component parameters of gravity function provides the ability to calculate quality indicators of performance and planning parameters of considered transport system. In view of the above-mentioned, new information about studied system is obtained in prediction of intercity correspondence. The results can be used for calculations of intercity passenger correspondence in Ukraine. This is advantageous in comparison with analogues due to:

– Analysis of actual data doesn't require additional resources.
– Possible increase of productivity by optimizing the use of financial resources of enterprises for the production process of satisfaction of transportation needs.
– Reduction of depreciation of manufacturing facilities.

Weaknesses. Weaknesses of research are the failure to take into account the fact of intercity passenger correspondence, which are implemented using cars. However, it should be noted that the aim of this research was to analyze a passenger correspondence being sold on the public routes. Also, when receiving data on constant correspondence, fluctuations of correspondence related to seasonal changes in population mobility aren't taken into account. At the same time the value of gravity functions is calculated that provide error of calculated data for valid within 10 %. It should be noted that application of research results for passenger transport system will not have additional financial pressures for transport companies or passengers.

Opportunities. Precisely calculated value of intercity passenger correspondence for public routes enables to secure interactions between systems of different transport modes to meet the needs of the population to meet the needs of the residents for movement within the studied system. At the same time there is a possibility of improving the quality of financial flows by optimizing the allocation of resources over time throughout the passenger system.

Threats. There are difficulties associated with the use of research results. This is due to the fact that the application of the chosen calculation model of potential correspondence it is necessary to determine the number of departures and the number of arrivals in the transport system points. An occurrence of such state of the system, in which it will require transport enterprises to provide more volume of transport services, is possible.

8. Conclusions

1. Passenger transport correspondence between cities with different number of inhabitants is experimentally defined. The quantitative indicators of passenger transport correspondence are obtained. It is established that intercity passenger transport correspondence can be predicted. It is proved that gravity modeling of passenger transport correspondence is suitable for this system.

2. Theoretical and experimental data are compared. Static error of calculations is defined as a comparison results. Previously unknown parameters of gravity function are defined. This allows to predict the passenger correspondence in this system.

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МОДЕЛИРОВАНИЕ ПАССАЖИРСКИХ ТРАНСПОРТНЫХ КОРРЕСПОНДЕНЦИЙ МЕЖДУ ОБЛАСТНЫМИ ЦЕНТРАМИ В УКРАИНЕ

Исследован процесс предоставления услуг по перевозке пассажиров на маршрутах общего пользования. По полученным данным фактических корреспонденций было проведено исследование возможности применения известных методов к расчету пассажирских транспортных корреспонденций. Установлены параметры составляющих, при которых применение рассмотренных методов возможно в рамках исследованной системы.

Ключевые слова: транспортная система, гравитационная модель, пассажирские транспортные корреспонденции, междугородние перевозки.

Dolya Constantine, *PhD, Senior Lecturer, Department of GIS, Land and Real Estate Appraisal, O. M. Beketov National University of Urban Economy in Kharkiv, Ukraine, e-mail: k.dolya@inbox.ru, ORCID: http://orcid.org/0000-0002-4693-9158*

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Nuriyev M., Hacimuradova R., Khalilov E., Aqayeva A., Jabbarova G.

ANALYSIS OF ERRORS OF PROFILE TRANSFORMATION SCALE

Проведено аналіз структури похибок при контролі форми пакувань хрестової мотки методом тіньової проекції. Отримані вирази для окремих складових похибки параметрів форми, що дозволяє обґрунтовано підійти до призначення допусків на взаємне розташування окремих елементів пристрою. Проведено аналіз пристроїв реєстрації зображень з точки зору можливості їх застосування в апаратному комплексі для реєстрації параметрів форми пакувань хрестової мотки.

Ключові слова: *форма пакувань, хрестова мотка, тіньова проекція, реєстрація параметрів, перетворення профілю.*

1. Introduction

Textile industry effectiveness is closely connected with the provision of the required quality for all technological steps. One of the most important processes in the textile industry is the winding process, which resulted in forming textile packages of various shapes. Defects of textile packages results in increased breakage in subsequent steps,

