Mykola Zhuk, Halyna Pivtorak, Ivanna Gits
Lviv Polytechnic National University
12, S. Bandery Str., Lviv, 79013, Ukraine

ASSESSMENT OF THE SERVICE QUALITY IN PUBLIC TRANSPORT (ANALYSIS OF RESEARCH IN LVIV, UKRAINE)

Summary. *The paper assesses the quality of public transport services and the influence of individual components on the value of the overall satisfaction level with transport services. Public transport has many benefits in terms of energy savings, environmental impact, social equity and urban economy. The analysis of existing research confirms that the quality of service provided by the public transport system affects the intentions of potential passengers to use it more. However, the level of economic well-being, the state of development of the transport system, and the national strategy for developing social mobility influence the different perceptions of the importance of similar parameters of public transport functioning. The research was conducted based on the results of surveys of the population of Lviv. It was found that the perception of value indicators (fare and methods of paying for travel) differs the most depending on age, average monthly income and type of employment. The socio-economic indicators of the respondents have the least influence on the change in the estimation of time indicators of displacement. In this case, the level of satisfaction correlates with the actual durations of individual components of the movement (the time of the trip and the waiting time at the stop). According to the results of the surveys, the time parameters of the movement, the occupancy of the vehicle, the cleanliness of the vehicle, and the behavior of the driver have more influence on the overall assessment of the transport service quality indicator than the equipment of the stop, the convenience of boarding/alighting, the noise in the vehicle, and the convenience of paying for the fare. The obtained results can be useful for providers and customers of transport services when determining priority measures to improve the quality of public transport.*

Keywords: *public transport, service quality, satisfaction level, travel time, waiting time, socio-economic indicators.*

1. INTRODUCTION

Managing the demand for transport services to increase the efficiency of the urban transport system involves reducing the level of use of private transport within the city by promoting more sustainable types of transport, in particular public transport. Public transport has many benefits in terms of energy savings, environmental impact, social equity and urban economy [1]. Urban transport systems play a decisive role in ensuring the sustainable development of cities [2].

When evaluating the operation of public transport, two categories are distinguished – satisfaction and loyalty [3]. Satisfaction is defined as the ratio between the level of service received by the consumer of the transport service and the level of service he expected to receive. Loyalty is a more difficult criterion to evaluate and characterizes the consumer's willingness to use services based on his previous experience. The survey is one of the main ways of obtaining information about the expectations of consumers and their perception of specific parameters of transport service, and it allows getting an actual assessment from the point of view of the consumer of the service.

2. RELEVANCE OF THE STUDY

The quality of services provided by the public transport system directly affects the intentions of potential passengers to use it more, which helps to reduce the flow of private cars and has a positive effect on the urban environment [4].

The European Union supports a customer-oriented service policy and encourages the study of passenger needs and expectations to improve the quality of trip demands [5]. Regional features affect users' perception of the quality of transport services [6]. The level of economic well-being, the state of development of the transport system, the national strategy for the development of social mobility, etc., can explain different perceptions of the importance of similar parameters of the functioning of public transport.

3. FORMULATION OF THE AIM AND ARTICLE TASKS

The purpose of the study is to assess the quality of the functioning of the urban public transport system and to study the influence of the socio-economic characteristics of the user of transport services and the time parameters of the movement on the change in the overall assessment. In connection with the set goal, the following tasks are defined:

- to analyze literary sources to determine general and distinctive features in users' assessment of the quality of transport services;
- based on the analysis of the results of the surveys conducted in the city of Lviv, to determine the overall assessment of the quality of transport services by urban public transport and the impact of individual components of the quality indicator on the overall result;
- to assess the impact of the socio-economic characteristics of the respondents on the perception of the quality of transport services provision;
- to form mathematical models for evaluating the quality of transport services depending on the change in time parameters of the trip.

4. ANALYSIS OF RESENT RESEARCH AND PUBLICATIONS

The analysis of the available literary scientific sources allows us to identify nine groups of indicators used to evaluate the quality of the provision of transport services (Fig. 1) [7]:
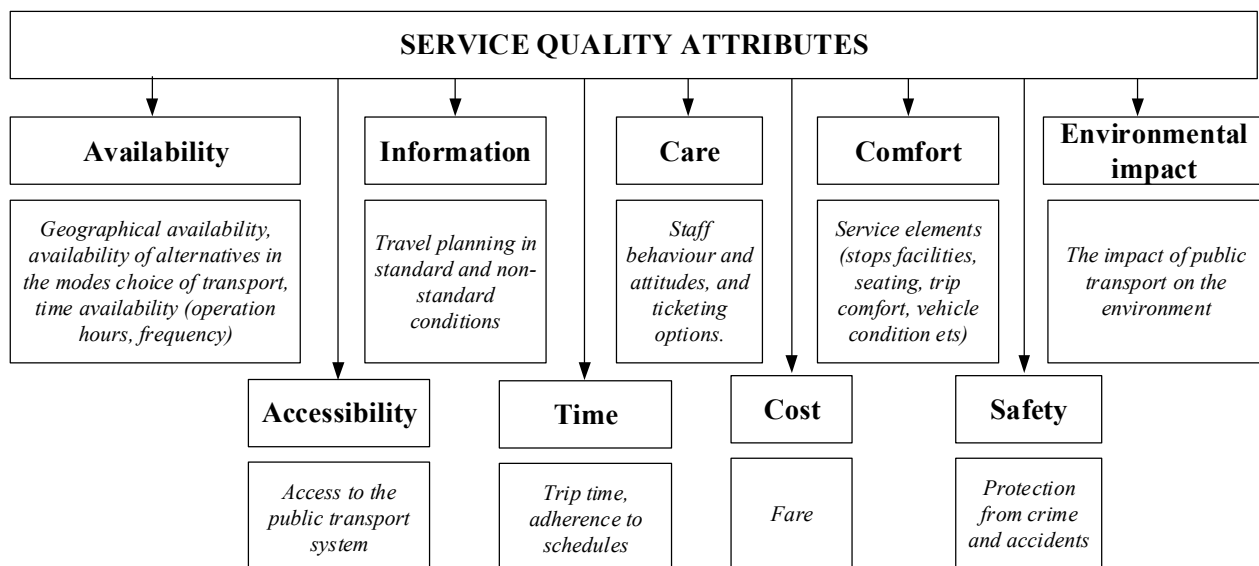

Fig. 1. Groups of transport service quality indicators [7]

Quality assessment can be carried out from the standpoint of various participants in the transport process: service providers, their consumers, management and control authorities [8]. Each party has different views on the importance and priority of separated quality components. However, even

representatives of the same group of participants can evaluate the same parameter differently. In particular, this concerns the population as users of transport services. Loyalty to public transport services depends on demographic and socio-economic factors [9–11].

Table 1 presents the results of literary sources analysis regarding studies of the importance of individual components of service quality indicator by urban public transport based on the results of surveys of the population in different countries.

Table 1

Importance of individual components of the transport service quality (theoretical analysis)

Article	Location	Sample size	Public transport quality indicators		
			the most important	medium importance	the least important
[12]	Germany	>3000	Travel time, ease of transfers	Travel cost, waiting time	Delay, access and egress time
[13]	Granada (Spain)	858	Frequency, speed, information, punctuality	Safety, access and egress time	Cleanliness
[14]	Madrid (Spain)	293+520	Frequency, safety, punctuality	Travel time, information, comfort and access of free seats, network, access and egress time	Cleanliness, safety, courtesy of drivers, network, comfort
[15]	Stockholm (Sweden)	Customer satisfaction survey 2008–2016	Frequency, reliability	Crowding, courtesy of drivers	Cleanliness, information
[16]	Stockholm (Sweden)	859	Cleanliness, frequency, punctuality, reliability	Information, comfort and access of free seats	The opportunity to work while traveling
[17]	Itajubá (Brazil)	220	Safety, courtesy of drivers, punctuality, the adaptation of the vehicle for people with special needs	Travel cost, cleanliness, information, waiting environment, comfort	Travel time, vehicle age, intermodality
[18]	Accra (Ghana)	134	Travel time, crowding, comfort and access of free seats, punctuality	Ease of transfer	Safety, security of luggage
[19]	Amman (Jordanian)	210	Safety, comfort and access of free seats	Travel cost, travel time, speed, reliability, directness	Information
[20]	Shenyang (China)	424	Cleanliness, ease of transfer, speed, safety, crowding, comfort and access of free seats, punctuality, waiting environment	Information, courtesy of drivers	Temperature on board

The theoretical analysis shows some regional differences in the assessment of individual quality indicators. For example, indicators such as cleanliness in the vehicle, awareness, safety, and even travel time are among the most important for respondents from some regions and have the smallest impact on the perception of the quality of transport services for respondents from other ones.

5. PRESENTATION OF BASIC MATERIAL

Experimental context. The research used data obtained in a survey of public transport users in Lviv city under the auspices of the Department of Transport and Communications of the Lviv City Council. Lviv is a large city with a population of 754.000 persons as of the beginning of 2022 and a population density of 5.060 people/km^2. The city route network of public transport consists of 67 routes, of which

eight tram routes, ten trolleybus routes and 49 bus routes (18 routes are served by high-passenger buses, 31 by medium-passenger buses). In Lviv, diametrical routes passing through the city center predominate (40 %), and another 33 % are radial, and the remaining 27 % are chordal. Also, more than 60 suburban public transport routes pass through the urban street and road network.

Data collection was carried out during October – December 2022. As a result of the survey, 4765 relevant answers were received: 52 % from male and 48 % from female. The general characteristics of the sample regarding age, employment, average monthly income and the type of public transport that people prefer are presented in Fig. 2.
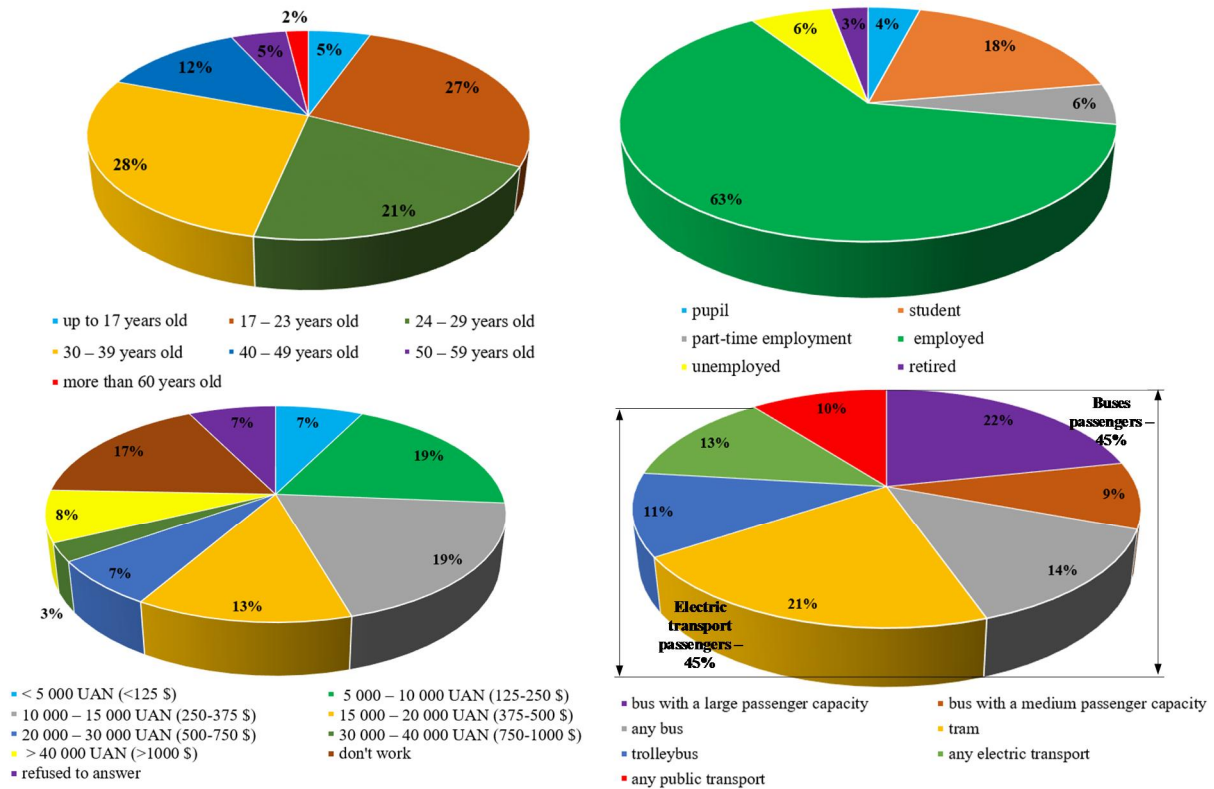

Fig. 2. General characteristics of the sample of interviewees
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When filling out the questionnaire, the respondents provided answers regarding the characteristics of their regular trips through the city and evaluated parameters of the functioning of public transport on a 5-point scale:

- the quality of the route network (nearness to a public transport stop, coverage of the city by the route network, equipment of stops);
- time parameters of movement (waiting time at the stop, trip time);
- parameters of comfort of movement (comfort of getting on/off, fullness of the vehicle during the trip, cleanliness of vehicles, comfort of seats, noise in the vehicle);
- cost parameters of movement (fare, ease of payment);
- other parameters (behavior of drivers, safety during the trip).

Respondents were also asked to choose the most important indicator when traveling by public transport for them. The answers were distributed as follows:

- for 45 % of respondents, the most important thing is to minimize the time they spend on trips;
- 28 % of respondents called the availability of a direct route to the destination as the main thing;
- another 23 % of respondents consider the short waiting time at the stop to be the most important.

The rest of the respondents did not decide on the answer.

General characteristics of public transport service quality assessment. In general, the quality of public transport services in Lviv is rated by passengers at 2.92 points out of 5. The indicator "nearness to a public transport stop" received the highest rating – 3.49 points. The fullness of the vehicle has the lowest rating by the respondents – this parameter received an average rating of 2.12 points. Complete information is given in Fig. 3.
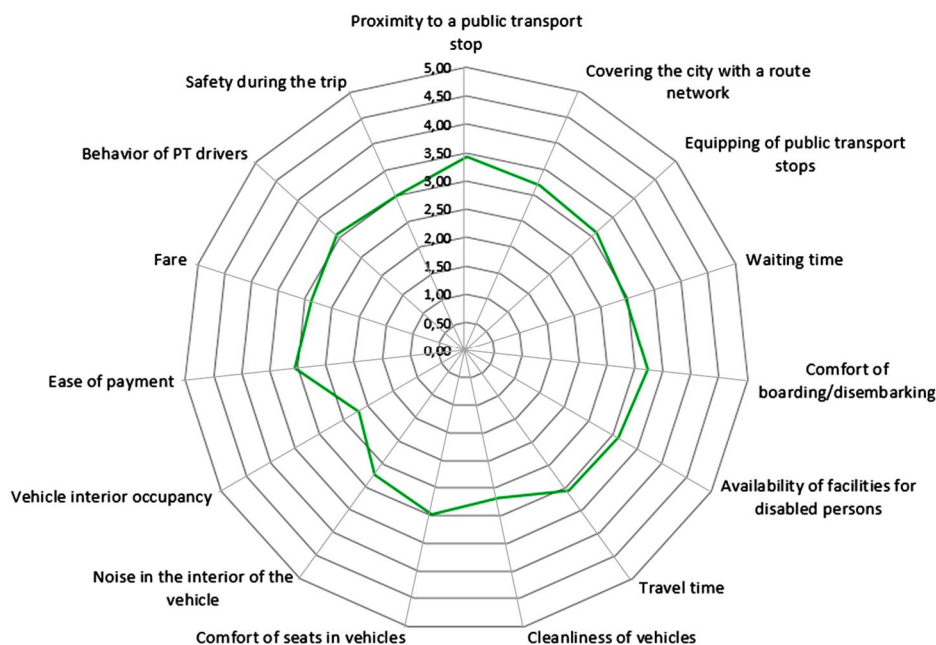

Fig. 3. Passengers' overall assessment of the quality of Lviv urban public transport

The impact of socio-economic characteristics of respondents on the evaluation of the quality of transport service. A general analysis of the groups of respondents who named a particular parameter of public transport as the most important saw that a direct route is more important for younger travelers with a lower income level. Older and more well-heeled people seek to minimize their waiting time at a stop (Table 2).

Table 2

The predominant type of interviewees among those who chose a particular parameter of movement by public transport as the most important

The most important indicator	Gender	Age	Employment	Income level
Direct route	female	up to 39 years	students, unemployed, retired	< 15 000 UAH
Waiting time	male	more than 40 years	employed, part-time employed	> 30 000 UAH
Trip speed	–	–	pupils	15 000–30 000 UAH

The socio-economic characteristics of the respondents have the greatest influence on the parameters` estimation of the cost of a trip. The smallest fluctuations are among the estimates of the time parameters of the trip. As for other elements, the assessment of the parameters of movement comfort and the driver's behavior is most influenced by age, and the assessment of the parameters of the route network quality and the safety of movement is influenced by the type of employment. The value of the dispersion of the average assessment of each parameter of public transport service quality by respondents with different socio-economic characteristics is presented in the Table. 3.

Table 3

**Dispersion of the assessment of quality indicators by respondents
with different socio-economic characteristics**

Socio-economic characteristics	Dispersion of estimates of quality indicators, %							
	Proximity to a public transport stop	Covering the city with a route network	Equipping of public transport stops	Waiting time	Comfort of boarding/dis embarking	Availability of facilities for disabled persons	Travel time	Cleanliness of vehicles
Age	1.26	3.95	2.34	3.07	0.34	2.28	0.92	7.28
Employment	2.07	2.58	3.61	1.28	0.42	1.92	2.61	4.18
Income level	1.15	0.58	0.19	0.64	0.74	0.41	0.71	0.99

Socio-economic characteristics	Comfort of seats in vehicles	Noise in the vehicle	Overcrowding of the vehicle	Ease of payment	Fare	Behavior of PT drivers	Safety during the trip
Age	4.11	4.55	4.38	10.50	14.16	1.41	3.94
Employment	5.71	2.96	3.31	14.87	5.66	1.18	4.99
Income level	1.00	0.11	0.81	3.92	16.39	0.54	0.88

A more detailed analysis for parameters of public transport service quality with the largest dispersion in relation to socio-economic characteristics is presented in the Table. 4.

Table 4

**Dependence of the evaluation of quality indicators
on the socio-economic characteristics of the respondents**

Quality indicator	Socio-economic characteristic	The highest average value of the quality indicator	The lowest average value of the quality indicator	Additional Information
Ease of payment	Age	more than 60 years old: 3.74	24–29 years old: 2.82	Regression function: $y = 0.079 \cdot x^2 - 0.6027 \cdot x + 3.99$ $R^2 = 0.87$ y − evaluation of the indicator of the ease of paying the fare $x = 1 \div 7$ − age range (according to the division by age presented in Fig. 1)
Fare	Age	more than 60 years old: 3.75	up to 17 years old: 2.58	Regression function: $y = 0.04 \cdot x^3 - 0.47 \cdot x^2 + 1.655 \cdot x + 1.27$ $R^2 = 0.83$
Cleanliness of vehicles	Age	more than 60 years old: 3.13	50–59 years old: 2.37	Regression function: $y = 0.02 \cdot x^3 - 0.191 \cdot x^2 + 0.4 \cdot x + 2.51$ $R^2 = 0.83$
Ease of payment	Employment	retired: 3.91	unemployed: 2.91	–
Fare	Income level	> 40 000 UAH: 3.74	5 000–10 000 UAH: 2.7	Regression function: $y = 0.1843 \cdot x + 2.4094$ $R^2 = 0.97$ y − evaluation of the fare indicator $x = 1 \div 7$ − the range of the average monthly income level (according to the division by income level presented in Fig. 1)

In general, age is the indicator that, among socio-economic characteristics, has the greatest impact on the change in the quality assessment of transport service parameters. The variation of estimates depending on the level of income is the smallest (except for the estimate of the fare). Young people under 23 years and people over 60 years old (when compared by age), students and pensioners (when compared by type of employment) and the population with an income of up to UAH 5000 (≈ € 125) or more than UAH 30000 (≈ € 750) rate the quality of transport service the highest.

The influence of time parameters of trip on the evaluation of the quality of transport service. The correlation between the quantitative parameters of the time characteristics of trips by public transport and the qualitative assessment of these parameters by passengers` is presented in Fig. 4.
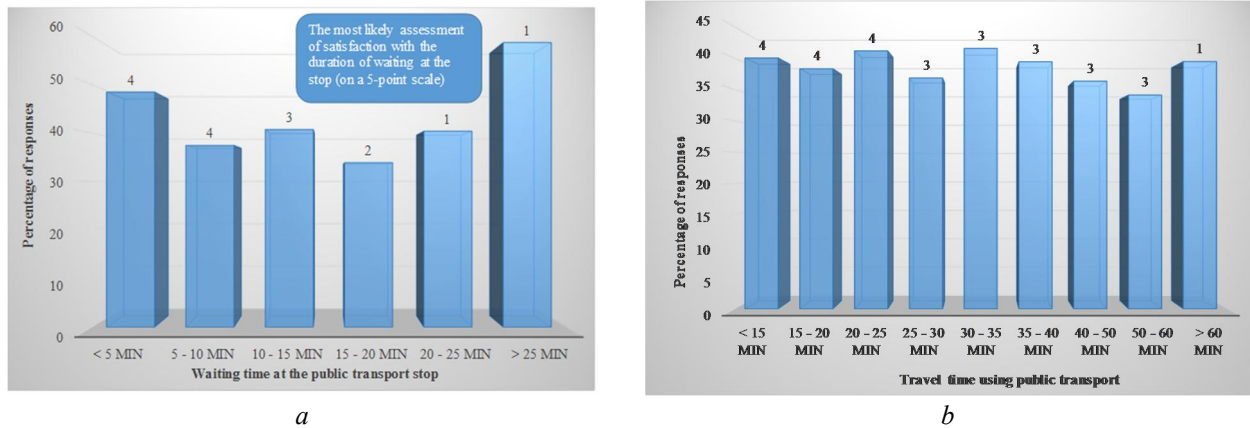

Fig. 4. Parameters of a qualitative assessment of time characteristics: a) waiting time at the stop; b) trip time

When the waiting time is up to 10 minutes, the most frequent rating of this parameter is 4 – "good", and rating 3 ("normal") is found most often when the actual waiting time is between 10 and 15 minutes. Longer waiting times are mostly negatively perceived by passengers: a third of the respondents rate a time of 15–20 minutes as 2 ("bad"), and for a duration of more than 20 minutes, the most likely rating is 1 – "very bad". The probability of a rating of 5 ("excellent") is highest when the waiting time is up to 5 minutes and is 0.16. At longer waiting times, this probability drops to values less than 0.05.

Trip duration up to 25 minutes is mostly rated by respondents as 4; a rating 3 prevails among respondents for whom the average trip time is within 25–60 minutes, and longer trips are rated by the majority of respondents as 1 point. The probability of the highest score is greatest for the shortest trips, lasting up to 15 minutes, and is 0.11. For trips lasting from 15 to 20 minutes, the probability of a score of 5 is 0.08. For longer trips, this probability is less than 0.05.

Analytical functions of changes in the level of satisfaction with the quality of movement on the waiting time at the stop and the trip time were formed based on information about the time parameters of movement and the evaluation of these parameters by consumers of transport services. These functions are presented in Fig. 5.

An increase in the waiting time at a stop reduces the average assessment of this indicator fairly evenly: minus 10–15 % to the value of the average assessment for every 5 minutes of increase in the waiting. The rate of decrease in the estimate of the trip time increases with the increase of the trip: if the difference between the estimate of a trip lasting up to 10 minutes and a trip lasting 10–15 minutes is 1.3 %, then the difference between a trip lasting 40-50 minutes and a trip lasting 50–60 minutes – 9 %. Overall, the effect of waiting time on the mean quality score is greater than the effect of trip time: the range of change in mean waiting time scores is 1.72 to 3.58 (108 % difference), and the range of change in mean trip time scores is 2.05 to 3. 47 (a difference of 41 %).

The regression model of the dependence of the overall average assessment of the quality of public transport system functioning on the time parameters of the trip has the form:

$$y = -0.023 \cdot x_1 - 0.295 \cdot x_2 + 3.797, \tag{1}$$

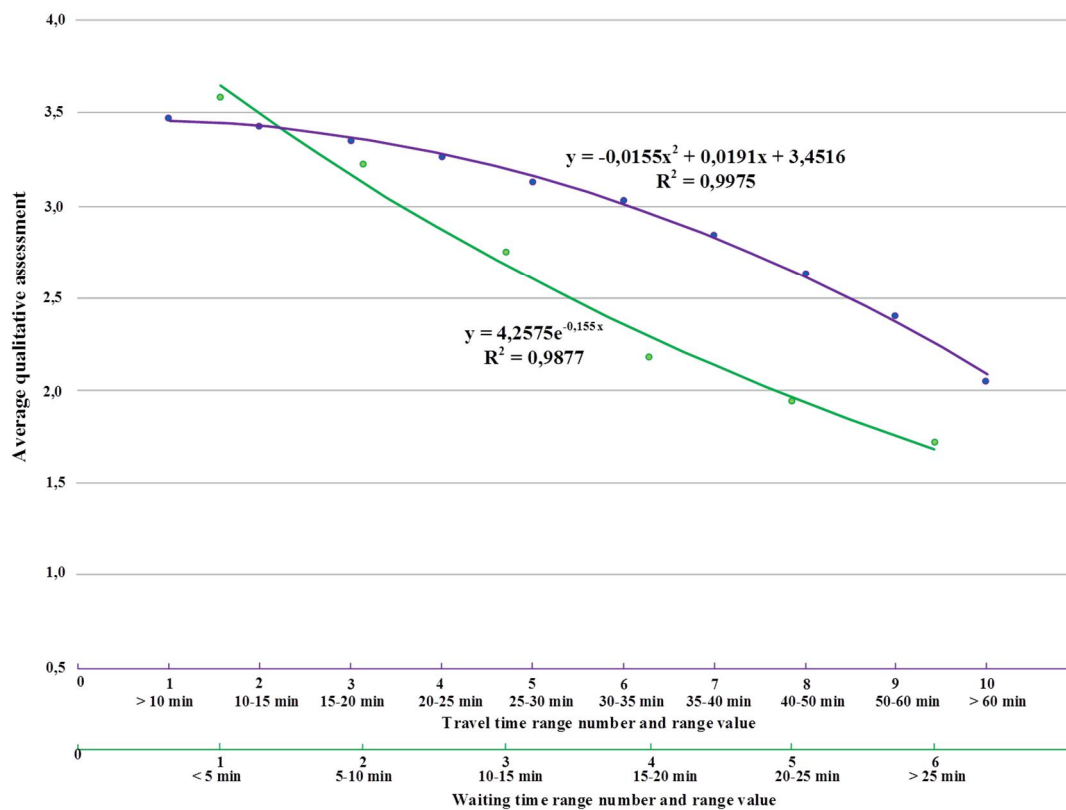where $x_1 = 1 \div 10$ – ranges of trip time; $x_2 = 1 \div 6$ – ranges of waiting times at a stop.

Fig. 5. Dependence of the average estimate of the components of travel time on the actual value of these components

The coefficient of determination of the function is $R^2 = 0.88$, parameter Significance F = 0.5·10^{-26}, the actual value of Fisher's test is 201, which is greater than the table value 0.31 (for probability 95 %). P-value for parameter "trip time" is equal 0.01, for parameter "waiting time" – 2.56·10^{-27} (both values are less than 0.05).

Assessment of the influence of individual components on the general indicator of the quality of transport services. The search for correlations between the general assessment of the quality of the functioning of the public transport system and assessing the individual functioning parameters did not show a sufficiently significant correlation (the maximum observed value of the coefficient of determination was $R^2 = 0.57$). However, the obtained results make it possible to form different groups of factors depending on the degree of their influence on the overall assessment:

– group 1, factors of greatest influence. These factors include the coverage of the city by the route network and the waiting time;

– group 2, factors of medium influence: trip time, cleanliness in the vehicle and comfort of the seats, availability of free space (overcrowding of the vehicle), driver behavior and safety during the trip;

– group 3, factors with the least influence: the availability of a route within 500 m to the stop, comfort at the stop, comfort of getting on/off, noise in transport, and convenience of payment have little influence on the final assessment of the quality of transport services.

Based on the construction of four correlation matrices for four randomly generated parts of the available data sample, it is also possible to select pairs of indicators for which the value of correlation coefficients exceeds 0.5 in all samples:

– "the availability of a route within 500 m to the stop" and "coverage of the city by the route network";
– "equipment of the stop" and "comfort of getting on/off";
– "cleanliness in the vehicle" and "comfort of the seats";
– "noise in transport" and "availability of free space in vehicle";
– "safety during the trip" and "driver behavior".

The obtained results can be useful both for providers and for customers of services for the transportation of passengers through the route network for the formation of correct criteria for assessing the quality of these services.

6. CONCLUSIONS AND FUTURE RESEARCH PERSPECTIVES

As a result of this research, such conclusions can be made:

1. The perception of public transport by users of urban transport system directly affects the population's willingness to use public transport and, therefore, the possibility of sustainable development of the city. Understanding what factors are essential for passengers when they evaluate the quality of the operation of public transport opens up wider opportunities for service providers, allowing them to form a plan of priority measures, especially in conditions of limited resources. The theoretical analysis revealed some regional differences in the assessment by passengers of individual components of the quality of the urban public transport system, which confirms the feasibility of analyzing Ukrainian conditions.

2. Data from surveys conducted by the Transport and Communications Department of the Lviv City Council during October – December 2022 were used for the analysis. The questionnaire consisted of three parts: socio-economic characteristics of the respondent, characteristics of regular trips through the city, and evaluation on a 5-point scale of the general level of the quality of transport service and separated parameters of public transport functioning (route network quality, time parameters, parameters of comfort of movement, safety and fare parameters).

3. In general, the quality of public transport services in Lviv is rated by passengers at 2.92 points out of 5. Passengers rated the indicator "nearness to a public transport stop" the highest (3.49 points), the lowest – overcrowding of the vehicle (2.12 points).

4. Socio-economic characteristics of respondents have a different impact on the assessment of various parameters of the quality of transport service: the smallest difference between the assessments of respondents with different socio-economic characteristics is observed in the assessment of the quality of time parameters of public transport service, the largest difference is in the assessment of the cost and convenience of fare payment. Age has a greater influence on the assessment of the parameters of the comfort of movement and the behavior of the driver, the type of employment – on the assessment of the parameters of the quality of the route network and the safety of movement. Young people under 23 years and people over 60 years old (when compared by age), students and pensioners (when compared by type of employment) and the population with an income of up to UAH 5.000 (≈ € 125) or more than UAH 30.000 (≈ € 750) rate the quality of transport service the highest.

5. Numerical values of time parameters of movement directly affect the quality assessment of these parameters by consumers of transport services. The formed mathematical models have high correlation coefficients. Most passengers have a negative perception of waiting times of more than 15 minutes. Trip duration up to 25 minutes is rated mostly by respondents as 4, a rating 3 prevails among respondents for whom the average trip duration is between 25 and 60 minutes.

6. According to the results of surveys, time parameters, vehicle occupancy, vehicle cleanliness, and driver behavior have a greater impact on the overall assessment of the transport service quality indicator than stop equipment, the convenience of boarding/disembarkation, noise in the vehicle and convenience of fare payment. The obtained results can be useful for providers of transport

services when determining priority measures for improving the quality of public transport. The presence of a correlation between particular parameters of quality assessment can be taken into account when forming the correct criteria for assessing the quality of services provided and composing questionnaires for passenger surveys (to find a compromise between the size of the questionnaire and the completeness of the received information).

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ОЦІНКА ЯКОСТІ НАДАННЯ ПОСЛУГ ГРОМАДСЬКИМ ТРАНСПОРТОМ (АНАЛІЗ ДОСЛІДЖЕНЬ У ЛЬВОВІ, УКРАЇНА)

Анотація. В роботі здійснено оцінювання якості надання послуг громадського транспорту та впливу окремих компонентів на значення загального рівня задоволеності транспортним обслуговуванням. Громадський транспорт має багато переваг щодо енергозбереження, впливу на навколишнє середовище, соціальної справедливості та міської економіки. Аналіз виконаних досліджень підтверджує, що якість надання послуг системою громадського транспорту безпосередньо впливає на наміри потенційних пасажирів більше ним користуватися. Проте рівень економічного добробуту, стан розвитку транспортної системи, національна стратегія щодо розвитку соціальної мобільності тощо впливають на різне сприйняття важливості тих самих параметрів функціонування громадського транспорту. Дослідження ґрунтуються на результатах опитувань населення м. Львова. Виявлено, що сприйняття показників вартості (ціни та способів оплати проїзду) найбільше відрізняється залежно від віку, середньомісячного рівня доходу та виду зайнятості. Найменше соціо-економічні показники респондентів впливають на зміну оцінки часових показників переміщення. В цьому випадку рівень задоволеності корелює із фактичними тривалостями окремих компонентів переміщення (тривалості поїздки та тривалості очікування на зупинці). Згідно з результатами опитувань, часові параметри переміщення, заповненість салону транспортного засобу, чистота в салоні та поведінка водія істотніше впливають на загальну оцінку показника якості транспортного обслуговування, ніж облаштування зупинки, зручність посадки/висадки, шум в салоні та зручність оплати проїзду. Отримані результати можуть бути корисними для надавачів та замовників транспортних послуг під час визначення першочергових заходів для поліпшення якості громадського транспорту.

Ключові слова: громадський транспорт; якість обслуговування; рівень забезпечення потреб; тривалість руху; тривалість очікування.