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Analysis of Effectiveness of the Public Transport System in Modern Conditions of Development

Liya Panferova
Department of Accounting and Electronic Business
Chuvash State University
Cheboksary, Russia
2013-leto@list.ru

Alevtina Kulagina
Department of Actuarial and Financial Mathematics
Chuvash State University
Cheboksary, Russia
agkul68@bk.ru

***Abstract*—This article discusses the role of urban public transport, its social significance, lists the problems faced by the organization of urban public transport in Russia, gives its features and distinctive features. Various information sources offer their own parameters for assessing the quality of transport services; in this regard, the main subjective and objective indicators for assessing the quality of urban public transport are considered. To assess the dynamics of public transport development indicators in the Russian Federation, chain growth indices were calculated. Among all the existing methods for calculating the generalizing indicator, the most affordable and less costly in practice method was chosen - calculating the indicator using the geometric mean formula. An analysis of the current development of transport in the Russian Federation was carried out, as well as measures to further improving the quality of transport services in the country were proposed.**

Keywords—quality of transport services, urban transport, indicators, accessibility of public transport, development of public transport, public transportation, assessment methods.

I. INTRODUCTION

Urban public transport plays a significant role in the development of both municipal and regional economies. To carry out their activities enterprises and organizations of cities need a workforce, which in turn is represented by passengers who need transport to get to their workplace. Also we shouldn't forget about the social importance of public transport, which is to ensure public access to social security, education and health institutions.

The big problems in organizing urban public transport in Russia are related to the low level of passenger service, poor road conditions, high deterioration of vehicles, and inadequate funding of this sector by state, regional and local budgets. In this regard, the development of a system of indicators for assessing the quality of transport services and measures to develop the urban transport system in the country is becoming more and more important.

II. LITERATURE REVIEW

The need of the population for transportation is connected both with production activities and with cultural and everyday necessities. The main advantages of public transport are the factors of convenience and speed of delivery.

In the scientific literature urban public transport is understood as a multifunctional transport system that combines various types of transport and carries out traffic on the territory of the city and the nearest suburban area [1].

The main purpose of urban public transport is to transport passengers with minimal time and money costs, but with maximum possible comfort for the client.

Distinctive features of urban public transport are presented in Fig. 1.

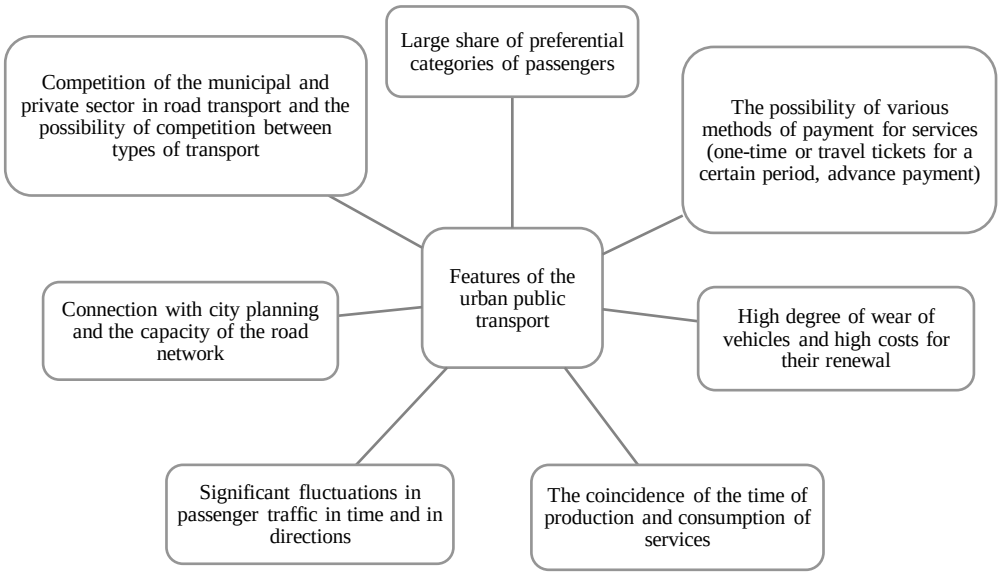

Fig. 1. Features of the urban public transport.

Various information sources offer their own parameters for assessing the quality of transport services, but in general, they agree that the most important factors are accessibility, mobility and safety of urban public transport, the quality of services, its negative impact on the environment and human health and fare.

Modern literature devoted to the study of the problems of transport services quality indicators system elaboration closely links the issues of quality and efficiency of transport organizations [2-6].

III. Research methodology

There are several approaches to the transport services quality indicators system elaboration. According to one of them, all indicators can be divided into the following groups:

- indicators as a measure of the quality of services according to subjective assessments of passengers;
- performance indicators, reflecting the output parameters of the public transport system;
- cost effectiveness indicators of transport organizations.

Subjective indicators characterize the quality of transport services from the point of view of an ordinary passenger so they give an empirical assessment of the quality of services. These indicators are of qualitative nature, and it is difficult to imagine them in the form of any quantitative characteristics. These indicators include:

- Convenience, safety of expectation and availability of public transport.
- Simplicity and convenience of fare payment.
- Visual assessment of the design of the vehicle and appearance of the staff.
- Professionalism and courtesy of staff.
- Comfort and interior design of the vehicle.
- Safety and reliability of the vehicle.
- Ability to communicate with vehicle personnel through information and communication networks.
- Vehicle speed and driver's style.

Objective indicators no longer affect the consumer perception of the quality of transport services, but they have specific quantitative terms. These indicators include:

- Depreciation of fixed assets (vehicles, roads, other transport infrastructure).
- Staff qualification.
- Privileges for socially unprotected segments of population.
- The degree of fullness of the vehicle.
- Frequency and speed of the vehicle on the route.
- Accessibility of the vehicle for people with disabilities
- Noise and gas pollution of the road and the vehicle interior.
- Number of car accidents on the route.
- Availability of first aid items.

However, in practice, the compilation of quality assessments based on subjective indicators requires significant financial investments which are related to the fact that it is necessary to compile questionnaires with an appropriate list of questions, conduct opinion polls to collect the necessary information and then process the resulting statistical data. In this regard, priority is given to objective indicators.

IV. Results

We have proposed the following indicators for the evaluation of these parameters:

1) Accessibility - includes such characteristics as the time spent on the same trip on different types of transport, the number of types of transport, the cost of one trip and transportation conditions, the speed of movement of public transport, average time to the nearest stop, average waiting time at the bus stop, the time interval between transport, etc.

2) Mobility - characterized by such indicators as the average time spent by passengers in the vehicle, the average number of trips made by 1 passenger for a certain period of time, average distance on public transport, transport speed of different types of public transport, etc.

3) Security - can be characterized by such indicators as the number of death accidents differentiated by types of public transport; the number of road accidents involving public transport, as well as with the fault of the driver of a public vehicle, etc.

4) Quality of service, which includes the following indicators: the proportion of the population, distributed by segments of society, living directly next to the stops; quality of transport infrastructure; vehicle comfort; accessibility of transport for people with disabilities, etc.

5) Reducing the negative impact on the environment and human health. This parameter is characterized by volume of carbon dioxide emissions per capita; the number of eco-cars running on alternative energy sources that do not cause such damage to the environment as petroleum products.

6) The cost of transportation should be at such level that public transport is accessible to all social groups of the population. It can be described by such indicator as the share of transportation costs differentiated by the incomes of different groups of the population.

However, in practice, it is difficult to carry out an assessment of all these indicators in the Russian Federation, due to the lack of most of the necessary statistical data. In this connection, we chose only those indicators for calculating of which there is data on the official website of the Federal State Statistics Service of the Russian Federation. The results are presented in Table 1.

The following types of transport prevail in the Russian land transport system: buses, trolleybuses, trams (Fig. 2).

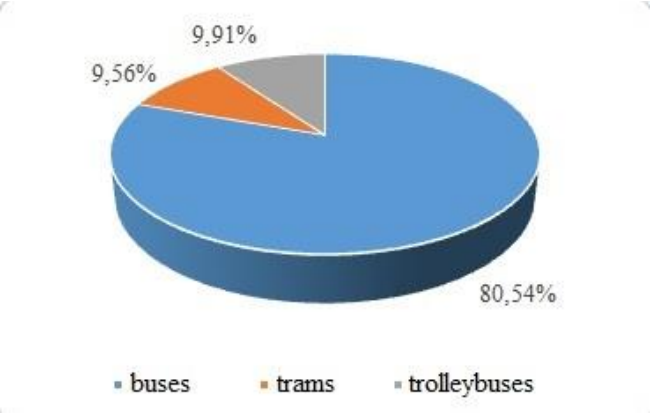

Fig. 2. The structure of land public transport in the Russian Federation in 2017.

Thus, in Russia, 80.54% of the entire vehicle fleet is presented by buses, and the remaining part is divided almost in half by trams and trolleybuses. Each type of transport has its drawbacks, which are offset by benefits. Buses have high mobility, short commissioning time, low costs for the development of new routes, but they are characterized by an increased level of environmental load and less reliable operation. Trolleybuses, on the contrary, have less maneuverability and mobility and require special power supply devices. However, they do not have a negative impact on the environment and have greater capacity. Trams are environmentally friendly and do not depend on climatic conditions, but require significant initial investments for commissioning [7].

To assess the dynamics of public transport development indicators in the Russian Federation chain growth indices were calculated, and general average growth indices for indicators considered separately for specific types of transport (trolleybuses, buses and trams) were calculated using the geometric average formula.

TABLE I. DYNAMICS OF INDICATORS OF PUBLIC TRANSPORT DEVELOPMENT IN THE RUSSIAN FEDERATION FOR 2013-2017

№	Indicator	2013	2014	2015	2016	2017
1	The average number of passenger trips by types of public transport for 1 person					
	bus	80.86	80.40	78.76	77.11	76.19
	tram	11.37	10.79	10.10	9.54	9.04
	trolleybus	12.11	12.55	11.05	10.12	9.37
	Overall growth index	1.000	0.993	0.931	0.946	0.954
2	The number of road accidents per 100 thousand persons	142.2	138.9	125.7	118.4	115.4
	Growth index	1.000	0.977	0.905	0.942	0.974
3	Emission of air pollutants, thousand tons	32063	31228	31269	31617	32068
	Growth index	1.000	0.974	1.001	1.011	1.014
4	The amount of expenses for environmental protection, mln. rub.	479169	559703	582128	590865	657024
	Growth index	1.000	1.168	1.040	1.015	1.112
5	Urban (intracity) public transportation by types of public transport, million people					
	bus	11 587	11 554	11 523	11 296	11 184
	tram	1 629	1 551	1 478	1 397	1 327
	trolleybus	1 735	1 803	1 616	1 483	1 376
	Total average growth index	1.000	0.996	0.948	0.947	0.956
6	Availability of vehicles by types of public transport, thousand pieces					
	bus	166	167	175	171	170
	tram	8.3	8.3	8	7.8	7.7
	trolleybus	10.7	10.7	10.2	9.7	9.4
	Total average growth index	1.000	1.002	0.968	0.968	0.983

From the data obtained in the table, you can see an annual decrease in the number of passengers traveling by public transport. First of all this trend is associated with an increase in private cars among citizens, as well as with the simultaneous trend of a decrease in the number of public vehicles. It is important to note the positive trend in reducing the number of road accidents from year to year. Despite the decrease in emission of pollutants into the atmosphere in 2014, their increase is generally observed. However, at the same time, the volume of costs for environmental protection is growing even at a higher rate than pollutant emission into the atmosphere.

The main reason for many of the existing problems in the field of transport services provided to the population is the lack of funding. In most cases, municipal authorities, represented by municipal transport enterprises and organizations, financed by the local budget, are responsible for the organization of public transportation, which, in turn, usually also suffers from a deficit. And there is a problem of obsolescence of the fleet of vehicles, and, as a consequence, low satisfaction of passengers from the use of public transport. In addition, older models of vehicles have a stronger negative impact on the environment [8-10].

In addition, a passenger who is not satisfied with the quality of public transport services can switch to personal vehicles. And the lower the satisfaction with the use of public transport is, the greater the number of private cars will be on the road, which in turn leads to another problem - «traffic jams». Congestion on the roads leads to an even greater increase in travel time, which leads to the violation of regular flights and reliable transportation. As a result, in order to maintain regularity of routes, local authorities need to increase the public transport fleet, and, accordingly, the costs of public transportation.

Also, a long stay in a traffic congestion increases driver fatigue, which can lead to a decrease in concentration on the road. In addition, «traffic jams» contribute to excessive fuel consumption, which has a negative impact on the environment [11,12].

The assessment of the dynamics of indicators is not possible without the integral indicator calculating, which can be determined with the help of various methods. [3].

Firstly, the method, which is based on the use of weighting factors characterizing the degree of influence of each particular indicator. Most often, the method of expert assessments is used to determine the weight of a particular indicator.

Secondly, it is possible to use the method of rank correlation, which is based on the ranking of particular indicators and their indices.

Among all the existing methods for calculating the generalized indicator, we chose the most accessible and less expensive method - the calculation of the indicator using the geometric average formula. When calculating the general indicator, the orientation of particular indicators – positive or negative-was taken into account.

If the indicator is positive – its indices remain unchanged, and if negative the values are replaced with the reverse ones. The obtained values are presented in Table 2.

TABLE II. INDICATORS OF THE DEVELOPMENT OF PUBLIC TRANSPORT IN THE RUSSIAN FEDERATION FOR 2013-2017

Indicator	2013	2014	2015	2016	2017
Average number of passenger trips (direct index)	1.000	0.993	0.931	0.946	0.954
The number of traffic accidents (reverse index)	1.000	1.024	1.105	1.061	1.026
Emission of air pollutants (reverse index)	1.000	1.027	0.999	0.989	0.986
The amount of expenses for environmental protection (direct index)	1.000	1.168	1.040	1.015	1.112
Urban (intracity) public transportation (direct index)	1.000	0.996	0.948	0.947	0.956
Availability of vehicles (direct index)	1.000	1.002	0.987	0.968	0.983
Integral index	-	1.033	1.000	0.987	1.001

Thus, we see that compared to 2013 in 2014 there was a slight acceleration by 3.3% of the development of the transport system in the Russian Federation, which was most associated with a decrease in the number of road traffic accidents and a decrease in emission of pollutants into the atmosphere. However, there was no further acceleration in 2015, and in general the level of development of public transport remained at the same level. On the contrary in the following 2016 a slowdown in development by 1.3% occurred. The greatest impact was the decrease in the average number of trips made by passengers and the reduction in the number of vehicles. Indicators for 2017 as a whole increased by only 0.1%, so we can say that the development of public transport remained at the level of 2016.

V. CONCLUSION

According to the results of the study the following measures to improve the quality of urban transport services were proposed:

1) Increasing the availability of urban transport for people with disabilities.

2) Public transport travel charging taking into account the average per capita income of the population.

3) Updating of worn vehicles and replacing them with modern samples.

4) Organization of the road space in such a way that the priority of public transport is ensured (a separate lane for public transport, etc.).

5) Organization of transport routes in order to minimize transfers made by passengers.

6) Application of modern economic and mathematical methods and models of management decision-making by transport operators and municipal authorities.

7) Optimization of the fare payment process in direction of its acceleration and simplification.

REFERENCES

[1] A. G. Mal'chikova, Organization of logistic flows in the system of urban passenger traffic: Authors Abstract of Candidate of Sciences (PhD) Dissertation (Economic sciences). Saint-Petersburg: Publisher SPBGTUEF, 2000. (in russ.)

[2] S. A. Kirsanov and T. Y. Anopchenko, "Problems of organization of urban transport in Russia," State and Municipal Management. Scholar Notes, No. 4, pp. 62-69, 2014. (in russ.)

[3] I. A. Toymensteva, "Determination of the integral indicator of the development of public transport services on the basis of economic and mathematical modeling," Vestnik of Samara State University of Economics, No. 2 (64), pp. 115-119, 2010. (in russ.)

[4] D. E. Bryazgina, "'Chinese' markets and urban mobilities: public transport system in everyday life in the city (the case of Irkutsk)," Siberian Historical Research, No. 1, pp. 138-148, 2017. (in russ.) https://doi.org/10.17223/2312461X/15/9

[5] A.A. Pozanenko, "'A Kinda Separate Little Republic': Structural Specifics of Spatially Isolated Local Rural Communities," Universe of Russia. Sociology. Ethnology, Vol. 27, No. 4, pp. 31-55, 2018. https://doi.org/10.17323/1811-038X-2018-27-4-31-55

[6] A. A. Agafonov, A. V. Sergeev, and A. V. Chernov, "Forecasting of the motion parameters of city transport by satellite monitoring data," Computer Optics, Vol. 36, No. 3, pp. 453-458, 2012. (in russ.)

[7] V. A. Paonchugin and V. N. Shirin, "Concept of integration of management of various types of public land passenger transport," Privolzhsky scientific journal, No. 2 (34), pp. 186-191, 2015. (in russ.)

[8] P. P. Volod'kin and I. N. Pugachyov, "Influence carry to abilities of the urban passenger transport on level of the transport servicing the population," Vestnik Moskovskogo avtomobil'no-dorozhnogo instituta (gosudarstvennogo tehnicheskogo universiteta), No. 4 (23), pp. 121-127, 2010. (in russ.)

[9] V. A. Serova and N. A. Serova, "Problems of passenger municipal transport and life quality," Sever i rynok: formirovanie èkonomičeskogo porâdka, No. 2 (28), pp. 107-110, 2011. (in russ.)

[10] M. N. Kripak and A. I. Kolesnik, "Problems and prospects for the development of transport infrastructure in modern cities," Sbornik nauchnykh trudov Angarskogo gosudarstvennogo tekhnicheskogo universiteta (Collection of scientific works of Angarsk State Technical University), Vol. 1, No. 1, pp. 194-198, 2014. (in russ.)

[11] M. V. Fjodorova, "Speed urban transport for modern agglomeration", Transport systems and technologies, Vol. 1, No. 1, pp. 26-36, 2015. (in russ.)

[12] V.I. Prusova, V.O. Kayl, "Prospects for the development of urban transport," Avtomobil'. Doroga. Infrastruktura (Car. Road. Infrastructure), No. 3 (5), pp. 7, 2015. (in russ.)