Quality Ratios for Public Transport Services

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Abstract. The system of quality indicators used for public transportation is proposed by the authors. Additionally, the paper considers the necessity to develop an assessment ratio, which defines a competitiveness level among enterprises. To assess the activities of a transport operator, the authors proposed to apply a four-level system that will assess the quality of transportation: the level of service may be "excellent", "good", "satisfactory" and "unacceptable".

1. Introduction
When transporting cargo, the main criteria for quality are delivery speed and cargo safety. If these two things are fulfilled in accordance with customers' requirements, then the level of quality can be rated as high. At the same time, if some discrepancies between the delivery speed and cargo safety indicators are observed as they have been originally declared in the contract, the transport service provider (operator) reimburses a customer for the costs paid for these services. So, for example, in case of damage or shortage of cargo during transportation, an operator pays the cost of the missing or damaged cargo. And if the delivery time is exceeded by the fault of an operator, he/she must pay the fines in the amount that has been previously agreed in the contract between the parties.

When carrying out passengers' transportation, the end consumer of this service is a passenger. When traveling by public transport, the main quality criteria will be: the time spent on moving and the level of comfort provided in this trip. If we make an analogy with cargo transportation, then these two quality indicators are quite close by their nature: in both cases, the end consumer is concerned, by and large, only two parameters – delivery speed and safety [1]. When transporting cargo, a consumer is concerned about the cargo safety, and when taking the public passenger transport he/she expects health safety.

2. Ratio system used to assess quality of public transport services
To express the intangible indicators of transportation quality through numerical equivalents, the ratio system is used aimed at assessing the quality of public transport services [2]. The ratio \( K_f \) shows how full a passenger’s cabin of a road vehicle is. The ratio of relative filling is used when assessing the quality of passengers’ services, and defined as the standardized ration \( Y_s \) to the actual one \( Y_a \).

\[
K_f = \frac{Y_s}{Y_a}
\]
In calculations, the ratio value can be greater than unity, because the actual filling of the passenger’s cabin in "pre-rush", "inter-rush" and "post-rush" time is less than the standard. In such cases, the filling factor is taken equal to unity (1). The ratio \( K_r \) shows the regularity of vehicles movement on the route.

\[
K_r = \frac{n_i}{N_i}
\]  

(2)

For intra-city transportation, when calculating the ratio \( K_r \), the values of the numerator and denominator correspond to:
- \( n_i \) - the number of intervals in traffic that meet the standard indicators, within the permissible deviations;
- \( N_i \) - the total number of traffic intervals.

For suburban transportation, when calculating ratio \( K_r \), the values of a numerator and denominator correspond to:
- \( n_i \) - the actual number of arrivals and departures of road vehicles to the final and intermediate stopping points according to the established schedule within the permissible deviations;
- \( N_i \) - the total number of arrivals and departures of road vehicles.

For suburban transportation, when calculating the coefficient \( K_r \), the values of the numerator and denominator indicators correspond to:
- \( n_i \) - the actual number of arrivals and departures of road vehicles to the final and intermediate stopping points according to the established schedule, within the limits of permissible deviations;
- \( N_i \) - the total number of arrivals and departures of vehicles.

Ratio \( K_r \) must be different for urban and suburban road vehicles, because not for every urban route there is a schedule. It is convenient to determine the traffic regularity for suburban road vehicles exactly according to the traffic schedule, because the intervals on these routes are usually long. The value of the permissible deviation in this ratio is taken equal to ± 2 minutes.

The ratio of relative time spent on a trip \( (K_t) \) is defined as the ratio of the time spent on the trip in the established standardized comfortable conditions \( (T_s) \) to the real time spent on the trip \( (T_r) \).

\[
K_t = \frac{T_s}{T_r}
\]  

(3)

According to the developed standard offered by the State Unitary Enterprise "Mosgortrans", the standardized time for a passenger on the way is 27 minutes. Service organization ratio \( (K_o) \) - which shows the actual level of organizational service is defined for a specific route by the number of proposals and complaints for a certain time.

\[
K_o = 1 - \frac{n}{N}
\]  

(4)

where \( n \) - is the number of complaints and proposals for a certain time; \( N \) - the total number of passengers transported during this time period.

Complaints and proposals from passengers can be received both through telephone or a messenger, the numbers of which are in the passenger cabin of a road vehicle, and by interviewing passengers through a comprehensive survey. Only complaints from passengers are taken into account, which cannot be taken into account in the existing ratios. It means that the complaints regarding regularity violations towards the vehicles’ moving, the excess filling of a road vehicle cabin, failure to provide the transport services, etc. are not taken into account, since these violations are already reflected in other ratios [3].

In a number of studies on this topic, a different approach was used to define the value of this ratio [4]. The Passenger Motor Transport Company carried out an examination and identified some violations that occurred on the route. The indicator \( n \) was the number of movements performed with a violation and indicator \( N \) was the total number of movements done on this route. The inconsistency of the approach consisted in the fact that a motor transport company was the executing and controlling body. Under the new interpretation of the formula, the “controlling authority” is passengers.
Traffic safety ratio ($K_{ts}$) – the level of transportation quality is characterized to a large extent by traffic safety.

$$K_{ts} = \frac{1}{1 + A_t B_a}$$  \hspace{1cm} (5)

where $A_t$ - time losses ratio associated with road accidents; $B_a$ – the number of accidents caused by a driver’s fault per 1 million km, where $B_a$ is calculated with formula:

$$B_a = \frac{n}{L}$$  \hspace{1cm} (6)

where $n$ – is the number of accidents caused by a driver of a bus (trolleybus, tram); $L$ – the total mileage of vehicle stock in the current year, million km;

However, when the system for measuring the degree of a driver’s fault in penalty points has been cancelled, such a formula became irrelevant. Therefore, it is proposed to define the dynamic indicator showing the level of road accidents at an enterprise based on the statistics of the number of violations for a certain period of time, regardless of their severity. The ratio of non-provision of transport services ($K_n$) is defined as:

$$K_n = \frac{Q_u}{Q_s + Q_{np}}$$  \hspace{1cm} (7)

where $Q_u$ is the number of passengers who use the transport service;

$Q_{np}$ - the number of passengers who did not use the transport service for various reasons (inability to board the vehicle, use of an alternative travel option (taxi, route taxi, walking)).

The analysis among research and practical works within this topic has showed that the ratio for assessing the quality level regarding passengers’ motor transport enterprises has not been used before.

3. **Integral quality assessment for passengers transport services**

An integral assessment of quality of transport services for passengers has already been presented in different ways in a number of works addressing this topic. However, as a rule, the applied methodology did not take into account the fact that transport operators have to work in the competitive environment. For the correct assessment applied to evaluate the quality level, it is necessary to introduce another ratio that would demonstrate the level of competitiveness for a passenger-motor-transport enterprise. This ratio is the fact of transport service non-provision ($K_n$).

| Service level   | Standards for quality ratios |
|-----------------|------------------------------|
|                 | $K_f$ | $K_i$ | $K_l$ | $K_o$ | $K_{ts}$ | $K_n$ | $K_{sq}$ |
| Unacceptable    | Below 0.77 | Below 0.81 | Below 0.95 | Below 0.91 | Below 0.81 | Below 0.84 | Below 0.5 |
| Satisfactory    | 0.86 | 0.86 | 0.95 | 0.92 | 0.84 | 0.91 | 0.5 |
| Good            | 0.93 | 0.93 | 0.96 | 0.96 | 0.93 | 0.94 | 0.7 |
| Excellent       | 1 | 1 | 0.99 | 0.99 | 0.99 | 1 | 0.95 |

The integral assessment of quality of transport services for passengers is calculated by the total impact on the service quality ratio ($K_{sq}$) relating to the vehicle filling ($K_f$), the regularity of vehicles traffic on the route ($K_i$), the passenger’s time spent on the trip ($K_l$), the general organization of service ($K_o$), and traffic safety when transporting passengers ($K_{ts}$) and total demand response to passenger transport services ($K_n$):
To assess the activities of a transport operator, it is proposed to apply a four-level system that will assess the quality of transportation: the level of service may be "excellent", "good", "satisfactory" and "unacceptable".

According to the results of the survey, the activities of the transport operator belong to 1 out of 4 quality levels, and certain actions are undertaken within the contract concluded between the customer of transportation and the route operator:

- unacceptable level of quality – the contract for transportation services is broken or not extended with the operator; if the operator undertakes to correct the deficiencies within the prescribed time, then after an expert meeting, only a large fine may be imposed on the operator.
- satisfactory level of quality – the operator is issued a warning of the recommendation nature to improve the quality of transportation; the contract is concluded (extended) with the term that the operator will reach a higher quality level by a certain time; also the operator may be fined.
- good quality level – the contract for carrying out transportation activities on the route is extended.
- excellent level of quality – upon reaching this level, the operator is paid a bonus in the amount specified in the terms of the concluded contract.

4. Conclusions
The study resulted in establishing the main values of indicators used to assess the quality of public transport; the indicators’ system has been proposed in which the ratio enabling to identify the competitiveness level of a passenger-motor-transport enterprise has been defined.

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