Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 68 (2023) 925–930

Transportation Research Procedia

www.elsevier.com/locate/procedia

XIII International Conference on Transport Infrastructure: Territory Development and Sustainability

Expert Assessment of the Factors of the Impact of Road Capacity on the Environment

Kalmamat Atabekov[a], Bakytbek Sarymsakov[a]*, Sergey Voinash[b], Irina Troyanovskaya[c,d], Adelya Sayfutdinova[b], Yuliya Balabanova[b]

[a]*Kyrgyz State Technical University named after I.Razzakov, 66, Chyngyz Aitmatov Avenue, Bishkek, Republic of Kyrgyzstan*
[b]*Kazan Federal University, 18, Kremlin Street, Kazan, Russia*
[c]*South Ural State University, 76, Lenin Avenue, Chelyabinsk, Russia*
[d]*South Ural State Agrarian University, 13, Gagarina Street, Troitsk, Russia*

Abstract

This article examines the factors that affect the capacity of the road network and environmental safety. The expert questionnaire was carried out by ranking the factors affecting the traffic capacity of the road network and environmental safety. The ranking of the factors showed that the knowledge of the Traffic Rules has the greatest impact on the throughput of the road network, and the quality of driver training is also an important factor. The article presents the results of an expert assessment, from which it follows that in order to increase the throughput of the road network and environmental safety, it is necessary to strengthen control over the observance of the Traffic Rules and improve the quality of driver training, taking into account ethics and eco-driving.

Keywords: Road Capacity; Traffic Laws; Automobile Transport; Expert Review; Environmental Safety.

1. Introduction

The conducted studies of the traffic capacity of the road network mainly consider many factors: road conditions, the composition of the traffic flow of cars, the availability of technical means of regulation, weather and climatic conditions and the design of cars. The influence of the driver on road throughput and the environment is poorly

* Corresponding author. Tel.: +9-9670-498-99-56.
E-mail address: bakay495.ru@mail.ru

10.1016/j.trpro.2023.02.129

understood. In this regard, the study of the driver's influence on the throughput of the road network and environmental safety is an urgent task. A large number of driver factors, such as qualifications, experience, age, and other components, are difficult to formalize and develop a mathematical apparatus for its analysis.

Expert assessment methods are widely used in various fields of research, which al-low making decisions and drawing conclusions. The simplicity of the technique in comparison with the creation of mathematical models for decision making has served its widespread use in research (Atabekov, 2017; Gaysin and Koutenev, 2020; Lozhkin et al., 2018; Voinash et al., 2018; Atabekov et al., 2020; Troyanovskaya et al., 2022; Tuffour and Asiama, 2022).

The procedure for conducting expert assessments has been widely developed, well-grounded and formalized as much as possible. In addition, the mathematical apparatus for assessing the accuracy of determining expert assessments has been effectively developed, including on the basis of a modern understanding of the distribution of expert opinions (Dobretsov et al., 2021).

According to the expert evaluation procedures were carried out: selection of experts, the procedure for organizing the questionnaire and its implementation, processing of the results (Farooq et al., 2020; Sarymsakov, 2014).

The selection of experts was carried out taking into account the competence and with sufficient practical experience in the field of ensuring the transportation process and road safety. The experts included current employees of the Department of Internal Affairs, transport enterprises and university researchers engaged in scientific research in the field of transportation and road safety (Sathasivam et al., 2021).

2. Materials and Methods

The number of experts was determined according to the method developed by V.L. Ruposov (2013). It was assumed that the range of expert assessments did not differ above 25%, therefore, a coefficient of variation of 25% was applied. According to the method of Ruposov V.L. (Fig. 1) with a probability of p = 0.95 and ν = 25%, it was determined that the number of required experts should not exceed 10 people. We took the required number of experts equal to 11 people.

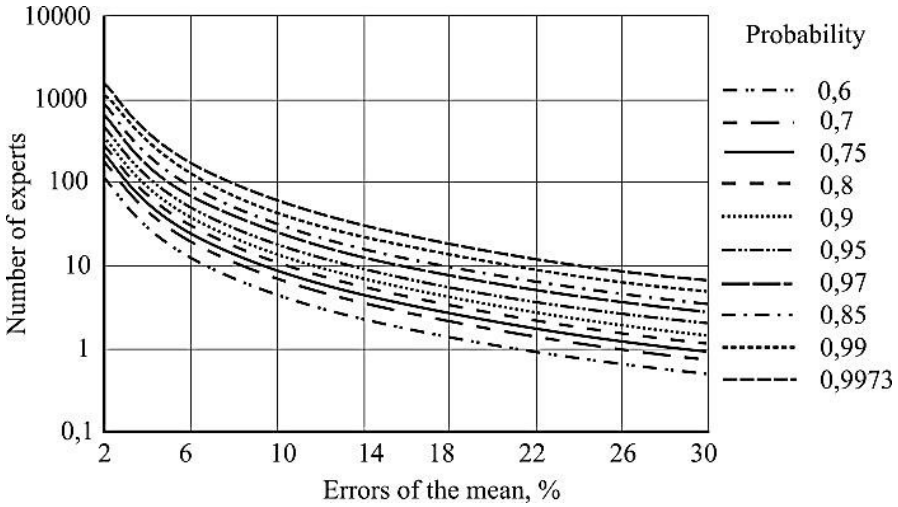

Fig. 1. Graph of the dependence of the number of experts on the errors of the mean at ν = 25%.

The n-factors were ranked according to expert estimates m, which determine the sequence of ranks. In order to check the consistency of m-expert assessments with each other, we determine the consistency coefficient (Kendall's concordance coefficient) W, calculated by the formula (Lazko, 2018):

$$W = \frac{12S}{m^2\left(n^3 - n\right)} \tag{1}$$

where n is the number of evaluated factors, m is the number of experts participating in the expert survey, S is the sum of the squares of the deviations of the sum of ranks by n-factors from their arithmetic mean.

The concordance coefficient W takes values from 0 to 1.0:

- $W = 1.0$ there is a complete agreement of expert opinions,
- $W > 0.7$ there is high agreement of expert opinions,
- $W < 0.5$ there is low agreement of expert opinions.

The expert questionnaire was carried out by ranking the factors affecting the carrying capacity of the railway lines and environmental safety.

According to the formula (2), the sum of the ranks received by the j-th element from all experts is calculated:

$$r_j = \sum_{i=1}^{N} r_{ij}; \tag{2}$$

Where r_j is the rank received by the j-th element from the i-th expert, N is the number of experts taking part in the examination. Table 1-2 shows the results of the expert survey and ranking. Calculation of the coefficient of concordance:

$$\mathrm{W} = \frac{12\mathrm{S}}{\mathrm{m}^2\left(\mathrm{n}^3 - \mathrm{n}\right)} = \frac{12 \cdot 745.4}{10^2\left(5^3 - 5\right)} = 0.745 \tag{3}$$

We check the significance of the concordance coefficient by the Pearson chi-square test using the formula:

$$x^2 = \frac{12S}{m \cdot n(n-1)}, \tag{4}$$

$$\mathrm{x}^2 = \frac{12 \cdot 745.4}{11 \cdot 5(5-1)} = 40.66$$

According to the tabular data of the χ^2-distribution, we determine the table for the degree of freedom $v = n$, the significance level $\alpha = 0.05$. We can conclude that the obtained values of the concordance coefficient are statically significant because $\chi^2_{table} = 16.75 < 40.66$.

Table 1. The results of the expert questionnaire of the quality of drivers.

Experts	Knowledge of traffic rules (X_1)	Drivers experience (X_2)	Driver qualifications (X_3)	Ethics and Ecodriving (X_4)	Psychophysiology (X_5)	Sum
1	5	2	2	4	4	16
2	4	1	2	3	3	13
3	5	2	2	3	3	19
4	4	2	2	4	4	21
5	4	2	2	5	4	21
6	4	1	2	5	3	24
7	5	2	3	4	4	24

8	5	2	2	3	4	25
9	5	2	2	4	3	25
10	5	1	2	4	3	27
11	4	2	1	4	3	14
Sum rank Δ	50	19	22	43	38	172
Δ_j	17.8	-13.2	-10.2	10.8	5.8	–
S	–	–	–	–	–	745.4

Table 2. Ranking factors.

Factors	X_2	X_3	X_5	X_4	X_1
Sum rank	19	22	38	43	50

Based on the data in Table 1, a histogram (Fig. 2) is built for ranking the quality (preparedness factors) of the driver for the throughput of the stretch of the road network and environmental safety.

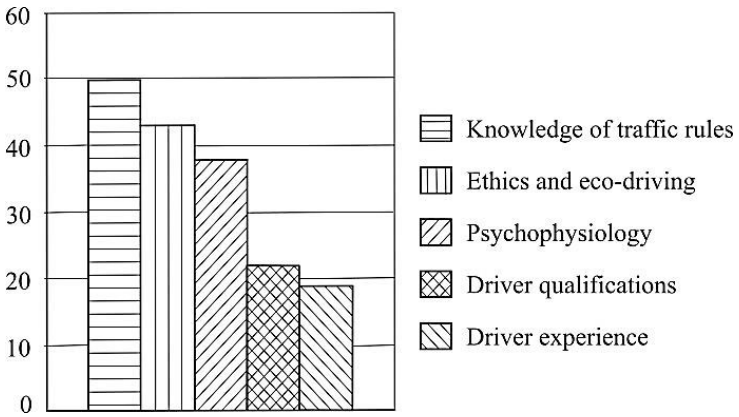

Fig. 2. Ranking the quality of drivers affecting the capacity of the road network and the environmental safety of vehicles.

3. Research Results

The results of the study of factors affecting the throughput of the road network are presented in Table 3.

Approximately the same research results were obtained S.E. Borisova (2011). At the same time, a questionnaire survey was carried out among employees of the Department of Internal Affairs and 58% of opinions were the importance of fostering a driving culture among drivers

Table 3. Expert questionnaire results.

Experts	Laws and regulations (X_1)	Road maintenance and infrastructure (X_2)	Driver qualifycation assessment method (X_3)	Driver training quality (X_4)	Monitoring compliance with legislation (X_5)	Summ
1	2	3	2	4	4	15
2	3	4	3	4	5	18
3	2	4	3	4	3	15
4	3	3	3	4	4	17

5	2	3	2	3	5	15
6	1	2	1	4	3	15
7	3	1	3	4	5	19
8	2	3	2	3	4	14
9	2	3	2	4	5	16
10	1	1	3	4	4	17
11	2	3	3	4	5	
Sum rank Δ	23	30	27	42	47	169
Δ_j	-8.6	-16.2	-19.2	-4.2	0.8	–
S	–	–	–	–	–	723.32

Table 4. Ranking factors.

Factors	X_1	X_3	X_2	X_4	X_5
Sum rank	23	27	30	42	47

Concordance factor:

$$W = \frac{12S}{m^2\left(n^3 - n\right)} = \frac{12 \cdot 723.32}{10^2\left(5^3 - 5\right)} = 0.723$$

We check the significance of the concordance coefficient by the Pearson chi-square test using the formula (4):

$$x^2 = \frac{12 \cdot 723.32}{11 \cdot 5(5-1)} = 39.45$$

According to the tabular data of the χ^2-distribution, we determine the table for the degree of freedom $v = n$, the significance level $\alpha = 0.05$. The obtained value of the concordance coefficient is also statically significant because $\chi^2_{table} = 16.75 < 40.66$.

Based on the data in Table 3, a histogram of ranking factors for the throughput of the road network and environmental safety is built (Fig. 3).

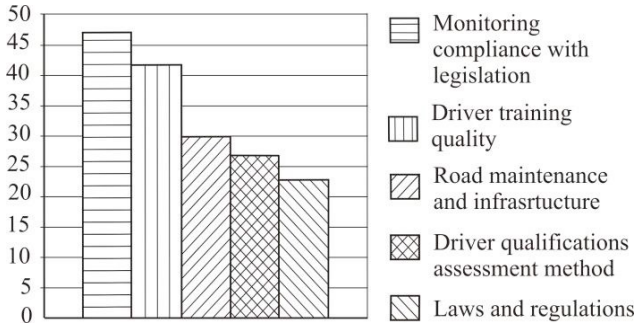

Fig. 3. Histogram of ranking the influence of factors on the throughput of the stretch and the environmental safety of vehicles.

4. Discussion

The conducted expert ranking showed that knowledge of the Rules of the Road, then Ethics and Eco-driving, as well as the psychophysiology of the driver, is of paramount importance. It is likely that the driver's qualifications and length of service in a dense traffic flow have little effect on the haul throughput.

The ranking of factors influencing the traffic capacity of the road network shows (Fig. 3) that the control of compliance with laws (traffic rules) has the greatest impact (47%), followed by the quality of driver training, road maintenance and infrastructure.

5. Conclusion

It follows from the expert assessment that in order to increase the throughput of the road network and environmental safety, it is necessary to strengthen control over the observance of the Road Traffic Rules and improve the quality of driver training, taking into account ethics and eco-driving.

The method presented in the article can be applied to assess the road network of settlements and determine the causes of poor environmental conditions.

References

Atabekov, K.K. et al., 2020. Decrease in average traffic speed and increase in harmful emissions of vehicles at unregulated pedestrian crossings in cities. Journal of Physics: Conference Series 1679(5), 052055. https://doi.org/10.1088/1742-6596/1679/5/052055

Atabekov, K.K., 2017. Influence of traffic intensity and public transport stopping points on environmental safety. Polytechnic Bulletin. Series: Engineering Research 1(37), 72-81.

Borisova, S.E., 2011. Psychological features of activity of inspectors of road patrol service of the state inspection of traffic safety. Moscow.

Dobretsov, R.Yu. et al., 2021. The Method of Expert Assessments as Applied to the Ranking of Technical Solutions in the Design of a Tractor Gearbox. Journal of Physics: Conference Series 2094, 042028. https://doi.org/10.1088/1742-6596/2094/4/042028

Farooq, D. et al., 2020. Analyzing the importance of driver behavior criteria related to road safety for different driving cultures. International Journal of Environmental Research and Public Health 17(6), 1893. https://doi.org/10.3390/ijerph17061893

Gaysin, S.V., Koutenev, V.F., 2020. Current issues of ensuring human safety in process of vehicles operation. IOP Conference Series: Materials Science and Engineering 819(1), 012019. https://doi.org/10.1088/1757-899X/819/1/012019

Lazko, I., 2018. Development of a method for ranking factors that influence the maturity of project quality management processes. Eastern-European Journal of Enterprise Technologies 4(3-94), 14-28. https://doi.org/10.15587/1729-4061.2018.140796

Lozhkin, V., Lozhkina, O., Dobromirov, V., 2018. A study of air pollution by exhaust gases from cars in well courtyards of Saint Petersburg. Transportation Research Procedia 36, 453-458. https://doi.org/10.1016/j.trpro.2018.12.124

Ruposov, V., 2013. Substantiation of expert assessment procedure for formalized Swot-Analysis. Proceedings of Irkutsk state technical university 10(81), 360-368.

Sarymsakov, B.A., 2014. Methodology for experimental - computational determination of an economical algorithm for driving a car. Results of science and technology. Mathematical analysis 89, 2.

Sathasivam, K., Che Hashim, R., Abu Bakar, R., 2021. Automobile industry managers' views on their roles in environmental sustainability: A qualitative study. Management of Environmental Quality 32(5), 844-862. https://doi.org/10.1108/MEQ-09-2020-0194

Troyanovskaya, I., Grebenshchikova, O., Erofeev, V., 2022. Pollution of the Atmosphere of Chelyabinsk by Transport Emissions of Non-Exhaust Origin. Transportation Research Procedia 63, 277-284. https://doi.org/10.1016/j.trpro.2022.06.014

Tuffour, M., Asiama, R.K, 2022. Public transport preferences amongst Ghana's urban dwellers. International Journal of Social Economics (in print). https://doi.org/10.1108/IJSE-05-2022-0360

Voinash, A.S., Voinash, S.A., Chernetskaya, N.A., 2018. Experience of reconstruction of the transport network with axis-oriented development. Transport and transport-technological systems: Proceedings of the International Conference, 64-68.