EKONOMICKÉ ROZHĽADY – ECONOMIC REVIEW, 2023, 52(4), 188 ─ 202
https://doi.org/10.53465/ER.2644-7185.2023.4.188-202

GREENING IN THE PROCESS OF PROVIDING MUNICIPAL SERVICES OF LOCAL COLLECTIVE TRANSPORT ON THE EXAMPLE OF POLAND AND SLOVAKIA

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Abstract: *The aim of the paper is to determine the relevance of services for public transport undertakings in terms of externalities. The article develops a methodology for researching and evaluating the quality of public utility services and the degree of saturation of the use of environmentally friendly modern technologies in the field of local public transport. Multi-criteria evaluation was used to assess the degree of quality of utility service delivery systems in the field of local public transport. The article is based on the experience of scientific partners from the University of Economics in Kraków and the University of Economics in Bratislava, using the examples of Poland and Slovakia.*

Keywords: *municipal enterprise, local public transport, public utility enterprises, environmentally friendly modern technologies, taxes*

JEL Classification: H23, Q56

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1 Introduction

The reasons for a special consideration of public utility services may be sought in many factors that result from the specific nature of such services. As a part of this study, the authors analyzed in particular one of such factors, i.e., occurrence of external effects and the related advantages and costs for a specific society and related evidence for greening of public transport in the light of greening of economy, meaning the attempts to lower the usage of energy, materials and the amount of created pollution and its burden.

The development of research concerning the costs and external advantages is determined by the level of awareness of the society. The currently conducted research in Poland and Slovakia is closely connected with the issues of road transport as the significant cause for the negative ecological impact on the environment we live in.

The development of urbanised areas is closely linked to the increasing demand for various modern local services, resulting in continuous expansion of urban infrastructure. At the same time, this development has also been the primary factor in the deterioration of the environment and thus the quality of life of city dwellers. This dichotomy occurring in the contemporary development of urban space highlights an important role for the use of municipal service facilities. Currently, the primary problem faced by urban areas in Poland lies in air pollution – the main culprits being substances generated by the combustion of fuels in internal combustion engines, such as particulate matter, soot and nitrogen dioxide (Filipowicz, Filipowicz & Zaprawa, 2017).

Studies in developed countries show that motoring contributes about 60% of total carbon monoxide and nitrogen oxide emissions, 50% of hydrocarbons and 15% of particulates. About 40% of emissions are pollutants from transport in Poland and Slovakia. However, the statistical data do not reflect the actual extent of the threat, as they do not identify the degree of concentration of transport in the vicinity of human settlements, the geographical and climatic conditions and the organisation of traffic. Therefore, transport in large urban areas accounts for up to 80% of pollutants, causing local safe levels to be exceeded by multiple times – the formation of smog being one of the most dangerous phenomena caused by motor vehicle exhaust emissions combined with high atmospheric humidity levels (Burnewicz, 2005).

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Studies carried out in European Union countries show that the contribution of buses to urban air pollution totals only 0.5 – 1%. A bus carrying an average of 100 passengers emits fewer hydrocarbons and carbon oxides, and uses less energy than a passenger car equipped with an exhaust gas catalyser carrying an average of 1.4 passengers. Data shows that transport consumes as much as 67% of liquid fuels, with bus transport notably being at least 3 times less energy intensive than car transport and at the same time emitting more than 100 times less pollution (Burnewicz, 2005).

Changes to make urban transport more attractive are necessary to increase the quality and comfort of life in large cities and reduce negative environmental impacts. The EU policy promotes the reduction of individual car transport in favour of modern, convenient collective urban transport (Korneć, 2018). All such measures form the concept of sustainable transport. This term implies high quality local public transport, at the same time linked to respect for the environment and the use of modern smart mobility technologies.

Smart mobility is about using modern technologies to get around in the city. This concept transforms the provision of local public transport services. Design and modelling with respect to communication networks and simulation of vehicle movement in the network are in common use.

Travel analytics for passengers, automatically monitoring information about travel time and possible risks is becoming more and more common. Adoption of these modern solutions combined with a number of preferences for public transport, pedestrian traffic and bicycles leads to a reduction in traffic and an improvement in the quality of living in cities as well as reducing inconveniences (Wolanski, 2015).

In summary, a modern local public transport system that meets the rationale of sustainability is one that: meets pollution and noise emission standards, meets the mobility needs of residents, minimises environmental interference as much as possible, is comfortable to use, improves the quality of life in the city and is affordable. This is why it is so important to use renewable energy sources in urban transport, purchase modern and environmentally friendly rolling stock, develop rail transport (tube, tram, Fast Urban Railway), and to apply innovative infrastructure solutions.

2 Literature review

In the majority of modern countries, economy is mixed: the activity of private sector is complemented with the tasks appointed to the public sector. This means that only a part of decisions is made by the state - the rest is by private entities. The market is usually inefficient and this is caused by its various faults. Market failures are, on the other hand, a justification for the country to interfere (Stiglitz, 2007). The essence of fiscal decentralization is to increase economic efficiency in the redistribution of resources in the public sector through more effective satisfaction of local public needs by lower levels of government. (Belkovicsová & Boór, 2021)

External effects have also a huge impact on the state of the natural environment. This is also confirmed by the followers of free market who focus on the environment and its protection. They state that *"existence of capitalism is the main cause of polluting the environment, because socialist economy presents far worse situation"* (Skousen, 2012). The socially effective production is higher in a situation of market balance for goods that generate positive external effects (e.g. public transport services) (Wolański, 2011). The failures give rise to inefficiency that constitutes justification for the country to interfere. It should also be highlighted that the term of failure of the market coexists with the term of failure of the state.

Governments can use taxation to regulate individual, collective, and corporate behavior (Guler, 2019). Taxation is also used as a mechanism to control negative externalities when these externalities cause pollution (Baumol, 1972; Carattini, Kallbekken & Orlov, 2019; Edenhofer, Franks, & Kalkuhl, 2021). In comparison to pollution taxes, so-called "sin taxes" are a tool used by governments to restrict or prohibit unhealthy behavior (Braillon, 2012; Gruber & Koszegi, 2002; Lorenzi, 2004; O'Donoghue & Rabin, 2006).

External costs incurred by the society are connected with the results of existence of transport that are negative for the natural environment and life of people. Those results are (Wyszomirski, 2010): pollution of natural resources, emission of noise, land taking over occupation, accidents and catastrophes in transportation. Noticing the problem of external costs is connected with their internalization, i. e. assigning particular negative results to entities that are responsible for their occurrence. This enables creating solutions that encourage users of transport to choose the correct measure of transportation.

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3 Methodology and data

The article develops a methodology for researching and assessing the quality of public utility services and the degree of saturation of the use of environmentally friendly modern technologies in the area of local public transport. To assess quality measures for municipal service provision systems in the local public transport industry, the authors used a multi-criteria ranking. They created rankings of cities using a synthetic variable, which was created using the zero unitarization method (MUZ). In the next step, they created a ranking of the examined cities according to the degree of use of pro-ecological technologies. In order to examine whether the rankings of cities according to quality and saturation with pro-ecological solutions are consistent, the authors calculated Spearman's rank correlation coefficient, presented a correlation diagram and determined the equation of the regression function.

The pro-environmental solutions used in the provision of public local public transport services, were used to develop a questionnaire which was addressed to the 12 largest Polish and Slovak cities in order to verify the use of these solutions for the provision of public transport services. These are: Warsaw, Bratislava, Krakow, Poznan, Lodz, Gdansk, Wroclaw, Kosice, Szczecin, Bydgoszcz, Lublin and Bialystok.

An original research questionnaire was developed in order to measure the quality of municipal services from the consumer's point of view, which includes a set of questions on specific standards for the provision of these services. The survey was conducted using the CAWI method on a sample of 1 400 residents of these cities. The research was carried out between September 2020 and December 2020. It was done by both direct and indirect methods in order to increase the relevance of the survey.

Cronbach's alpha coefficient was calculated as an additional measure to verify the reliability of the questionnaire (Cronbach, 1951):

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} s_i^2}{s_c^2}\right) \quad (1)$$

Where:
α – Cronbach's alpha
k – number of test items
s2c – total variance of overal test results
s2i – variance of test items

Average consumer satisfaction scores were determined for each aspect in the next stage of the study, as well as determining an aggregated average of the quality scores for the local public transport network under analysis.

A multi-criteria ranking (Młodak, 2006) was used to assess the quality measures for the local public transport service delivery systems in individual cities. In order to create a ranking of the cities characterised using a multi-criteria approach, a synthetic variable was used, the construction of which was based on the zero unitarisation method (ZUM). The ZUM method entails several stages. In the first stage, the diagnostic variables Xj are divided into stimulators, destimulators and nominators, followed by their normalisation to variables Zj. For stimulantors and destimulators the normalisation formulas are (2) and (3) respectively:

$$z_{ij} = \frac{x_{ij} - \min\limits_{i} x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}, \qquad X_j \in S, \tag{2}$$

$$z_{ij} = \frac{\max x_{ij} - x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}, \quad X_j \in D \tag{3}$$

In the case of a nominator, where the range of nominal values <b1j; b2j> is known, the normalising formula takes the following form:

$$z_{ij} = \begin{cases} \dfrac{x_{ij} - \min\limits_{i} x_{ij}}{b_{1j} - \min\limits_{i} x_{ij}}, & gdy \quad x_{ij} < b_{1j} \\ 1 \quad gdy \quad x_{ij} \in [b_{1j;}; b_{2j}] \\ \dfrac{x_{ij} - \max\limits_{i} x_{ij}}{b_{2j} - \max\limits_{i} x_{ij}} & gdy \qquad x_{ij} > b_{2j} \end{cases}, \quad X_j \in N \tag{4}$$

In the next step of the ZUM method, the normalised variables are aggregated, e.g. using the arithmetic mean:

$$Q_i = \frac{1}{k} \sum_{j=1}^{k} z_{ij} \tag{5}$$

The values of the synthetic variable Qi are normalised within the interval [0,1] and allow them to be ranked according to the intensity of the studied

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phenomenon. The higher the value of the variable Qi an object achieves (closer to 1), the higher it ranks in the ranking of the studied objects (and vice versa).

In order to examine whether the rank orderings of the quality of local public transport services are consistent with the saturation of innovative pro-environmental solutions in the area of these services, i.e. whether the degree of use of modern and green technologies translates into the quality of local public transport services, Spearman rank correlation coefficients were calculated:

$$r_s = 1 - \frac{6\sum_{i=1}^{n}(d_x - d_y)^2}{n(n^2-1)} \quad (6)$$

where:

d_x, d_y – the city's ranking positions for the quality of its services and the extent to which it uses innovative tech and environmentally friendly solutions,

n - number of ranked cities.

The r_s factor takes values from -1 to 1. A positive *r-factor* indicates congruence in the ordering of objects, while a negative *r-factor* indicates incongruence (contradictory rankings).

4 Assessment of the impact of implementing environmentally friendly solutions in local public transport utilities on the evaluation of the quality of their services

Overall values of the sums of indications made by individual cities were determined based on the indication of currently used pro-ecological technologies or those planned to be used in the nearest future, according to the following criteria – a value of 2 for technologies already used, a value of 1 for technologies planned in the next two years and a value of 0 for unused and unplanned technologies. A ranking of the use of green technologies in the public transport sector in selected cities was created in this way (Figure 1), in which a higher number of points achieved indicates a higher position.

Figure 1: Ranking of the use of environmentally friendly solutions in local public transport in the cities surveyed in 2020

Source: own elaboration

Local public transport in a city is supposed to improve the quality of life of the local community, which requires that the quality criteria that ensure a better and more complete satisfaction of needs are taken into account. In view of this, the recognition of the way in which public transport services are provided should take place through an analysis of how the inhabitants' expectations are met, in the context of the characteristics desired by the users of said services. Treating the concept of service quality in public transport as a set of characteristics describing this quality from the customer's point of view is the starting point for their identification. They reflect the preferences reported by residents in respect of public transport. A set of characteristics concerning the quality of urban public transport was created in this study (Table 1) considering the conditions imposed on public transport in urban areas in EU countries and the criteria that appear in European standards on the quality of transport services.

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Table 1: Social standards defining the quality of local public transport in the city

#	**Characteristics defining the quality of local public transport in the city**
1.	Availability of the transport network
2.	Frequency of service
3.	Service punctuality
4.	Travel safety
5.	Certainty of travel
6.	Speed and direct service
7.	Toll levels
8.	Travel comfort
9.	Information on transport options available
10.	Use of modern environmentally friendly technologies

Source: own elaboration based on Wąsowicz (2018).

An original research questionnaire was developed in order to measure the quality of municipal services from the consumer's point of view, on a sample of 1 400 residents of these cities. Complete responses were provided by 1 245 people (Table 2).

Table 2: Survey sample size

#	**City**	**Number of respondents**	#	**City**	**Number of respondents**
1.	Warsaw	142	7.	Bratislava	101
2.	Krakow	140	8.	Lublin	105
3.	Poznan	133	9.	Bydgoszcz	100
4.	Lodz	107	10.	Bialystok	108
5.	Gdansk	103	11.	Košice	102
6.	Wrocław	104	-	**TOTAL**	**1245**

Source: own study, 2023

The full questionnaire consisted of 20 detailed questions on the quality of municipal services in the sector under analysis (there was more than one question on certain characteristics). A direct method normally used in this type of study (a general question to assess the quality of a particular type of service) was complemented by an indirect method in order to increase the relevance of the survey. Under this method, respondents were asked to answer specific questions on each of the quality aspects of local public transport services indicated in Table 1. Respondents answered each question on a 5-point Likert scale (1 being the worst rating and 5 being the best rating). A multi-stage questionnaire development procedure was adopted in order to achieve construct validity of the research questionnaire. Cronbach's alpha coefficient was calculated (Cronbach, 1951) as an additional measure to verify the reliability of the questionnaire:

The score for questions about the quality of local public transport was 0.897. Average consumer satisfaction scores were determined for each aspect, as well as determining an aggregated average of the quality scores for the local public transport network under analysis. These values then formed the basis for further analysis.

A multi-criteria ranking (Młodak, 2006) was used to assess the quality measures for the local public transport service delivery systems in individual cities. In the area of local public transport quality, 8 of the 10 characteristics (presented in Table 1) are stimulantors, 1 is a destimulator and 1 is a nominator. Fare levels are one of the characteristics that provide the better assessment to the local public transport the lower value they achieve. The percentage of respondents using modern environmentally friendly technologies was classified as a nominator (maximum quality if the values are within a certain set). Bearing in mind the natural limitations experienced in this respect by elderly citizens, the optimum range for this characteristic was assumed to be between 30% and 70%. In order to create a ranking of the cities characterised using a multi-criteria approach, a synthetic variable was used, the construction of which was based on the zero unitarisation method (ZUM). The results of the rating of local public transport quality created using the ZUM method in 2020 are shown in Table 3.

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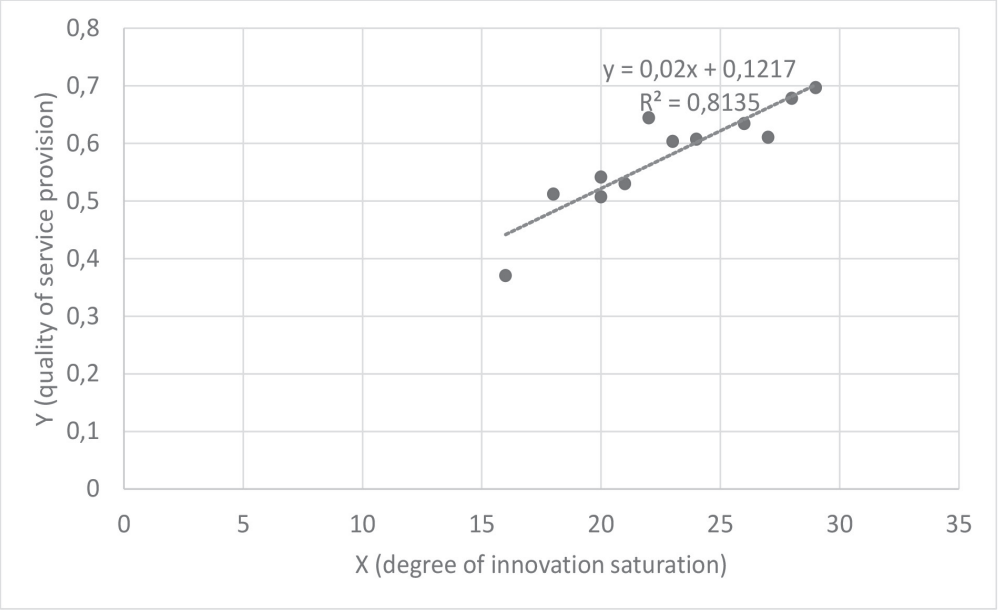
Table 3: Local public transport quality rankings created using the ZUM method in 2020

Position in the ranking	City	Value of the synthetic variable
1.	Warsaw	0.697139
2.	Bratislava	0.678581
3.	Krakow	0.644975
4.	Gdansk	0.634838
5.	Poznan	0.610780
6.	Łódź	0.607612
7.	Košice	0.604024
8.	Wrocław	0.542023
9.	Lublin	0.530615
10.	Bydgoszcz	0.512521
11.	Bialystok	0.507766
12.	Szczecin	0.370787

Source: own elaboration, 2023

The rank correlation coefficient value of 0.88090 indicates an almost complete correspondence between the orderings of the quality of service provided and the degree of saturation with modern green technologies in the local public transport industry, and this relationship is statistically significant (p-value = 0.002969 and is less than 0.05). The graph shows a correlation diagram in which the scores represent the quality of service provided in the local public transport industry with the corresponding aggregate measure of the degree of green innovations used in public transport (Figure 2).

Figure 2: Correlation diagram showing the dependence of the aggregated service quality of the local public transport industry on the degree of saturation with modern green technologies in local public transport.



Source: own elaboration, 2023

The line visible in the graph represents a regression function with the equation y=0.1217+0.002*x. Its positive slope confirms that a higher use of modern technologies corresponds to a higher quality of the services provided (an increase in the saturation of modern pro-ecological technologies by 0.1 will improve the quality of services provided by about 0.002 on average), this relationship being statistically significant (p-value for the regression coefficient is 0.000142).

A conclusion that can be drawn from the research (admittedly for a quantitatively modest sample) suggests that a high degree of advancement of modern pro-ecological technologies utilized in the process of providing local public transport services in urban areas translates into the quality of these services. With this in mind, a goal can be set for the rational management of local public services rendered by municipal companies to utilize modern ecological technologies to the highest possible degree in order to improve the general quality of life and ensure that the needs of the local community are met in a better and more thorough manner in line with the assumptions of sustainable development of cities in Poland and Slovakia.

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5 Conclusion

The presented considerations are of theoretical and empirical nature. As a result of the conducted analysis, tasks of public utilities have been identified through their specific objective, that is the current and continuous satisfaction of the collective needs of the society. The reasons for the special approach towards public utility services result from, among others, the occurrence of external effects. One of the types of enterprises that generate positive external effects that have influence on the natural environment are those of the local public transport.

Urban transport is a very important element of the modern, urbanized world since it gives the citizens of a particular city the opportunity to successfully move to their target location or from one place to another. Local public transport has a direct impact on the quality of life. Public transport that manages to acquire passengers who own and may use a car helps in lowering problems such as noise, emission of exhaust, as well as the problem of crowded roads and the number of accidents. The foundations of organizing urban transport should include the acknowledgment of the significant meaning of transport mobility for the social and economic development of cities, as well as of the negative consequences of car transport in form of congestion, communication accidents and damages to the environment.

The determination and assessment of damages in the environment, including, in particular, losses caused by transport, is a complex and very difficult task. The problem of measuring external costs requires an interdisciplinary approach, while the background for the economic losses caused by transport should be constituted by the circumstances resulting from geographical, ecological and technological deductions. Losses due to automotive pollution are estimated at the level of 0.5 - 5% of national income, considering only some of the threats since not all of them may be assessed with the money. The conducted analysis shows that the only alternative for the passenger car in cities (in the aspect of lowering environmental damage) is an efficient and cheap public transport, that we need to constantly invest in. There is a necessity to promote public transport, including bus transport, which causes significant external costs. That is why the argumentation for financing the public transport must draw attention to the fact that mass motorization requires much more financial resources, considering the negative external effects. Preventing the degradation of the environment is an expensive process, while the desirability

to incur those costs is a justified must of eliminating disadvantages brought to the society and economy by degradation.

The article develops a methodology for researching and assessing the quality of public utility services and the degree of saturation of the use of environmentally friendly modern technologies in the area of local public transport. A conclusion that can be drawn from the research (admittedly for a quantitatively modest sample) suggests that a high degree of advancement of modern pro-ecological technologies utilized in the process of providing local public transport services in urban areas translates into the quality of these services. With this in mind, a goal can be set for the rational management of local public services rendered by municipal companies to utilize modern ecological technologies to the highest possible degree in order to improve the general quality of life and ensure that the needs of the local community are met in a better and more thorough manner in line with the assumptions of sustainable development of cities in Poland and Slovakia.

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