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THE STRUCTURE OF DEMAND AND ITS ECONOMIC CONSEQUENCES FOR URBAN TRANSPORT

The structure of demand for urban transport services, determined by the share of passengers entitled to free travel and reduced fares, is an important factor influencing its economic condition. The aim of this article is to present the results of research into the structure of demand for urban transport as well as its economic consequences. The article begins by considering the nature of the determinants and consequences of the public utility of urban transport, before going on to discuss the methodology of research of the demand structure for these transport services. This provides the background for analysis of the results of demand srtucture in chosen cities and allows the economic consequences to be determined. The annual deficit of urban transport was compared with a hypothetical full reimbursement of revenue lost due to free travel and reduced fares.

Keywords: demand volume and structure, free travel and reduced fares, economic effectiveness

Introduction

Public services are provided as a part of urban transport which allows certain goals and tasks connected to the transport and social policy to be met. In effect, passengers possess rights granting them reduced fares or free travel.

The structure of demand for urban transport services, determined by the proportion of passengers who are entitled to reduced fares and free travel, constitutes a factor influencing its economic situation. Revenue from services do not cover the costs of operations.

Research of a particular methodology is conducted in order to determine the influence the structure of demand has on the economic effectiveness of urban transport. The sum of lost revenue due to reduced fares and free travel may be established on the basis of the results of the aforementioned research.

1. The nature, determinants and consequences of the public utility of urban transport

In legal and economic terminology the notion of public utility arises rather frequently. It also appears in a practical sense in the fulfilment of the tasks of local authorities.

The statutory definition of tasks connected with public utility is presented in Article 9 Point 4 of the Administrative District Authorities Act [*Ustawa o samorządzie gminnym*]. It states that "tasks of a public utility character, in the statutory meaning, are those which belong to a gmina, defined in Article 7 Point 1, which aim to meet the collective needs of citizens in a continuous and constant manner by providing widely accessible services" (Ustawa, 1990).

The notion of public utility is also mentioned in Article 1 of the Municipal Services Act [*Ustawa o gospodarce komunalnej*]. According to the definition in the aforementioned Act the nature of municipal services is for the *gmina* [administrative district] to carry out its tasks, as defined in Article 7 Point 1 of the Administrative District Authorities Act, in order to meet the common needs of local community. Municipal services are "first and foremost inclusive of public utility tasks which aim to meet the collective needs of citizens in a continuous and constant manner by providing widely accessible services" (Ustawa, 1996).

"The notion of public utility is defined by the law in an inaccurate manner. Therefore, it is difficult to distinguish in practice between the so-called commercial and public utility activity. According to many scholars the notion of public utility was carried over by the legislator to local government rights defined in the State Enterprise Act 1981" [Ustawa o przedsiębiorstwach państwowych z dnia 25 września 1981 r.] (Wojtkowiak, 2006).

The public utility of urban transport may be defined as services which (Bergel, 2008):
–   provide equal access on the basis of rules communicated to the public;
–   are economically accessible to the more underprivileged groups of society;
–   are of fundamental significance to society or certain groups of society;
–   are provided or contracted by appropriate public authorities.

It is notable that a populist approach to the public utility issue asserts that urban transport services should be accessible to and used by all, virtually regardless of the value attributed to such by society and the social costs involved. Such a concept leads to autarky and wider access to work in urban transport companies. Competition within transportation services is in this case perceived as a redundant feature leading to the wastage of transport capacity and the restriction of the availability of rolling stock.

The aims and tasks of transport and social policies are the determinants which assign urban transport to public utility.

The achievement of a rational division of tasks between private (cars) and public transport within an urbanised area is the main aim of transport policy. This aim makes possible the realization of other enterprises, such as those which aim to protect the natural environment or decrease congestion. It is assumed that in large

cities and agglomerations the modal split between private and public transport should not be in favour of cars.

Public authorities are fulfilling the aims of social policy by ensuring that all inhabitants – regardless of their financial situation and place of residence – have the minimal level of transport mobility. The scope of intervention of public authorities is usually restricted to establishing:

– the tariff for transport services,
– the range of transport services.

Public authority, when deciding on the tariff for transport services, led by social premises, decides mainly on the shape of entitlements to free and reduced fees. An appropriate solution is to connect the volume of passengers who used free and reduced fares with the funding of urban transport by the reimbursement of revenue lost due to such entitlements. Such a solution favours a rational approach of public authorities to the scope of reduction entitlements provided that the reimbursement of lost revenue comes from the budget of those authorities who passed the said entitlements. The revenue reimbursed due to reduced fares and free travel is accrued by the organiser proportionally to the volume of services provided as measured by passenger volume (Grzelec, 2011).

In practice the cost of reimbursement of revenue lost due to free and reduced fares, both for entitlements passed by the local authorities as well as resulting from statutory rights, is in its entirety covered by local governments. Nevertheless, some local governments, in order to reduce their spending, introduce solutions which allow such reimbursements to be obtained from the state's budget with regards to suburban routes. In such cases they adjust the range and the value of entitlements on these routes in order that they comply with statutory rights, whilst simultaneously introducing certain legal and operational solutions characteristic of regional passenger road transport.

2. Urban transport demand research methods

Research into demand should be complex and cyclic in order to establish the influence reduced fares and free travel have on the demand and, in consequence, on the economic and financial situation. Such research allows the number and structure of passengers, taking into account the type of fare they travelled on and possible entitlements to a free or reduced fare, to be established. Another aim of such research is to evaluate the revenue from given public transport routes in different periods, taking into account the specificity of the day of the week and month of the year (Wyszomirski, 2015).

The study of demand may be carried out using certain methods of measurement as well as classic or electronic measuring devices.

Such methods include:

– observation,
– registration,
– interview.

Observation is a method used to measure demand, which is carried out on board a vehicle. Alternatively, this method may be carried out at a stop. It should be noted, however, that the margin of error is much greater in the case of the latter method.

An observation card filed in by an observer is a classic measuring tool connected with this method. Electronic measuring devices are among modern tools of this type: optical turnstiles installed at the doors of vehicles; scales estimating the number of passengers by deducting the weight of an empty vehicle from the weight of the vehicle with passengers on board; CCTV cameras. However, none of these devices are completely reliable and the accuracy of each of them is lower than in case of the classic measuring tool.

Registration is a method of studying the structure of demand. Typically an observation card is filed in by an observer, who notes every passenger and the type of fare used. Modern measuring devices are E-ticket card readers installed on board vehicles. In order to use such devices as an exclusive measuring tool in a study of demand, e-tickets would have to be the only valid type of ticket used by passengers who would be obliged to register their card on the reader upon entering the vehicle. In practice, due to organizational, marketing, formal and legal reasons, this is difficult to achieve. The norm is that when in a given passengers may use two types of tickets (e-ticket and classic paper ticket), two measuring tools are found to be in operation: observation cards and card readers.

The conducting of interviews is a complimentary method aimed at establishing the number of trips completed on the basis of tickets which allow for an indefinite number of trips to be undertaken in a given timeframe. In such cases a survey questionnaire is used as a measuring tool which records all trips of passengers travelling on such a ticket. In the case of 30 day tickets and tickets valid for a longer amount of time, the only trips taken into account are those completed by the passenger on the day prior to the survey. In the case of hourly tickets, those already completed and planned for the remaining time when the ticket is valid are recorded.

The combination of all the above mentioned methods allows for a complex picture of the structure of demand to be drawn up, as well as the calculation of the volume of revenue from fares. Empirical data proves that the margin of error for a properly organized and completed study does not exceed 3%.

3. Analysis of the demand study in chosen Polish cities

The analysis of the studies on the structure of demand was carried out on the basis of data collected by the Urban Transportation Board in Gdynia (ZKM Gdynia) and the company Public Transport Consulting Marcin Gromadzki in 8 Polish cities in the years 2013–2016. The cities are listed in Table 1.

In all the cities research was carried out according to uniform methodology discussed in point 2. The volume of demand was established comprehensively. The structure of demand was recorded against chosen routes on a weekday, Saturday, and Sunday in a manner which allowed for the findings to be representative.

In order for the data to retain its comparability it was restricted to the cities exclusive of suburban areas served by public transport.

Table 1. Cities included in the studies on the structure of demand for urban transport

City	Year of study	No of inhabitants	City's area [km²]	No of vehicle-km in public urban transport	Annual No of public urban transport passengers
Boleslawiec	2015	39 215	22.81	802 072	1 658 644
Grudziadz*	2015	96 319	57.76	3 179 790	11 266 044
Jelenia Gora	2014	81 408	109.20	2 952 779	9 681 240
Rumia	2016	47 812	32.86	951 413	5 966 941
Rzeszow	2013	185 896	120.4	5 866 382	22 680 132
Sopot	2016	37 654	17.31	793 102	4 694 955
Tomaszow Mazowiecki	2013	64 289	41.30	1 290 147	3 984 480
Wloclawek	2016	115 982	84.32	3 267 502	10 290 648

* research carried out exclusively on bus transportation
Source: (own elaboration on the basis of Primary research conducted by Board of Public Transport in Gdynia, 2016 and Primary research conducted by PTC Marcin Gromadzki, 2013a, 2013b, 2014, 2015a, 2015b, 2016)

Table 2. Indicators characterizing urban transport within the cities included in the study of the structure of demand

City	Year of study	No of vehicle-km of public urban transport per 1 passenger	Annual No of urban transport passengers per 1 inhabitant
Boleslawiec	2015	20.5	42.3
Grudziadz*	2015	33.0	117.0
Jelenia Gora	2014	36.3	118.9
Rumia	2016	19.9	124.8
Sopot	2013	21.1	124.7
Rzeszow	2016	31.6	122.0
Tomaszow Mazowiecki	2013	20.1	62.0
Wloclawek	2016	28.2	88.7

* research carried out exclusively on bus transportation
Source: (own elaboration on the basis of Primary research conducted by Board of Public Transport in Gdynia, 2016 and Primary research conducted by PTC Marcin Gromadzki, 2013a, 2013b, 2014, 2015a, 2015b, 2016)

The data presented in both Tables 1 and 2 indicates the a diversity of the range and intensity of public urban transport services within the cities included in the study. The lowest number of vehicle-kilometres per 1 inhabitant was noted in the city of Rumia (19.9 vehicle-km per inhabitant), whilst the highest – in Jelenia Gora (36.3 vehicle-km per inhabitant). The intensity of services measured by the number of passengers per inhabitant also proved to be highly diversified

ranging from 42.3 in Boleslawiec to nearly 125 in cities which constitute part of an agglomeration (Rumia and Sopot).

Table 3 presents the structure of demand for urban transport within the cities included in the study taking into account areas beyond the city limits, inclusive of suburban areas served by urban transport.

Table 3. The structure of demand for urban transport within the cities included in the study [%]

City	Passengers who bought tickets			Passengers who payed	Average cost per vehicle-km [PLN]	Indicator of revenues from passengers to costs [%]
	single	hourly	periodic			
Boleslawiec	47.4	0.2	24.5	72.1	7.02	28.30
Grudziadz	34.4	0.1	33.6	68.1	6.66	41.63
Jelenia Gora	36.2	0.2	40.0	76.4	7.33	44.00
Rumia	21.9	3.8	42.8	68.5	7.12	64.83
Rzeszow	36.2	3.2	42.1	81.5	7.33	48.05
Sopot	22.0	1.8	32.6	56.4	7.23	46.00
Tomaszow Mazowiecki	44.7	–	24.1	68.8	5.44	45.48
Wloclawek	47.2	0.4	10.4	58.0	6.04	48.83

Legend:
– single tickets – entitle the holder to a single trip on a single mode of transport;
– hourly tickets – entitle the holder to travel within a specified amount of hours;
– periodic tickets – entitle the holder to travel within an extended amount of time, usually 30 days.
Source: (own elaboration on the basis of Primary research conducted by Board of Public Transport in Gdynia, 2016 and Primary research conducted by PTC Marcin Gromadzki, 2013a, 2013b, 2014, 2015a, 2015b, 2016)

Analysis of the data provided in both Tables 2 and 3 leads to the conclusion that the annual number of passengers per inhabitant has a positive influence on the revenue from passengers of public transport, although the correlation is not particularly strong (the correlation coefficient amounts to 0.63). The lowest indicator of revenue from passengers to costs was reregistered in Boleslawiec – 28.3% (42.3 passengers per inhabitant per annum), and the highest in Rumia – 64.83% (124.8 passengers per inhabitant per annum). The influence of unit cost and the share of passengers travelling free were not found to bear a significant influence on the share of public transport payable services.

Table 4. Entitlements to free travel and reduced fares within the cities included in the study

City	Type of entitlement	No of entitlements	Total No of entitlements
Boleslawiec	Reduced fare	17	39
	Free travel	22	
Grudziadz	Reduced fare	8	27
	Free travel	19	
Jelenia Gora	Reduced fare	14	41
	Free travel	27	

City	Type of entitlement	No of entitlements	Total No of entitlements
Rumia	Reduced fare	10	30
	Free travel	20	
Rzeszow	Reduced fare	10	31
	Free travel	21	
Sopot	Reduced fare	10	30
	Free travel	20	
Tomaszow Mazowiecki	Reduced fare	5	20
	Free travel	15	
Wloclawek	Reduced fare	12	28
	Free travel	16	

Source: (own elaboration on the basis of Primary research conducted by Board of Public Transport in Gdynia, 2016 and Primary research conducted by PTC Marcin Gromadzki, 2013a, 2013b, 2014, 2015a, 2015b, 2016)

The total number of entitlements to reduced fares fluctuates between 5 and 17 depending on the city, and in the case of free travel between 15 and 27 (Table 4). The share of passengers travelling free or on reduced fares dominates, amounting between 57% and 68% depending on the city (Table 5).

Table 5. The share of passengers travelling on normal fares, reduced fares and free within the cities included in the study [%]

City	Share of passengers travelling on normal fares	Share of passengers travelling on reduced fares	Share of passengers entitled to free travel	Total share of passengers travelling on reduced fares and free	Income/ costs indicator	Revenue per passenger [PLN]
Boleslawiec	28.3	38.8	24.7	63.5	28.30	1.08
Grudziadz*	35.7	32.2	24.4	56.6	41.63	0.85
Jelenia Gora	36.2	40.0	18.9	58.9	44.00	1.19
Rumia	34.0	34.6	23.8	58.4	64.83	0.74
Rzeszow	38.5	51.8	15.7	67.5	46.00	1.04
Sopot	25.9	30.0	32.2	62.2	48.05	0.56
Tomaszow Mazowiecki	28.4	40.5	26.9	67.4	45.48	1.02
Wloclawek	31.9	25.9	35.2	61.1	48.83	0.95

* research carried out exclusively on bus transportation
Source: (own elaboration on the basis of Primary research conducted by Board of Public Transport in Gdynia, 2016 and Primary research conducted by PTC Marcin Gromadzki, 2013a, 2013b, 2014, 2015a, 2015b, 2016)

There is a statistical interdependence between the share of passengers travelling on reduced fares or free and the revenue per unit. It is, however, weak ($\sigma = 0.27$) and may result from the fact that not a sufficient number of cities were included

in the analysis as well as the exclusion of such factors as the unit revenue and number of passengers per vehicle-kilometre.

The number of single tickets that can be purchased for the price of a monthly ticket was also analysed in the chosen cities. In Boleslawiec this amounted to 30; in Grudziadz – 29; in Jelenia Gora – 33; in Rumia – 21; in Rzeszow – 35; in Sopot – 21; in Tomaszow Mazowiecki – 34; in Wloclawek – 49. A clear correlation between the price of single tickets and periodic tickets and revenue per unit was not established.

The above analysis indicates that the economic effectiveness of urban transport is not determined by any one single parameter, but rather by a comprehensive combination of those factors which constitute the transport services offer. An attractive tariff, especially with regards to periodic tickets, is likely to result in an increase in the number of passengers. In Rumia and Sopot the number of passengers per vehicle-km amounts to 6.27 and 5.91 respectively, whilst in other cities included in the analysis it fluctuates between 2.86 and 3.86. The location of Rumia and Sopot (within an agglomeration) have undoubtedly contributed to the positive economical and operational results of their public urban transport systems. In the case of the other cities included in the study, suburban services possess a relatively higher share and service areas located in the outskirts characterised by low demand and long distance of travel. Consequently, this bares an influence on the economic result in those cities.

In certain cities on suburban lines the entitlements to reduced fares and free travel were divided into two categories – local (non-refundable from the state's budget) and statutory (refunded from the state's budget via the Marshall's Office). This was done in order to improve the economic and operational situation of public urban transport in these cities. Such a solution was introduced in Boleslawiec, where on suburban services statutory entitlements of 37%, 49%, and 78% reductions are honoured. The total share of passengers travelling within Boleslawiec on reduced fares that are refunded by the State amounts to 11.5%.

Statutory and local entitlements are also distinguished in other cities included in the study. In Jelenia Gora the share of passengers entitled to statutory reductions amounts to 10.6%; in Rzeszow the total number of such passengers within the network amounts to 52.1%, where the majority of them are students travelling on local lines which means their fares are not refunded to the operator from the State's budget. In Tomaszow Mazowiecki the share of statutory reductions amounts to 4%, whilst in Wloclawek to 0.2%.

An attempt was made to calculate the total amount of revenue lost due to entitlements to reduced fares and free travel for the chosen cities. The following methodology was assumed in calculating the result:

– the value of lost revenue due to services provided for reduced single fares was calculated according to the following formula: $\Sigma(n_i \times p_i)$, where n_i stands for a particular nominal value of i-this single reduced ticket, and p_i stands for the number of journeys completed on the basis of i-that nominal value;

– the value of revenue lost due to services provided for reduced periodical fares was calculated according to the following formula: $\Sigma(N_i \times P_i)$, where N_i stands

for the value of one trip completed on the basis of a periodical ticket of i-this nominal value, and Pi stands for the number of journeys completed on the basis of i-that nominal value ticket;
– the value of revenue lost due to services provided fare-free was calculated according to the following formula: $\Sigma(bp \times pb)$, where bp stands for the average value of one trip calculated on the basis of a normal fare, and pb stands for the number of free travel.

Table 6. Annual value of financial deficit and the hypothetical full reimbursement of revenue lost due to entitlements to reduced fares and free travel within the cities included in the study

City	Amount of deficit [PLN]	Reimbursement [PLN]	Difference between the reimbursement and deficit [PLN]	% of Reimbursement of the deficit
Grudziadz (2015)	1 108 621	598 767	–419 854	54
Jelenia Gora (2014)	932 217	516 207	–416 010	55
Rzeszow (2013)	1 633 422	1 500 273	–133 149	92
Wloclawek (2016)	962 628	751 590	–211 038	79

Source: (own elaboration on the basis of Primary research conducted by Board of Public Transport in Gdynia, 2016 and Primary research conducted by PTC Marcin Gromadzki, 2013a, 2013b, 2014, 2015a, 2015b, 2016)

The data presented in Table 5 indicates that in none of the cities included in the analysis would a full reimbursement of revenue lost due to reduced fares and free travel cover the financial deficit of urban transport. The level of reimbursement would amount to between 54% in Grudziadz and 92% in Rzeszow. This is the direct consequence of maintaining services characterised by a relatively low demand and high cost of operation per passenger (as a result of, among others, long distance routes).

Also noteworthy is the diverse range of municipal entitlements awarded by local authorities. However, there is no uniform catalogue of such entitlements to free travel and reduced fares. The analysis carried out suggests that there is a lack of cohesion between the rules pertaining to the granting of entitlements for free travel and reduced fares. Such entitlements are granted for social and political reasons and the economic consequences are, in the majority of cases, deemed to be of secondary importance.

Conclusions

On the basis of research and deliberations carried out in the chosen cities it can be stated that:
– Assigning urban transport to public utility determines the scope of entitlements to free and reduced fares.
– Studies of the volume and structure of demand are carried out in order to calculate the influence of the aforementioned entitlements on the revenue collected

from services provided. The studies are based on a particular methodology. Its findings suggest that:

a) passengers travelling free and on reduced fares constitute the majority of passengers within the passenger structure;

b) the share of passengers travelling free and on reduced fares does not bear a significant influence on the revenue per unit which denotes the existence of a stronger influence of other factors, such as ticket prices in a given city and the number of passengers per vehicle-kilometre.

– The economic and operations effectiveness of urban transport is not determined by any one single parameter, but rather by a comprehensive combination of those factors which constitute the transport services offer.

– There is a growing tendency to implement statutory fare reduction entitlements, which can be reimbursed from the state budget, in order to increase the revenue from services.

– Reimbursement of all revenue lost due to entitlements to free travel and reduced fares, regardless of their nature, would not cover the budget deficit of public urban transport.

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