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Problems of financing urban mobility resilience in Poland

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Abstract

Motivation: The efficient functioning of transportation systems is subject to various types of disruptions and risks. Transportation systems are strongly affected by all kinds of local, regional, national, or global crises. The European Union's transport policy indicates the need to build sustainable, intelligent, and resilient urban mobility systems based on public mass transit. The paradigm of resilience has gained particular importance in the context of the global crises of the last five years. Resilient urban mobility systems are intended to provide the ability to respond quickly to disruptions that occur, allowing urban organisms to achieve operational stability.

Aim: The purpose of the study is to identify the main problems with financing the resilience of public mass transit systems in Polish cities. The specific aims are the identification of the factors determining the resilience of urban mobility systems and tools supporting it, measures of resilience and ways of financing it. The study sought to verify whether the mobility systems of Polish regional cities can be considered resilient from a financial point of view.

Results: Financing urban public mass transport in Poland is based on two key sources of income: fees from ticket sales and payments (compensations) made by local governments. The economic and energy crisis contributed to a significant increase in the operating costs of public mass transportation providers. In this context, the key to building resilient public mass transport systems in urban areas is to make changes to existing models to ensure a stable PTA financing system.

Keywords: financing resilience; transport resilience; urban public transport; urban mobility
JEL: H72; R40; R51

1. Introduction

In December 2019 the European Commission (2019) has communicated the *European Green Deal*. The document indicates that one of the critical areas of transformation of the European Union economy in 2050 perspective will be the transition to sustainable and intelligent mobility. The objectives set out in the European Green Deal primarily address the need to decarbonise transport systems through significantly, among other things, the deployment and dissemination of zero-emission vehicles, the reduction of congestion, the improvement of public transport, multimodality, or the dissemination of intelligent communication tools to support sustainable mobility. Adopted a year later, during the COVID-19 pandemic, the *Strategy for sustainable and intelligent mobility…* (European Commission, 2020) emphasises the need to ensure the resilience of the transport system to all types of crises. It points to the need to promote resilient mobility that is at the same time sustainable, zero-emission, intelligent, multimodal, spatially, socially, and economically accessible.

According to United Nations (2022) projections, the global population in 2050 will be more than 9.6 billion people, almost 20% larger than at the end of 2022. Nearly 70% of the global population will live in urban areas in 2050 (United Nations, 2019). This means that building the resilience of global economies will largely depend on the resilience of cities (Przybylowski, 2019). For urban resilience one of the foundations is resilient mobility systems (ISO, 2019).

The aim of the study, the results of which are presented in this article, is to determine the factors determining the resilience of urban mobility systems and the tools supporting it, the measures of resilience and the ways of financing it. The study sought to verify whether the mobility systems of Polish voivodship cities can be considered resilient from a financial point of view. The study omitted aspects of building urban mobility resilience through the sustainable development of urban, suburban, local transportation, and road accessibility between cities. It focused on aspects of financing urban public transportation in Poland in the context of building resilient mobility systems.

The research used a literature analysis, an analysis of legal acts, strategic documents at the European and national level, reports of national and international organisations dealing with urban mobility issues and a study of selected cases based on the analysis of source documents. Particular attention was paid to the relationship between urban mobility resilience and public transport financing models, hypothesising that the main factor in urban mobility resilience is a crisis-proof urban transport financing system.

2. Literature review

The topic of urban mobility is characterised by its interdisciplinarity. It is a heavily exploited area of research in disciplines such as environmental sciences, technical sciences (including transport engineering), social sciences (including

economics and finance and management and quality), geography, urban planning, computer science, or energy (Web of Science, 2022).

Urban mobility is defined as the ability to carry out physical movements within an urban area. It can refer both to movements carried out by people and can also refer to movements of goods (Vidović et al., 2019). Mobility in urban areas can be realised by different means of transport — public, private, mechanised, non-mechanised or without using any vehicles (Goletz et al., 2020). The urban mobility paradigm points to the need for cities to change their approach to mobility planning in their areas. This shift relates to shifting the burden of urban development planning from transport system infrastructure planning to integrated sustainable urban mobility plans. It should not only take into account the need for efficient transport connections within urban areas but also better spatial planning that reduces the need for individual car transport in favour of better accessibility to alternative forms of mobility (e.g. walking, cycling, personal transport devices), the development of shared mobility such as public transport, car sharing, bike sharing, carpooling (Jordová & Brůhová-Foltýnová, 2021).

The new urban mobility paradigm is based on the concept of sustainable, low- and zero-emission development (Kovačić et al., 2022) based on modern technologies (Ceder, 2021) integrated, democratic (Lanzini & Stocchetti, 2021), taking into account different needs and accessible to all. Efficient mobility systems, in turn, are to be the foundation of urban resilience.

Natural disasters caused by climate change, energy crises, economic, political and social crises, terrorist attacks or biological threats, among others, strongly affect the functioning of cities, which contributes to the growing interest of researchers in the topic of resilience (Ba et al., 2022).

In the literature, urban resilience is defined as the ability of an urban system and its components to respond adequately to factors that pose a threat to its functioning and the ability to recover once the threatening factor has subsided (Meerow et al., 2016). A resilient city is able to identify potential threats, prepare for their occurrence, and when they do occur, take steps to minimise the negative impact on the various systems of city functioning (Mierzejewska & Wdowicka, 2018).

Urban resilience research focuses on identifying the vulnerability of urban systems to threats (Havko et al., 2017). It draws attention to the need for resilience planning, developing strategies to respond to hazards and recovering from a hazard condition. It emphasises the need for an integrated approach to resilience planning, considering all stakeholders needs and addressing different areas of urban functioning (Desouza & Flanery, 2013).

Researchers' interest also focuses on the capacity to adapt, absorb and transform urban systems (Zeng et al., 2022). An important research area is the reconstruction of urban systems after crises and using lessons learned to enhance their future resilience (Borsekova et al., 2018).

The concept of urban resilience is closely linked to the concept of sustainable development (Roostaie et al., 2019). Among the basic tools for building urban resilience, the implementation of modern ICTs that allow the monitoring of threat factors is indicated (Zhou et al., 2021b), implementing zero- and low-carbon solutions in urban systems, building sustainable energy systems to grid urban systems, including mobility systems (Sharifi & Yamagata, 2016). Attention is also given to the role of public engagement, not only in terms of building urban resilience strategies but also in terms of active participation in actions taken during an emergency (Gimenez et al., 2017).

3. Methods

The issue of economic resilience is a particularly high-profile and important one. An analysis of the Web of Science database indicates that in the last ten years resilience has been the subject of almost 6,000 scientific publications in economics and management. A co-occurrence analysis of keywords performed using the VOSviewer tool (Chart 1[1]) indicates that the topic of resilience in management science and economics is addressed in the context of four key thematic areas (so-called clusters):

- managing the resilience of businesses in the impact of the COVID-19 pandemic crisis (red cluster);
- the mental toughness of employees (green cluster);
- the resilience of economies related to climate change (yellow cluster);
- policymaking for the resilience of economies to crises (blue cluster).

A keyword linkage analysis: "resilience" — "urban mobility", "resilience" — "public transport", "resilience" — "urban transportation" allows the identification of four specific thematic areas studied in the last decade (Chart 2[2]):

- factors, measures, and outcomes of resilience activities (blue cluster);
- the resilience of the transport network in urban areas (red cluster);
- impact of the COVID-19 pandemic on the operation of urban mobility systems (green cluster);
- public transportation (service demand, passenger transport behaviour) — yellow cluster.

The analysis allowed a preliminary identification of the research problem — the keyword co-occurrence visualization (Charts 1 and 2[3]) identified a knowledge gap regarding financing models for resilient urban public transport systems.

To define a funding model for resilient urban mobility systems, of which public transport should be the backbone, it is necessary to answer the following research questions:

[1] Available online at: https://doi.org/10.12775/EiP.2023.037.

[2] Available online at: https://doi.org/10.12775/EiP.2023.037.

[3] Available online at: https://doi.org/10.12775/EiP.2023.037.

– How to define resilience in the context of urban mobility?
– What events can affect the resilience of urban mobility systems?
– What factors support the construction of resilient urban mobility?
– How to measure the resilience of urban mobility systems?
– How to achieve resilience in urban mobility financing?
– Does Poland's current system of financing public transport in urban areas allow for resilient urban mobility?

The research procedure used tools such as literature analysis, analysis of legal acts, strategic documents at European and national levels, reports of national and international organisations dealing with urban mobility issues and a study of selected cases based on the analysis of source materials. Particular attention was paid to the relationship between urban mobility resilience and public transport financing models, hypothesising that the main factor in urban mobility resilience is a crisis-proof urban transport financing system. Based on expert knowledge, the problems generated by the current public transport financing system in Poland were identified in relation to the need for resilient urban mobility systems.

An analysis of the Web of Science Core Collection database identified 274 publications meeting the search condition ((ALL=(resilience) AND ALL=("public transport")) OR (ALL=(resilience) AND ALL=("urban mobility")) OR (ALL=(resilience) AND ALL=("urban transportation"))) and 2023 or 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 (Publication Years). In the next step, a limitation to three scientific areas was introduced: Transportation Economics and Management, resulting in a catalogue of 105 publications being selected. The search results were then restricted to articles and chapters in monographs, limiting the collection of documents to 89 publications. In the next step, the list of publications was restricted to those published in the open access system, resulting in 46 publications. The full texts of the selected publications were analysed, resulting in the identification of 29 articles meeting the study criteria. The selection procedure for the publications to be analysed is shown in Scheme 1.

The selected catalogue of publications was analysed to answer research questions on the definition of the concept of resilience in the context of urban mobility, the identification of tools supporting resilient urban mobility, factors influencing the resilience of urban mobility systems, methods for measuring the resilience of urban mobility systems and identified models for financing the resilience of urban mobility systems.

In the next step, an analysis of legislation, statistical data, source documents provided by public bodies and reports from urban mobility organisations was carried out to identify the main issues related to financing the resilience of urban mobility systems.

4. Results

Based on the literature analysis, it should be noted that no uniform definition of "resilient urban mobility" has been developed to date. The definitions used mainly refer to the issue of maintaining the ability of transport systems to function under specific conditions (Li et al., 2022), the ability to resist undesirable events leading to transport network failures (Ge et al., 2022), effective mitigation of external shocks, maintenance of essential functions and the ability to quickly restore full functionality once the crisis has ceased. Resilient urban mobility is characterised by the ability to maintain its functionality while the elements that make up the mobility system are exposed to threats (Ge & Zhang, 2022), as well as the ability of participants in the mobility system to cope with crises (Verlinghieri, 2020). The resilience of urban mobility based on urban public transport can also be understood in terms of the ability to absorb additional passenger numbers in the event of an emergency requiring the movement of more people than demand analyses suggest (Scheurer, 2016) or the ability to move passengers at all in the event of one or more factors preventing the regular operation of the public transport system (Moraci et al., 2020). Resilience can also be considered as a comprehensive indicator to assess the performance of the system in case of disruptions (Szymula & Besinovic, 2020). In addition to the ability to maintain functionality and regain stability of urban mobility, attention is drawn to the need for the continuous accumulation of experience and knowledge regarding methods of avoiding future threats (adaptive capacity), as well as the need to plan ways to respond to crises in order to reduce the vulnerability of threats (Fernandes et al., 2019).

The sustainability of urban mobility systems is susceptible to various extraordinary events. The most commonly identified include:

- a local scope:
  - mass events (Li et al., 2022);
  - system maintenance (Ge et al., 2022);
  - congestion (Ge et al., 2022; Ge & Zhang, 2022; Scheurer, 2016);
  - violent weather events and natural disasters (Chaiechi et al., 2022; Ge et al., 2022; Moraci et al., 2020);
  - terrorist attacks (Ge et al., 2022);
  - absence of staff operating urban transport systems due to illness or strike (Ge et al., 2022);
  - failures of public transport system components (Ge et al., 2022; Moraci et al., 2020; Sun et al., 2022);
- a supra-local scope:
  - crises related to the price and availability of energy carriers used to power urban transport systems (Fernandes et al., 2019; Leung et al., 2018);
  - public health crises, e.g. COVID-19 (Campisi et al., 2020; Chaiechi et al., 2022; Hasselwander et al., 2021; Li & Xu, 2022; Liouta et al., 2022;

Nikiforiadis et al., 2020; Teixeira et al., 2021; 2022; Thombre & Agarwal, 2021; Zhang et al., 2021; Zhou et al., 2021a);
- climate risks (Chaiechi et al., 2022; Lanza & Durand, 2021).

The listed phenomena are not a closed catalogue — they are identified, researched and most frequent. As it turns out, the basis for building resilient mobility is the efforts to build sustainable mobility by ensuring an efficient public transport system and high availability of alternative mobility infrastructure — walking, cycling or using UTO devices (Campisi et al., 2020, 2020; Dias et al., 2021; Hasselwander et al., 2021; Li et al., 2022; Li & Xu, 2022; Liouta et al., ; Moraci et al., 2020; Nikiforiadis et al., 2020; Shaer & Haghshenas, 2021; Teixeira et al., 2021; 2022; Thombre & Agarwal, 2021; Zhou et al., 2021a). Particular attention is given to urban planning issues towards building decentralised, 15-minute cities, allowing for the efficient use of soft mobility (Chaiechi et al., 2022; Fernandes et al., 2019; Nikiforiadis et al., 2020; Shaer & Haghshenas, 2021). The need to promote alternative forms of work provision to reduce the burden on urban mobility networks is also indicated (Leung et al., 2018). An underestimated area seems to be the need to build mobility crisis management plans that allow for the advance preparation of procedures necessary to be implemented when a factor threatening the stability of the system occurs (Ge et al., 2022; Moraci et al., 2020; Sun et al., 2022; Thombre & Agarwal, 2021). Attention is also given to the need of diversifying power sources for urban public transport vehicles (Leung et al., 2018).

The studies analysed proposed that the assessment of the resilience of urban mobility systems should be based on the following:
- an indicator of the potential accessibility of urban mobility subsystems (Liao & van Wee, 2017);
- the number of car journeys that can be converted to active transport modes or reduced through a car-sharing service under conditions of limited car use (Li et al., 2022);
- an algorithm that takes into account the current mobility patterns of the city's residents, the socio-economic conditions (wages of residents in each neighbourhood, a matrix of residents' most essential expenditures by income level, the possibility of generating savings, labour market information), the available mobility options and household expenditure on transport; the model also takes into account the city's actual and expected costs of organising mobility (Fernandes et al., 2019);
- the metrics indicated in ISO 37120 and ISO 37123 examine the reliability and punctuality of public mass transport, the availability of evacuation routes and strategies for the mass movement of people from disaster areas, understood as the availability of highways and other vehicular roads, railways and waterways to allow rapid evacuation of the population (Moraci et al., 2020; Przybylowski, 2019).

Attention should be drawn to the fact that, although the studies so far point in the direction of measures to build resilient mobility systems, they do not indi-

cate the sources of funding for these projects or their ongoing maintenance. It is not possible to build a resilient urban mobility system without a stable funding model.

The rules of its operation and financing of urban public transport in Poland are regulated by the *Act on public mass transport* (2010). According to the content of this act, public mass transport services may have the character of public utility services. The implementation of services in this model assumes that the main objective of the entities responsible for their organisation is to reduce transport exclusion and ensure the availability of other public services, e.g. education, culture, health care, trade or the labour market (Błażewski, 2020). Public transport services may also lack the attribute of public utilitarianism — in such cases, the responsibility for the delivery of transport services lies primarily with the entrepreneur, who bears the risk of doing business.

Local authorities or their associations are responsible for organising public transport in urban areas in Poland. Local authorities most often carry out the tasks of a public transport organiser through a specialised organisational unit. The tasks of the public transport organiser include planning the development of transport, organising, and managing public transport.

The cited law identifies two critical sources of funding for public service transport. These include:

– own funds of the local authority organising public transport;
– state budget funds;
– revenue from ticket sales and revenue from additional charges levied on passengers.

Studies carried out in previous years show that the financing of public transport in urban areas mainly falls on local government units (Dydkowski, 2014). Receipts generated from ticket sales and fare revenue cover less than 40% of the costs of organising public transportation (Zioło & Niedzielski, 2019). The provisions of ISO 37123: *Sustainable cities and communities: indicators for resilient cities* (ISO, 2019) allow for the identification of three indicators relating to the issue of financing urban mobility resilience:

– indicator of annual expenditure on modernising and maintaining the urban mobility system;
– indicator of annual expenditure on the provision of public services in the area of urban mobility;
– the rate of allocation of reserve funds to cover unforeseen expenses related to ensuring the functioning of the urban mobility system in an emergency.

The analysis of budget resolutions of the Polish PTAs for 2023 conducted for the purposes of the study (Table 1) operating in the areas of Polish voivodship cities indicates that total expenditures on the organisation of the local public transportation in the studied cities make up a significant share in the budget expenditures of the municipalities — between 5.5% and 21.0%. The only exception is the Upper Silesian Metropolitan Union (GZM), which is the PTA of the municipality boroughs for 40 municipalities in Silesian voivodeship —

expenditures related to the organisation of the municipality boroughs in this case account for 85.6% of the entity's budget expenditures. It should be noted, however, that the tasks of the GZM are significantly limited in relation to those of the other local government units, with transport tasks being the primary area of the association's activity.

On average, fare revenues cover 27.6% of the operating costs of public mass transport in their area. The highest share of revenues from ticket sales is planned to be achieved in Krakow (56.2%) and the lowest is in Zielona Góra (9.5%). It means that 72.4% of expenditures of the analysed entities will be financed from the cities' budgets. When relating fare revenues to current expenditures, we note that the share of fare revenues increases to an average level of 34.1% (from 18% in the case of Zielona Góra and GZM, to 50% in the case of Toruń and 56% in the case of Krakow). The remainder of the expenditure is paid directly from the budgets of the analysed entities. This means that the resilience of public transportation financing in the analysed cities depends on their budgetary stability. It should be noted, however, that the costs of organising public mass transport have been growing rapidly in recent years. One of the reasons for this is the significant increase in the prices of key inputs for transport services, linked to the sharp rise in core inflation from 5.1% in 2021 to 14.4% in 2022 (NBP, 2023), an increase in the price of fuel used to power public transport vehicles of 34% over 2021 for diesel and 21% for gas (POPiHN, 2022). At the same time, the total revenue of local government units increased by only 3.7% in 2022 (Ministry of Finance, 2022). This means that local government units will have significant problems not only with the development of urban public transport but perhaps with maintaining the transport offer at the current level.

What draws attention is the significant variation in investment expenditure between the individual entities analysed — in four cases no investment tasks are planned for 2023, which may mean that these municipalities cannot afford to finance a resilient mobility system or do not see the need to implement such tasks. The largest property expenditures are planned for Warsaw (over PLN 1 billion), Poznań (approximately PLN 410 million), Szczecin (approximately PLN 350 million) and the GZM (approximately PLN 230 million). However, the most favourable relation between property expenditures and total expenditures was recorded for Szczecin (56%), Zielona Góra (54%), Rzeszów (43%), Białystok (39%) as well as Poznań (38%) and Toruń (36%). It can be concluded that these municipalities will be more involved in building the resilience of their mobility systems than the others in 2023.

The analysis of the available budget documents did not make it possible to determine the allocation of reserve funds for the need to ensure the operation of a mobility system for emergency events in the cities analysed.

5. Conclusion

The conducted study does not allow confirming or rejecting the hypothesis of the study — the conducted literature review indicates a significant research gap regarding the role of the urban transport financing system in building system resilience. The researched studies indicate various directions of activities supporting the construction of resilient urban mobility, but do not indicate sources of funding for projects supporting the resilience of mobility systems, including, above all, ways to effectively maintain resilient mobility. It should be noted, however, that the proposed solutions require significant investments related to, among other things, the implementation of low- and zero-emission solutions for public transport, or the construction of alternative mobility infrastructure. Solutions of this type require the incurring of appropriate financial outlays. The Polish system of financing urban public transportation, based on the legislature's transfer of responsibility for organizing and financing urban mobility to the local government level, makes the resilience of mobility dependent on the will and financial capacity of individual local governments.

The study shows that Polish cities have a systemic problem with the ongoing financing of resilient mobility. As a rule, investments in this area are made only in cases where external financial support is obtained — whether in the form of European Union funds or national funds supporting transport investments. While it is possible to obtain external support for investment tasks, operational expenditure must be covered by the organisers from their own revenues. Considering the significant share of expenditures on public mass transport in the overall expenditures of cities, the growing burden resulting from the crisis on the fuel and energy sources market, the low dynamics of income growth, cities will be faced with the dilemma of having to limit their current expenditures. This situation may lead to a reduction in the availability of public transport in urban areas. This, in turn, may lead to an increased outflow of public transport passengers in favour of individual public transport. This situation poses a threat of permanent destabilisation of mobility systems in cities, jeopardising the achievement of the objectives of the European Green Deal policy. Without the systemic support of Polish self-governments in bearing the expenses of the day-to-day operation of PT, cities may have difficulties in building and maintaining sustainable and resilient mobility systems. To ensure the smooth functioning of urban mobility systems in crisis situations, it is worth considering the introduction of an obligation for public transport organisers to create reserve funds and a national resilient mobility fund to support mobility in disaster areas.

The presented study is of a review nature, which constitutes the main limitation of its results. The data analysis was limited to information from budget resolutions for 2023, which may have a significant impact on the assessment of the resilience of urban mobility financing in the cities studied. The study does not consider financial data of public transport operators in the cities analysed, which may also affect the assessment of urban mobility resilience. The study

also omitted aspects of building urban mobility resilience through the sustainable development of urban, suburban, local transportation, and road accessibility between cities. However, it should be noted that the conducted review study is basis for further empirical research in resilience of urban mobility financing.

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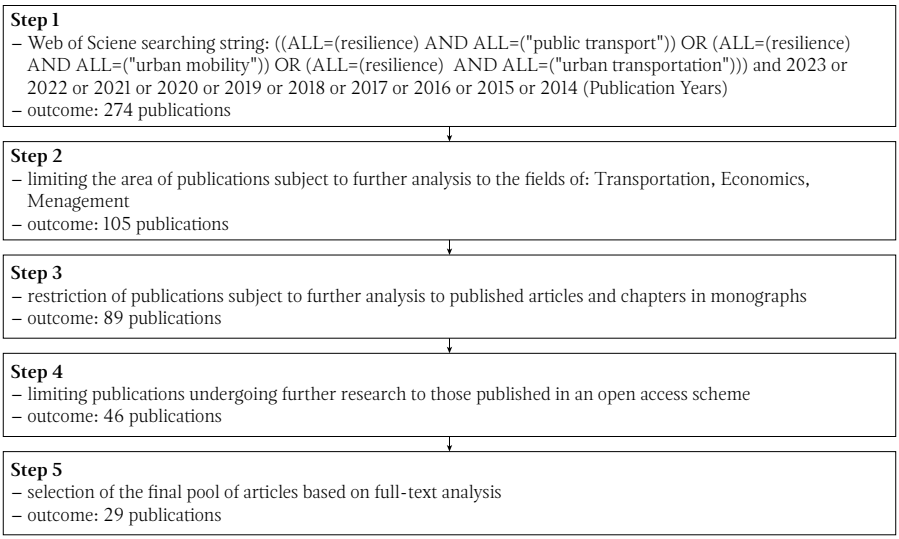
Appendix

Table 1.
Summary of PTA expenses and receipts related to the organisation of public transportation

PTA	Total expenditure on public transportation (PLN million)	Current expenditure on public transportation (PLN million)	Property expenditure on public transportation (PLN million)	Revenue from ticket sales and surcharges (PLN million)	% coverage of total expenditure from ticket revenue and surcharges (%)	% coverage of current expenditure from ticket receipts and surcharges (%)	Share of public transportation expenditure in the municipal budget (%)	Current expenditure in total expenditure (%)	Property expenditure in total expenditure (%)
Bialystok	230.1	140	90.1	55	23.9	39.3	9.3	60.8	39.2
Bydgoszcz	277.8	201.5	76.3	73.6	26.5	36.5	12.6	72.5	27.5
Gdansk	633.6	564.4	69.1	165.7	26.2	29.4	21.0	89.1	10.9
GZM	1813.6	1584.4	229.2	285.9	15.8	18.0	85.6	87.4	12.6
Kielce	95.8	95.7	0.1	38.5	40.2	40.2	5.8	99.9	0.1
Krakow	640.4	640.4	0.0	360	56.2	56.2	8.0	100.0	0.0
Lublin	221	204	17.0	80	36.2	39.2	7.7	92.3	7.7
Łódź	579.1	549.8	29.3	230.1	39.7	41.9	8.9	94.9	5.1
Olsztyn	111	111	0.0	36.2	32.6	32.6	5.6	100.0	0.0
Opole	62	61	1.0	24.3	39.2	39.8	5.6	98.4	1.6
Poznan	1079.6	667.6	412.0	218.2	20.2	32.7	18.5	61.8	38.2
Rzeszów	204.4	117.5	86.9	42	20.5	35.7	10.7	57.5	42.5
Szczecin	619.7	272.8	346.9	70.2	11.3	25.7	18.8	44.0	56.0
Torun	111.5	71.3	40.2	36	32.3	50.5	7.1	63.9	36.1
Warsaw	5021.6	4012.7	1008.9	1000	19.9	24.9	20.6	79.9	20.1
Wrocław	575.7	569.5	6.2	190.3	33.1	33.4	9.0	98.9	1.1
Zielona Góra	122.1	56.5	65.6	11.6	9.5	20.5	9.2	46.3	53.7
Gorzów Wlkp.	117.7	84	33.7	15	12.7	17.9	11.0	71.4	28.6
Medium					27.6	34.1	15.3	78.8	21.2

Source: Own preparation based on budget resolutions of selected local government units for 2023.

Scheme 1.
Selection procedure for publications to be analysed



Source: Own preparation.