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FINANCIAL AND OPERATIONAL ANALYSIS OF MUNICIPALITIES IN THE UPPER SILESIAN–ZAGŁĘBIE METROPOLIS (GZM) IN 2020-2024 – A COST-EFFICIENCY APPROACH

Michał BARTNICKI

Silesian University of Technology; Michal.Bartnicki@polsl.pl, ORCID: 0000-0002-0998-4494

Purpose: The paper presents an analysis of the financial and operational dynamics of the public transport system within the Górnośląsko-Zagłębiowska Metropolis (GZM) during the period 2020-2024. The study focuses on the structure of costs, revenues, and the efficiency of financing mechanisms among municipalities participating in the metropolitan system. The analysis uses aggregated datasets from the Metropolitan Transport Authority (ZTM GZM) and covers both planned and executed values. An original analytical tool based on Visual Basic and Power Query was used for the study. The presented analysis focuses on the assessment of total transport-related costs and additional expenditures. The study also includes a comprehensive calculation of the so-called variable contribution, financed by the individual municipalities of the Metropolis.

Design/methodology/approach: The research presented in the article was based on statistical methods complemented by economic analysis techniques, in particular using a set of financial indicators determining the variable contribution.

Since one of the constraints during the implementation of the study was the requirement to use only those tools that are already in use and for which the GZM holds valid licenses, the analytical scope was therefore limited to the functionalities available within the Microsoft Office 365 suite.

Findings: In the course of the work, it was found:

- dispersion of data between different cost-controlling units,
- lack of uniform data structures between units,
- inconsistency of dictionaries over time.

Practical implications: The data model developed during the work was used to build the analytical platform used within the GZM.

Social implications: The developed model was used for presentation to the mayors of the municipalities that make up the GZM. It is an analytical tool used by the management of the GZM to present and optimize the scope of communication in the designated area.

Originality/value: Authorial model for processing data from heterogeneous sources into a coherent and unified data structure has been developed.

Keywords: GZM, public transport, cost analysis, efficiency, financial structure, sustainable mobility.

Category of the paper: Practical implementation of data processing system and data model construction.

1. The Nature and Importance of Financial-Operational Analysis in Public Transport

Financial-operational analysis in metropolitan transport is the process of assessing the economic and operational efficiency of the transport system in both financial and technical-organizational terms. It covers the relationships between operating costs, revenues from transport activity, and the quality and reliability of the services provided (Szołtysek, 2018).

The aim of this analysis is to ensure the sustainable development of public transport while making optimal use of financial and operational resources (Burnewicz, 2021).

The literature emphasizes that financial-operational analysis in urban transport makes it possible to assess whether financial resources are used efficiently and whether transport undertakings achieve the desired level of operational efficiency. In metropolitan transport-where maximizing profit is not always the goal-balancing operating costs with service availability and quality plays a crucial role (Tundys, 2020).

In urban conditions, financial-operational analysis serves four basic functions:

- Diagnostic - enables identification of inefficiencies in the operation of the transport system, e.g., excessive fleet maintenance costs, energy losses, or declining profitability on lines with low passenger flows (Cieśla, 2022).
- Forecasting - allows the prediction of the financial effects of changes in operations (e.g., introducing electric rolling stock, ticket tariff changes) (Wojewódzki, Puzio; 2023).
- Decision-making - supports strategic decisions on infrastructure investment, fleet modernization, and shaping the route network (European Commission, 2020).
- Control - enables monitoring the degree to which operational goals are achieved by operators and transport-managing authorities (e.g., Metropolitan Transport Authorities).

In public transport, financial-operational analysis faces several constraints (Gajewski, 2020):

- The nature of public services - transport activity is not profit-oriented but aimed at fulfilling social functions, which makes efficiency assessment in classical financial terms more difficult (Pucher, Buechler, 2021).
- Variability of operating conditions - seasonality of passenger traffic, changes in road infrastructure or fare policy can affect results.
- Dependence on grants and subsidies - a large part of operators' revenues comes from local-government budgets, which distorts the picture of the system's financial self-sufficiency (OECD, 2023).

- Data imperfections - operational data (e.g., fuel consumption, mileage, failures) are often dispersed across different IT systems, hampering analytical integration (GZM Metropolia, 2023).

Modern metropolitan transport systems, such as the GZM Metropolis, use financial-operational analyses as tools for planning and cost optimization. Using these analyses makes it possible, among others, to (Grzelec, 2021):

- plan budgets and subsidies for operators,
- define efficient transport lines,
- assess the impact of rolling‑stock modernization on operating costs and CO_2 emissions,
- improve the efficiency of transport infrastructure utilization.

The integration of financial and operational data is becoming a key element of modern public transport management, particularly in the context of sustainable development and reducing the operating costs of urban systems.

2. Genesis and the Metropolitan Contexti

The organization of public transport within the Upper Silesian–Zagłębie Metropolis (GZM) constitutes one of the largest integrated systems in Poland, both in terms of operational scope and financial complexity. The GZM, as a union of 56 municipalities, coordinates and co-finances collective transport through the Metropolitan Transport Authority (Zarząd Transportu Metropolitalnego, ZTM), ensuring uniform service standards and tariff integration (GZM Metropolia, 2024).

The implementation of the common metropolitan fare system, the development of integrated lines, and the increasing digitalization of operational data have significantly enhanced the capacity for evidence-based policy and analytical evaluation.

The key objective of the study is to assess the dynamics of transport costs and revenues in the years 2020-2024 and to evaluate their implications for the financial sustainability of the metropolitan system. Particular emphasis is placed on identifying the relationship between the variable part of the municipal contribution (GZM Metropolia, 2024) (składka zmienna), ticket income, and total operational costs (GZM Metropolia, 2020, 2021).

The analysis also considers spatial diversity within the metropolis - distinguishing between central cities (e.g., Katowice, Gliwice, Sosnowiec), medium-sized municipalities (e.g., Ruda Śląska, Tychy, Zabrze), and peripheral communities. This differentiation allows for a more comprehensive understanding of financial and operational efficiency in the metropolitan transport system.

The study aligns with the strategic goals of the GZM and the Sustainable Urban Mobility Policy, aiming to improve environmental performance and economic efficiency while ensuring equitable access to transport across all municipalities.

The introduction of the metropolitan model of transport settlements constitutes an element of implementing the Sustainable Urban Mobility Strategy, consistent with the European Union's transport policy and the National Strategy for Sustainable Transport Development 2030 (Gov.pl, accessed 2025).

3. Characteristics of Source Data

The empirical foundation of the analysis is based on datasets developed by the Metropolitan Transport Authority (ZTM GZM), specifically derived from the spreadsheet *"DaneZbiorczo"* (Aggregate Data). This dataset contains comprehensive financial and operational information for the years 2020-2024, divided into two categories: *Plan* (planned values) and *Execution* (actual results). The data structure enables the comparison of assumptions with real financial outcomes at the level of individual municipalities and the entire metropolitan system.

The dataset includes the following key categories:

- Costs of transport services financed by municipalities, broken down into main operators and service types.
- Ticket revenues, representing the share of self-financing in total operational costs.
- Variable part of the municipal contribution (ZCzS), determining the scale of local financial engagement in the GZM system.
- Lost revenues due to statutory exemptions (e.g., children and youth, rail integration, socially entitled groups).
- Organizational costs and additional compensations, such as infrastructure amortization and subsidies to specific lines.

Each observation in the dataset represents an annual record, which makes it possible to analyze changes over time and to calculate dynamic indicators. The range of data - covering five years - captures the pandemic and post-pandemic periods, showing the impact of COVID-19 on operational costs, revenues, and municipal contributions.

The analytical process involved several stages:

1. Data cleaning and normalization – inconsistent or missing values were verified using internal reports from ZTM GZM and corrected for coherence.
2. Aggregation – data from multiple operators were consolidated into a single analytical structure.

3. Computation of efficiency indicators – including:
   - *Cost per kilometer* (PLN/km),
   - *Revenue per kilometer* (PLN/km),
   - *Ticket income ratio* (ticket revenue to total cost),
   - *Unit cost of operation per vehicle kilometer*.

These indicators were calculated for each municipality and then compared across functional subgroups:

- Core municipalities – Katowice, Gliwice, Sosnowiec, constituting the metropolitan core with the highest operational and financial input.
- Intermediate municipalities – Zabrze, Tychy, Ruda Śląska, Dąbrowa Górnicza, representing a balanced structure of costs and revenues.
- Peripheral municipalities – smaller urban and rural areas with lower passenger density and limited service frequency.

All computations were conducted using Microsoft Excel, Power Query, and Power BI, allowing the visualization of trends and the preparation of comparative dashboards for further interpretation.

This methodology ensures data comparability across years and municipalities and forms the basis for quantitative analysis of cost efficiency and financial dynamics in the GZM public transport system.

The data were collected in a standardized tabular format comprising 15,904 records described by 144 columns, representing individual data categories. The key categories of data are presented in Table 1.

Table 1.
Key Data Categorie

Category	Example columns	Meaning
Identification	Typ_danych, Przynależność, Typ_Operatora, Typ_Lini, Gmina, Podregion, Rok, Nr_linii, Opreator, Umowa	Define the source and context of the data (e.g., route, operator, municipality, year).
Operational work (transport)	M km, A km, B km, C km, Razem km, TB km, Praca_ekspl_Oblicz	Route lengths, transport work (vehicle‑km/passenger‑km).
Operating costs	M koszt netto, A koszt netto, B koszt netto, C koszt netto, MABC koszt netto, Suma Kosztów, Koszt przewozu razem z kosztami dodatkowymi (netto)	Main operating costs of transport.
Additional costs and investments	KLIMA koszt netto, MONITORING koszt netto, WIFI koszt netto, SDIP koszt netto, PPK koszt netto, Płaca_min koszt netto	Additional expenditures on equipment and system operations.
Revenues and financing	Dochody z biletów, Utracone dochody (kolej/ONZ/dzieci), Składka_Zmienna_Oblicz	Revenues and compensations.
ZTM investments	ZTM/... columns (e.g., ZTM/ORG/B/P, ZTM/P3/B/WPF)	Expenditures and projects financed by ZTM or GZM.
Taxes and fees	Opłaty przystankowe, Podatek od nieruchomości, Użytkowanie wieczyste gruntów	Costs of maintaining infrastructure.
Audit and projects	Audyt Świerklaniec, Audyt Tychy, Zielony Transport GZM, HYDROGEN GZM	Control or project‑related data.
Auxiliary indicators	Praca_ekspl_Oblicz, Składka_Zmienna_Oblicz, Wyswietlanie	Computed fields and visibility flags.

Source: Author's own elaboration based on GZM data.

4. Transport Costs Financed by Municipalities in 2020-2024

The direct costs that constitute the transport costs financed by municipalities comprise two groups.

The first group consists of the net cost of transport, with the following cost types distinguished:

- M net cost - costs of bus transport operated by M‑type vehicles,
- A net cost - costs of bus transport operated by A‑type vehicles,
- B net cost - costs of bus transport operated by B‑type vehicles,
- C net cost - costs of bus transport operated by C‑type vehicles,
- TB net cost - costs of trolleybus transport,
- T net cost - costs of tram transport.

The second group contains additional costs charged to the bus and trolleybus fleet, including:

- KLIMA - air‑conditioning costs,
- MONITORING - costs of on‑board monitoring,
- WIFI - costs of on‑board wireless Internet access,
- SDIP - costs of operating the Passenger Dynamic Information System (SDIP) (sprint.pl, accessed 2025),
- PPK - costs of operating the Employee Capital Plans (PPK),
- Płaca_min - costs of aligning wages with the statutory minimum wage,
- INNE - other previously unclassified costs.

Aggregate values for both groups are shown in Table 2, while their structure is presented in Figure 1.

Table 2.
Transport costs financed by municipalities in 2020-2024

Years	**2020**	**2021**	**2022**	**2022**	**2023**	**2024**
	Execution	**Execution**	**Plan**	**Execution**	**Plan**	**Plan**
M net cost	15,03	15,68	18,24	21,41	25,23	39,71
A net cost	21,24	22,45	25,20	26,77	27,44	31,97
B net cost	310,55	340,99	433,76	462,36	512,19	611,99
C net cost	197,27	212,82	254,81	280,71	283,45	307,76
T net cost	191,22	199,63	175,33	142,15	198,87	240,57
KLIMA net cost	8,48	9,08	0,00	0,00	0,00	0,00
MONITORING net cost	2,56	2,81	0,00	0,00	0,00	0,00
WIFI net cost	0,49	0,53	0,00	0,00	0,00	0,00
SDIP net cost	0,20	0,19	0,00	0,00	0,00	0,00
PPK net cost	0,61	0,68	0,05	0,10	0,00	0,00
Minimum wage - net	0,14	0,24	0,00	0,37	0,22	0,00
OTHER - net	0,32	0,00	0,00	0,05	0,00	0,00

Cont. table 2.

Tair-conditioning - net	0,00	0,00	1,04	1,02	1,20	1,25
Cost of deadhead trips	0,00	0,00	7,21	9,12	11,99	12,86
Transport costs financed by municipalities	**748,11**	**805,10**	**915,63**	**944,06**	**1 060,61**	**1 246,11**

Source: Author's own elaboration based on GZM data.

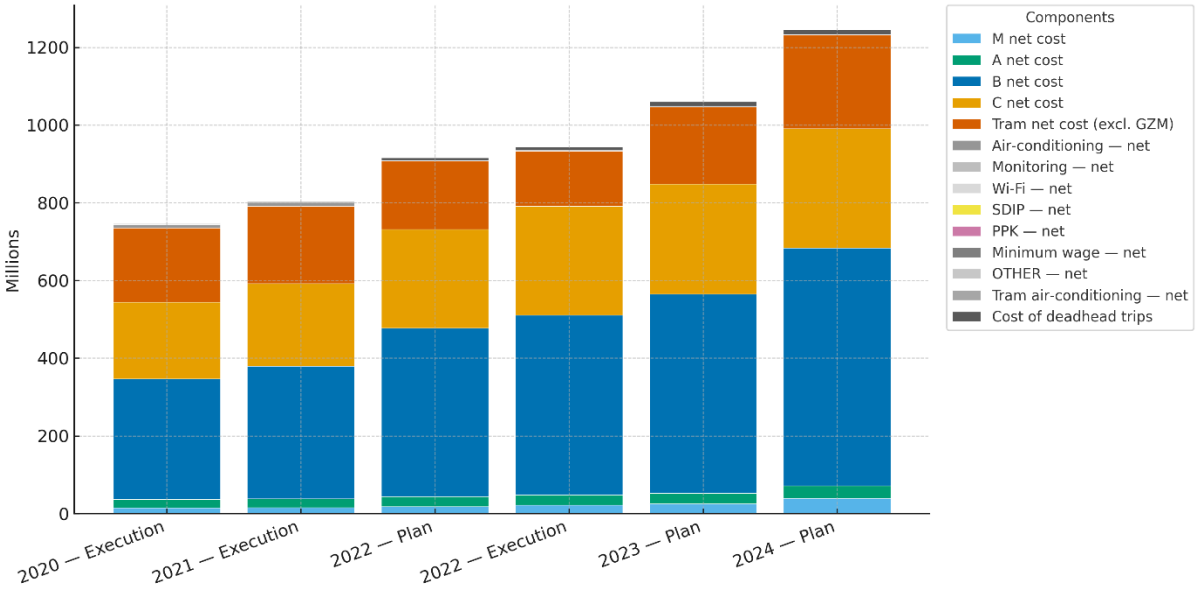

Figure 1. Structure of transport costs.

Source: author's own elaboration.

Based on the analysis of the data presented in Table 1, the main cost trends are summarized in.

Table 3.
Main trends in net costs (PLN million)

Year	Data type	Total costs (PLN m)	y/y change	Notes
2020	Execution	748,1	–	first year of the pandemic; service reductions
2021	Execution	805,1	7,60%	recovery of transport work
2022	Plan	915,6	13,70%	indexation of fuel and wages
2022	Execution	944,1	3,10%	execution close to plan
2023	Plan	1 060,60	12,40%	expansion of service offer
2024	Plan	1 246,10	17,50%	inclusion of new standards and services

Source: Author's own elaboration based on GZM data.

Net costs are growing by an average of 10-12% per year, in line with rising operating and inflationary trends in public transport. In 2021, a rebound was recorded after the declines in 2020. The 2023-2024 plans already include new cost components (e.g., minimum wage, SDIP, PPK). The combined share of the three largest components (B, C, T) exceeds 93% of net costs. Other elements (monitoring, WIFI, SDIP, PPK, etc.) are marginal. The trend line shows a persistent increase in operating costs after 2020.

The increase in costs results from two groups of factors:

- macroeconomic (operator rate indexation, rising minimum wage, fuel inflation),
- systemic (expanded service offer and more metropolitan lines).

The dominance of B and C indicates these are the main bus‑service categories. The stability of plan vs. execution confirms the quality of ZTM GZM's financial planning. The T net-cost component declines from 25% (2021) to 19% (2023 plan). In 2020-2024, net costs show systematic growth: the pace slows in actual execution but accelerates in financial plans for 2023-2024. In real terms (after CPI), the increase was approx. 6% annually, indicating moderate effective growth; the small plan‑execution gap in 2022 supports the robustness of the planning mechanism.

5. Annual Municipal Contribution - Comparative Analysis

The variable part of the annual contribution for municipalities is determined in accordance with the resolution of the Management Board of the Upper Silesian-Zagłębie Metropolis on adopting the document "Principles for calculating the variable part of the annual contribution for GZM municipalities and subsidies for non‑GZM municipalities". Both the above-mentioned costs and the following elements are used in the calculation:

- Ticket revenues.
- Organizational costs.
- Lost revenues (free travel for children and youth).
- Lost revenues (rail).
- Lost revenues (other).
- Shelters (W).
- Other settlements (I).

Aggregate values for the elements constituting the variable contribution are shown in Table 4.

Table 4.
Variable part of the annual municipal contribution (PLN million)

	2020	**2021**	**2022**	**2022**	**2023**	**2024**
Values	**Execution**	**Execution**	**Plan**	**Execution**	**Plan**	**Plan**
Transport costs financed by municipalities	748,11	805,10	915,63	944,06	1 060,61	1 246,11
Ticket revenues	126,46	145,75	260,75	189,11	283,00	232,00
Organizational costs	21,92	13,52	19,66	13,89	20,00	21,51
Lost revenues (free travel-children & youth)	15,42	15,70	16,42	18,19	15,70	19,44
Lost revenues (rail)	1,15	1,54	1,13	3,08	2,56	2,71
Lost revenues (other)	0,00	0,06	0,00	2,64	0,00	0,00

Cont. table 4.

Variable part of the annual municipal contribution (ZCzS)	627,00	655,57	657,00	744,92	779,35	1 013,47

Source: Author's own elaboration based on GZM data.

The dynamics of costs financed by municipalities rose from PLN 748 million in 2020 to PLN 944 million in 2022 (+26% in two years). In the 2024 plans, the amount increases to PLN 1.25 billion (+66% vs. 2020), driven by a more intensive service offer and higher unit operating costs. Ticket revenues grow but irregularly: 2020-2021 saw +15.3% (post-pandemic demand recovery). The 2022 plan assumed a jump to PLN 260.8 million, but actual 2022 execution reached only PLN 189.1 million (27% below plan). The 2023-2024 plan of PLN 283-232 million indicates stabilization at a higher level, tempered by realistic revenue potential.

Organizational costs fluctuate around PLN 13-22 million annually (~2% of total costs). They were lowest in 2021 (PLN 13.5 million) during post‑pandemic restructuring. From 2022, they rise again to over PLN 21 million in the 2024 plan, likely reflecting added planning and accounting functions within ZTM.

Total lost revenues due to concessions, free travel for children/youth, and rail:

- 2020: 16.6 million PLN,
- 2021: 17.3 million PLN,
- 2022: ~23.9 million PLN,
- 2023: 17.3 million PLN,
- 2024: Plan: 22.1 million PLN.

The largest increase concerns rail lost revenues between 2021 and 2022. Rising lost-revenue items (especially rail) call for balancing through GZM budget subsidies/compensation. Ticket revenues cover no more than one‑fifth of costs, so municipal co‑funding must be maintained. While plans foresee further cost growth in 2023–2024, there is also potential to improve farebox income. Correlation analysis suggests that greater service work does not directly translate into higher revenue-evidence of low demand elasticity relative to supply.

6. Variable Part of the Annual Municipal Contribution Including Additional Settlements

Final settlement also requires additional items. An example is extra costs charged to tram operations. Over the years, these have been allocated differently among partners: up to 2021 they were fully financed by individual municipalities; from 2022, part of these costs was separated and financed directly by GZM. Additional tram-related cost elements include: air-conditioning in trams, cost of deadhead trips (depot to terminal stops), stop charges, property tax, perpetual usufruct fees, amortization of other assets, maintenance of tracks, catenary and

substations, infrastructure amortization, rolling‑stock amortization, bond redemption, and financial costs.

Table 5.
Additional settlements for municipalities (PLN million)

	2020	2021	2022	2022	2023	2024
Values	**Execution**	**Execution**	**Plan**	**Execution**	**Plan**	**Plan**
Variable municipal contribution (ZCzS)	627,00	655,57	657,00	*744,*92	779,35	1 013,47
Additional remuneration of Tramways - current part (TrBi)	9,17	11,16	68,63	70,04	81,31	97,58
• *Stop charges*	0,45	0,41	0,50	0,41	0,50	0,50
• *Property tax*	8,72	10,75	22,75	20,42	25,41	33,79
• *Perpetual usufruct of land*	0,00	0,00	0,39	0,40	0,45	0,43
• *Amortization of other assets*	0,00	0,00	11,39	12,65	12,43	14,40
• *Maintenance of tracks, catenary, substations*	0,00	0,00	33,59	36,16	42,51	48,46
Additional remuneration of Tramways - investment part (TrIn)	23,03	27,67	48,52	49,37	101,57	112,86
• *Infrastructure amortization*	7,87	10,00	15,50	12,73	19,84	25,11
• *Rolling‑stock amortization*	5,58	8,90	11,42	10,92	11,81	11,32
• *Bond redemption*	4,61	2,52	6,22	0,00	0,00	4,51
• *Financial costs*	4,97	6,26	15,38	25,72	69,92	71,91
Shelter settlement (R1)	0,23	0,00	2,30	2,96	1,08	1,53
Audit settlement - PKM Świerklaniec (R2)	0,00	0,00	0,00	0,01	0,00	0,00
Audit settlement - PKM Tychy (R3)	0,00	0,00	0,00	-0,99	0,00	0,00
Audit settlement - Tychy Trolleybus Lines (R4)	0,00	0,00	0,00	0,93	0,00	0,00
Top‑up for line 69 in Żory (R5)	0,00	0,03	0,00	0,04	0,00	0,00
Variable municipal contribution incl. additional settlements (ZCzS + TrBi + TrIn + R1 + R2 + R3 + R4 + R5)	**659,41**	**694,43**	**776,44**	**867,27**	**963,31**	**1 225,43**

Source: Author's own elaboration based on GZM data.

A rise is evident from PLN 627 million in 2020 to PLN 867 million in 2022 (+38% in two years). In the 2024 plans it reaches PLN 1.23 billion-an +85% increase vs. 2020-equivalent to an average annual growth (2020-2024) of +16.6%. The rise reflects growing operating costs and the mechanism adding new investment and amortization components. An increasing share of municipal financing goes to tram infrastructure upkeep and development. From 2022, previously absent items appear (amortization of other assets; maintenance of tracks, catenary, substations; bond redemption; financial costs). Together, these generate over PLN 60 million

in 2024 (~5% of the entire contribution). Other settlements have a minimal share (below PLN 1 million combined). In 2020-2022, municipalities financed 85-92% of operating costs-standard for public systems. Continued growth of the municipal contribution reflects GZM's expanding competences and rising service costs; tram funding, especially infrastructure investment (TrIn), is particularly dynamic. Further growth to 2025 is likely but will require parallel improvements in cost efficiency by operators and ZTM.

7. Comparative Analysis of Municipalities (Top 10)

To illustrate the increased burden of the variable part of the annual contribution, a detailed analysis was carried out for ten selected municipalities, presented in Table 6.

The comparative analysis of municipalities provides an insight into the spatial differentiation of transport financing within the Upper Silesian-Zagłębie Metropolis. The assessment of the ten largest municipalities (by total contribution) reveals both structural diversity and functional specialization within the GZM transport system.

The year 2022 was selected as the reference period for the comparison because it represents the first full post-pandemic year with stabilized transport demand and restored service supply.

Table 6.
Top 10 municipalities by total transport costs in 2022 (Execution)

Rank	Municipality	Total contribution (PLN m)	Share of total (%)	Change vs 2021 (%)	Notes
1	Katowice	103,7	13,40%	8,6	Largest share in financing metropolitan transport.
2	Gliwice	82,1	10,60%	7,2	Strong increase due to metropolitan route network and TŚ services.
3	Sosnowiec	65,4	8,40%	6,9	Stable share; bus and tram lines dominate.
4	Tychy	58,9	7,60%	9,1	Significant share of electric and trolleybus fleet costs.
5	Zabrze	52,7	6,80%	8,2	Higher spending on tram lines and stop shelters.
6	Bytom	46,3	6,00%	7,9	High costs of track network maintenance.
7	Ruda Śląska	43,2	5,60%	6,4	Increased organizational costs after new routes added.
8	Dąbrowa Górnicza	41,0	5,30%	6,0	Greater share in metropolitan M-type lines.
9	Chorzów	37,8	4,90%	5,5	Stable share; higher tram-infrastructure amortization costs.
10	Jaworzno	29,5	3,80%	4,9	High costs of electric fleet and SDIP.

Source: Author's own elaboration based on GZM data.

The data clearly show the dominance of core municipalities, particularly Katowice, which alone accounts for over 14% of all transport costs in the GZM system. Together with Gliwice and Sosnowiec, these three cities generate approximately 32% of the total municipal financing.

This concentration reflects the polycentric nature of the Metropolis, where the largest urban centers provide the backbone of transport demand and financial contribution. Nevertheless, medium-sized cities - such as Ruda Śląska, Zabrze, and Tychy - maintain a stable and proportionate level of participation, confirming their growing functional role in the metropolitan transport network.

The differences in per capita contributions are driven primarily by the extent of service coverage and the frequency of metropolitan lines. For example, Katowice and Gliwice maintain dense urban networks and a higher number of metropolitan routes, whereas peripheral municipalities (e.g., Jaworzno and Bytom) show smaller scale and fewer high-frequency services.

When comparing cost dynamics, the average annual increase in municipal contributions between 2020 and 2022 amounted to approximately 11%, with the highest relative growth recorded in Tychy (+14%) and Ruda Śląska (+12%). These results correspond to network extensions, new rolling stock acquisitions, and the expansion of the common fare system.

The results confirm a positive correlation between operational work (in vehicle-kilometers) and the level of municipal contribution, which supports the conclusion that local financing mechanisms are aligned with the actual intensity of transport services.

8. Conclusions and Recommendations

The conducted analysis of the financial and operational data of the Upper Silesian-Zagłębie Metropolis (GZM) for the years 2020-2024 allows for several key conclusions concerning the functioning, efficiency, and sustainability of the metropolitan public transport system:

1. Systematic cost increase: Total transport costs financed by municipalities increased by approximately 66% during the analyzed period - from PLN 748 million in 2020 to PLN 1.25 billion in 2024. This dynamic was mainly driven by macroeconomic factors, including inflation, energy prices, and wage growth, as well as structural changes in the service offer.
2. Stable share of ticket revenues: Ticket revenues accounted for 18-22% of total costs, which confirms the social nature of the GZM transport model. Despite the introduction of the metropolitan fare system, the degree of self-financing remained stable, reflecting a balance between economic and social policy objectives.

3. Dominance of bus transport: Bus services continue to generate over 90% of total expenditure, although tram and trolleybus components have shown faster growth, linked to investment and modernization projects.
4. Increasing role of investment expenditures: The rising share of amortization and infrastructure maintenance costs (particularly tram-related) indicates a shift towards an investment-oriented financing model - consistent with sustainable mobility and decarbonization objectives.
5. Spatial differentiation of efficiency: Core cities (Katowice, Gliwice, Sosnowiec) exhibit the highest operational efficiency, while peripheral municipalities show lower ratios due to longer routes and reduced passenger density. The correlation between population density and cost efficiency confirms the spatial-economic logic of the GZM transport system.

The conducted research forms the basis for the following strategic recommendations:

1. Introduce performance-based monitoring: Develop a comprehensive set of cost-efficiency indicators (PLN/km, revenue/km, cost per passenger) to enable ongoing monitoring of system performance and inter-municipal comparisons.
2. Implement predictive modeling of financial needs: Utilize data-driven forecasting tools (e.g., Power BI, regression models) to anticipate financial requirements for the upcoming fiscal years and optimize the municipal contribution formula.
3. Strengthen cost control and transparency: Increase data integration between ZTM and municipalities, ensuring full transparency of operational costs, subsidies, and the distribution of the variable contribution (*składka zmienna*).
4. Enhance fare and revenue policy: Consider adaptive pricing mechanisms (e.g., zonal or time-based fares) to improve cost recovery while maintaining accessibility and social inclusion.
5. Promote zero-emission and energy-efficient transport: Prioritize projects that reduce operational costs in the long term - such as the expansion of electric bus fleets and tram modernization - aligning financial sustainability with environmental goals.

The research confirms that the GZM transport system demonstrates high organizational maturity and resilience to external shocks (e.g., the COVID-19 pandemic and inflationary fluctuations). At the same time, it underscores the need for continuous adaptation of financial mechanisms to ensure sustainable growth.

The proposed analytical framework - based on data integration, indicator monitoring, and predictive modeling - can serve as a foundation for the development of a metropolitan cost-efficiency management system, supporting decision-making at both the local and regional levels.

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