



SPATIOTEMPORAL ANALYSIS OF PARCEL LOCKERS DISTRIBUTION IN KATOWICE

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Abstract

Purpose. The aim of this article is to present how the number of parcel lockers has changed in individual districts of Katowice, categorized by the five largest operators of this delivery method.

Methodology. To achieve this aim, data on the number of parcel lockers were collected for three periods: October 2023, April 2024 and October 2024. Their addresses were collected, and then, using statistical measures such as Pearson's correlation coefficient, skewness, kurtosis and global Moran's I statistic, the changes that occurred during the studied periods were analyzed. QGIS software was used to determine the isochrones of 500 m for pedestrian traffic from each parcel locker and to calculate the percentage of buildings in individual districts that are out of their reach.

Findings. Based on the Pearson correlation coefficient, a strong positive correlation was found between the number of parcel lockers and the population of a given district. Kurtosis and skewness indicators did not show significant deviations in the distribution of parcel locker numbers across individual districts. Global Moran's I statistic revealed no spatial autocorrelation. It has been shown that the increase in the number of parcel lockers in the district did not always translate into an improvement in availability – in the case of the Wełnowiec-Józefowiec district, a deterioration in availability was recorded despite the increase in the number of lockers.

Keywords: parcel lockers, e-commerce, location

JEL classification: L87, R41, O30

Introduction

The e-commerce market has demonstrated sustained dynamic growth over the past several years, reflected in its steadily increasing value. In 2025, the global e-commerce market value is estimated to reach \$4,32 trillion. Currently, approximately 26% of global retail sales take place online, compared to 18% in 2017 (Hinga, 2025). Forecasting analyses indicate this expansion will continue (Shepherd, 2025). The observed growth is driven by a complex interplay of multiple factors, including economic factors, public policy, technological development, social factors and

legislation (Jekabsone & Gudele, 2020). This paper aims to answer the following research questions:

1. How has the number of parcel lockers in Katowice changed during the studied period?
2. What factors are correlated with the number of parcel lockers in districts – population, area, or population density?
3. Is there a spatial autocorrelation in the distribution of parcel lockers?
4. Does the increase in the number of parcel machines in the district translate into an improvement in the spatial accessibility of this service?

1. Challenges of last-mile logistics

Among the economic and financial drivers of global trade expansion are factors such as the rise in disposable income and the increased capacity to reach international consumers via digital distribution platforms (Kalinić, Ranković & Kalinić, 2016).

Technological progress, in this context, refers primarily to the development of the Internet and mobile devices, which have enabled enterprises to explore new modes of customer engagement and market access. Mobile devices, in particular, facilitate continuous purchasing opportunities for consumers by removing temporal constraints. For both businesses and customers, this evolution in commerce improves accessibility, supports data-driven decision-making, enabling more informed and effective sales and purchasing decisions (Soegoto, Christiani & Oktafiani, 2018).

Social factors, particularly evolving consumer behaviors and preferences, significantly influence the structure and delivery of online services. Empirical observations indicate that customers increasingly expect convenience, rapid transaction processing, and personalized interactions from e-commerce providers. Additional valued aspects include the ability to shop from home, simplified return procedures and broader product availability (Tagizade & Mammadov, 2024).

The biggest challenges associated with last-mile logistics include: time pressure (offering next-day or even same-day delivery), the aging of the logistics workforce, the increasing volume of goods (reflected in the rising market value and the percentage of electronic purchases). Additional challenges pertain to sustainable development (e.g., pollution and noise emissions in cities generated by deliveries) as well as high operational costs (this is the most expensive stage of the supply chain) (Mohammad, Diab, Elomri & Triki, 2023).

Despite the challenges, innovations in last-mile logistics continue to drive the dynamic development of this sales model. As the final and operationally intensive stage of the supply chain, last-mile delivery remains one of the most critical components of the logistics process. Its complexity is particularly evident in urban environments, where infrastructural constraints – such as narrow streets, limited parking availability and traffic congestion – intersect with rising consumer expectations regarding delivery speed, cost-efficiency and convenience. Consequently, logistics providers must ensure fast, reliable and adaptable delivery solutions while complying with urban regulations, vehicle access restrictions and time-specific delivery windows (Fegde, 2025).

Last-mile delivery constitutes the most cost-intensive stage of the supply chain, accounting for approximately 53% of total logistics expenditures. This significant share results primarily from the dispersed nature of recipients and the high level of customer expectations regarding delivery speed, flexibility, and convenience. Additional cost-driving factors include the implementation of value-added services, such as real-time tracking and the operational consequences of failed delivery attempts – whether due to technical malfunctions or recipient unavailability. Moreover, servicing a large network of pickup locations necessitates a substantial number of couriers, adequate warehouse infrastructure, and regular vehicle maintenance. These

elements collectively contribute to the overall cost structure of last-mile logistics and must be carefully considered in cost-efficiency analyses (Patil, 2025).

Consequently, ongoing efforts are being made to develop innovative solutions capable of meeting the increasing demands associated with last-mile delivery. These efforts include route optimization (now using artificial intelligence), establishing smaller urban fulfillment hubs and the implementation of crowdsourcing-based solutions (Patil, 2025). Additionally, advancements in transportation technologies contribute to reducing delivery costs. Among these technologies are: reception boxes, pick-up points, drones, trunks and robots (Mangiaracina, Perego, Seghezzi & Tumino, 2019).

Another such technological solution are parcel lockers. Their implementation represent a notable technological advancement that has significantly transformed the last-mile delivery process by directly addressing several key logistical challenges. These secure, automated compartments facilitate the delivery and collection of parcels without requiring direct contact with the recipient. A critical factor in their effectiveness is strategic placement in high-footfall areas such as shopping centers, office buildings, and residential complexes, allowing a single unit to serve a wide range of customers (DHL Logistics of Things, 2023). This model enables more efficient route planning (fewer packer lockers than recipients), and the number of packages delivered in a shorter time frame increases (more parcels are placed in one locker at a time). As a result, logistics operators benefit from reduced delivery costs (more successful deliveries, fewer delivery attempts, fewer trips), lower rate of failed deliveries (no dependence on recipient availability), and greater package protection against weather conditions and the risk of theft or damage (access to the locker is only possible via a specific code) are achieved (Stević, Huskanović, 2025).

The spatial placement of parcel lockers constitutes a critical aspect in the development and optimization of this delivery model. Various methodological approaches are employed to determine optimal locations, including efficiency analyses, utility-based assessments, spatial data modeling, and multi-criteria decision-making techniques. It is important to emphasize that location preferences vary significantly across countries. For instance, commercial zones are considered favorable in Sweden and Brazil, whereas in Poland, they are deemed among the least suitable – similar to public transport stops, which are preferred in countries such as France or Australia (Moslem, Pilla, 2023).

2. Methodology

To address the research questions, data on the number of parcel lockers in Katowice were collected for three periods: October 2023, April 2024, and October 2024. These correspond to the third quarter of 2023 (Period 1), the second quarter of 2024 (Period 2), and the third quarter of 2024 (Period 3). The detailed figures are presented in Table 1.

Table 1. Number of parcel lockers in Poland

Operator	Q3 2023	Q2 2024	Q3 2024
InPost	21 227	26 822	28 055
DPD	5 600	8 000	8 342
Orlen	3 535	6 000	6 056
DHL+Cainiao	2 000	3 000	4 000
Allegro	3 200	3 500	3 824
Poczta Polska	200	800	1 131

Source: Bednarek (2024).

In the subsequent stages of the study, the five largest parcel locker operators in Poland were identified. Using data publicly available on their official websites, the number of parcel lockers operated by each entity within the city of Katowice was determined (see Table 2).

Table 2. Number of parcel lockers in Katowice

	October 2023	April 2024	October 2024
InPost	195	202	214
DPD	76	90	97
Orlen	51	118	73
DHL	23	58	64
Allegro	72	83	95

Source: based on own elaboration: InPost (n.d.), DPD Polska (n.d.), ORLEN Paczka (n.d.), DHL Express Polska (n.d.), Allegro.pl (n.d.).

In the next step of the analysis, parcel locker locations were verified and classified by district. Using the addresses of individual lockers and an official list of streets assigned to each district in Katowice, each locker was allocated to its corresponding administrative unit (Budżet Obywatelski Katowice, n.d.). The aggregated number of parcel lockers per district for each time period is presented in Table 3.

Table 3. Number of parcel lockers in districts of Katowice

District	October 2023	April 2024	October 2024
Bogucice	32	31	29
Brynów Część Wschodnia – Os. Zgrzebnioka	15	20	20
Dąb	15	19	19
Dąbrówka Mała	7	13	11
Giszowiec	24	31	33
Janów – Nikiszowiec	7	10	13
Kostuchna	18	27	34
Koszutka	17	20	18
Ligota – Panewniki	36	53	52
Murcki	6	9	8
Os. Paderewskiego – Muchowiec	18	29	27
Osiedle Tysiąclecia	18	23	20
Osiedle Witosa	18	22	20
Piotrowice – Ochojec	50	64	66
Podlesie	6	8	8
Szopienice – Burowiec	17	23	23
Śródmieście	38	44	42
Wełnowiec – Józefowiec	31	38	39
Załęska Hałda - Brynów Część Zachodnia	18	27	29
Załęże	8	15	12
Zarzecze	5	7	6
Zawodzie	13	18	14

Source: based on own elaboration: InPost (n.d.), DPD Polska (n.d.), ORLEN Paczka (n.d.), DHL Express Polska (n.d.), Allegro.pl (n.d.).

Additional data used in the subsequent stages of the analysis included the population of individual districts and their area. Population figures were obtained from the participatory budgeting (PB) documentation for Katowice for the 2023 (Budżet Obywatelski Katowice, n.d. a) and 2024 editions. (Budżet Obywatelski Katowice, n.d. b), while the district areas were sourced from the Study of Conditions and Directions of Spatial Development for the city of Katowice (Studium uwarunkowań i kierunków zagospodarowania przestrzennego miasta Katowice) (Rada Miasta Katowice, 2012). The compiled data are presented in Table 4.

Table 4. Population and area of districts

District	PB 2023	PB 2024	Area [km ²]
Bogucice	13 005	12 710	2,78
Brynów Część Wschodnia – Os. Zgrzebnioka	6 517	6 691	4,08
Dąb	6 533	6 353	1,86
Dąbrówka Mała	4 457	4 412	3,68
Giszowiec	14 662	14 409	12,03
Janów – Nikiszowiec	9 322	9 188	8,65
Kostuchna	11 758	11 760	8,59
Koszutka	9 543	9 667	1,38
Ligota – Panewniki	27 500	27 052	12,59
Murcki	4 618	4 520	41,53
Os. Paderewskiego – Muchowiec	11 236	11 391	7,42
Osiedle Tysiąclecia	19 874	19 568	1,88
Osiedle Witosa	11 770	11 612	3,49
Piotrowice – Ochojec	21 894	21 783	12,08
Podlesie	7 009	7 116	8,28
Szopienice – Burowiec	12 812	12 429	8,47
Śródmieście	23 866	24 662	3,81
Wełnowiec – Józefowiec	13 304	13 166	3,15
Załęska Hałda - Brynów Część Zachodnia	12 939	12 755	6,54
Załęże	8 120	7 960	3,39
Zarzecze	3 122	3 153	5,08
Zawodzie	10 289	10 234	4

Source: Budżet Obywatelski Katowice (n.d. a), Budżet Obywatelski Katowice (n.d. b.), Rada Miasta Katowice (2012).

The collected data on parcel lockers and districts were used to calculate population density, resulting in the following variables:

- x_1 – number of parcel lockers in a given district,
- x_2 – population of a given district,
- x_3 – district area [km²],
- x_4 – population density of the district [persons/km²], calculated for the years 2023 and 2024,
- x_5 – number of parcel lockers per km² – an indicator to be maximized; a higher number of lockers per unit area is desirable as it can contribute to a shorter distance to the nearest locker, on the other hand, too many machines in a given area may limit the effectiveness of logistics activities in a given area, but this article takes the customer's perspective,
- x_6 – number of people per locker – an indicator to be minimized; a lower number of people per locker is desirable as it can reduce the risk of the locker being full,

The next step of the analysis was to calculate Pearson's correlation coefficient (formula 1) (Balcerowicz-Szkutnik, Sojka, Szkutnik, 2014).

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}} \quad (1)$$

Where:

x, y – values of variable,

\bar{x}, \bar{y} – mean values of variables.

Several Pearson correlation coefficients were calculated, with the number of parcel lockers in each district (x_1) serving as the independent variable. The dependent variables were:

– the population of each district (x_2),

– the area of each district (x_3),

The skewness coefficient was calculated (formula 2) to check if the distribution deviates from the mean and to identify potential inequalities in the distribution of lockers within the city (Naukowiec, n.d.).

$$NA = \frac{n \sum (x_i - \bar{x})^3}{(n-1)(n-2)s^3} \quad (2)$$

Where:

– n – number of observations (districts of Katowice),

– x – value of parcel lockers in given district,

– \bar{x} – average number of parcel lockers,

– s – standard deviation.

The calculated results can have the following values:

– $NA = 0$ – symmetrical distribution,

– $NA > 0$ – right asymmetrical distribution,

– $NA < 0$ – left asymmetrical distribution.

The kurtosis coefficient (formula 3) was also calculated to determine how the number of parcel lockers in the city's districts is concentrated around the mean (Obliczenia statystyczne, n.d.).

$$K = \frac{\frac{1}{N} \sum_{i=1}^N (x - \bar{x})^4}{\left(\frac{1}{N} \sum_{i=1}^N (x - \bar{x})^2\right)^2} - 3 \quad (3)$$

The calculated results can have the following values:

– $K = 0$ – mesokurtic distribution,

– $K > 0$ – leptokurtic distribution,

– $K < 0$ – platykurtic distribution.

The skewness and kurtosis coefficients were calculated depending on the variables: x_1, x_5, x_6 .

This article also utilized a spatial autocorrelation method. The global Moran's I statistic (formulas 4-6) was employed to check for the overall presence of district clustering with regard to the number of parcel lockers (Miśkiewicz-Nawrocka, Zeug-Żebro, 2017):

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n \sum_{j=1}^n w_{ij} \sum_{i=1}^n (x_i - \bar{x})^2} = \frac{n}{S_0} \cdot \frac{z^T W z}{z^T z} \quad (4)$$

$$I^S = \frac{I - E(I)}{\sqrt{\text{Var}(I)}}, E(I) = -\frac{1}{n-1}, \text{Var}(I) = \frac{n^2 S_1 - n S_2 + 3 S_0^2}{(n^2 - 1) S_0^2} - \frac{1}{(n-1)^2} \quad (5)$$

$$S_0 = \sum_{i=1}^n \sum_{j=1}^n w_{ij}, S_1 = \frac{1}{2} \sum_{i=1}^n \sum_{j=1}^n (w_{ij} + w_{ji})^2, S_2 = \sum_{i=1}^n (\sum_{j=1}^n w_{ij} + \sum_{j=1}^n w_{ji})^2 \quad (6)$$

Where:

– x_i, x_j – values of variables in spatial unit i and j ,

– \bar{x} – arithmetic mean,

– n – total number of spatial units included in the study,

– S_0 – sum of all elements of the weight matrix,

– z – column vector with elements $z_i = x_i - \bar{x}$

– W – Spatial weight matrix of order n defining the neighborhood structure,

- w_{ij} – element of the zero-one weight matrix W , 1 – have a border, 0 – does not have a border).

In cases where the Global Moran's I statistic takes on values:

- $I = 0$ – no spatial correlation (randomly dispersed),
- $I = 1$ – positive spatial correlation (perfectly clustered),
- $I = -1$ – negative spatial correlation (perfectly dispersed).

In the final stage of the study, QGIS software and the OpenRouteService API key (OpenRouteService, n.d.) were used to determine the isochrone of 500 m for pedestrian traffic from each parcel machine. The 500 m threshold was adopted in accordance with the literature on the availability of last-mile services (Viri, Sievers, Liimatainen, Schütze & Siefer, 2022). Data on buildings was obtained from OpenStreetMap (as of May 2026). Then, for each of the three periods studied, the percentage of buildings in individual districts remaining outside the range of the designated isochrones was calculated.

3. Results

As shown in Table 1, InPost remained the leading parcel locker operator in Poland throughout all analyzed periods, consistently accounting for more than half of the total devices on the market. However, its market share gradually declined in favor of emerging competitors.

In the case of Katowice (Table 2), the largest shares were held by InPost and DPD, reflecting national trends. Allegro ranked third, while DHL and Orlen exhibited comparatively lower market presence. Notably, Orlen reduced the number of its lockers in the study area, despite the overall growth in parcel locker infrastructure operated by other companies.

Based on the data presented in Tables 3 and 4, several key indicators were calculated: population density in 2023 and 2024, the number of parcel lockers per 1,000 inhabitants, the number of parcel lockers per square kilometer, and the number of inhabitants per parcel locker. The results for each of the three time periods are summarized in Tables 5.

Table 5. Basic variables for researched periods

District	October 2023			April 2024			October 2024		
	x_4	x_5	x_6	x_4	x_5	x_6	x_4	x_5	x_6
Bogucice	4 678	11,51	406	4 572	11,15	410	4 572	10,43	438
Brynów Część Wschodnia – Os. Zgrzebnicka	1 597	3,68	434	1 640	4,90	335	1 640	4,90	335
Dąb	3 512	8,06	436	3 416	10,22	334	3 416	10,22	334
Dąbrówka Mała	1 211	1,90	637	1 199	3,53	339	1 199	2,99	401
Giszowiec	1 219	2,00	611	1 198	2,58	465	1 198	2,74	437
Janów – Nikiszowiec	1 078	0,81	1 332	1 062	1,16	919	1 062	1,50	707
Kostuchna	1 369	2,10	653	1 369	3,14	436	1 369	3,96	346
Koszutka	6 915	12,32	561	7 005	14,49	483	7 005	13,04	537
Ligota – Panewniki	2 184	2,86	764	2 149	4,21	510	2 149	4,13	520
Murcki	111	0,14	770	109	0,22	502	109	0,19	565
Os. Paderewskiego – Muchowiec	1 514	2,43	624	1 535	3,91	393	1 535	3,64	422
Osiedle Tysiąclecia	10 571	9,57	1 104	10 409	12,23	851	10 409	10,64	978
Osiedle Witosa	3 372	5,16	654	3 327	6,30	528	3 327	5,73	581
Piotrowice – Ochojec	1 812	4,14	438	1 803	5,30	340	1 803	5,46	330
Podlesie	846	0,72	1 168	859	0,97	890	859	0,97	890
Szopienice – Burowiec	1 513	2,01	754	1 467	2,72	540	1 467	2,72	540
Śródmieście	6 264	9,97	628	6 473	11,55	561	6 473	11,02	587
Wełnowiec – Józefowiec	4 223	9,84	429	4 180	12,06	346	4 180	12,38	338
Załęska Hałda – Brynów Część Zachodnia	1 978	2,75	719	1 950	4,13	472	1 950	4,43	440
Załęże	2 395	2,36	1 015	2 348	4,42	531	2 348	3,54	663
Zarzecze	615	0,98	624	621	1,38	450	621	1,18	526
Zawodzie	2 572	3,25	791	2 559	4,50	569	2 559	3,50	731

Source: own elaboration

In the next step, Pearson's correlation coefficient, skewness, the kurtosis coefficient, and the absolute value of the Global Moran's I statistic were calculated, with the results presented in Table 6.

Table 6. Calculated statistics

Statistic	October 2023	April 2024	October 2024
Pearson's correlation ($r_{x_1x_2}$)	0,8371	0,8636	0,8328
Pearson's correlation ($r_{x_1x_3}$)	-0,0943	-0,0487	-0,0187
Skewness (x_1)	1,0489	1,1737	1,1586
Skewness (x_5)	0,9375	0,7808	0,7446
Skewness (x_6)	1,0640	1,4085	1,0370
Kurtosis (x_1)	0,7797	1,4084	1,3476
Kurtosis (x_5)	-0,5842	-0,6680	-0,7852
Kurtosis (x_6)	0,7258	1,4347	0,7825
Global Moran's I indicator	-0,0714	-0,0246	-0,0344

Source: own elaboration

Table 6 reveals a strong positive correlation between the population of a district and the number of parcel lockers. No similarly strong relationships were observed for the other calculated correlation. This suggests that population size is the primary determinant in the placement of new parcel lockers, whereas district area appears to exert minimal influence.

The analysis of skewness values indicates that all coefficients are close to 1 (ranging from 0,74 to 1,4), suggesting a mild right-skewed distribution. This implies that most districts feature relatively low numbers of parcel lockers, a lower number of lockers per unit area, and a higher number of residents per locker, with only a few districts exhibiting notably higher values across these indicators.

Regarding the kurtosis coefficient, the values are close to 0 (ranging from -0,79 to 1,4), suggesting that the distributions of the analyzed variables approximate a normal distribution. A slightly leptokurtic distribution was observed for the variables "number of parcel lockers" and "number of people per locker," whereas the "number of parcel lockers per unit area" exhibits a platykurtic distribution.

Nevertheless, for both the skewness and kurtosis coefficients sufficiently close to zero that no substantial deviations from normality can be conclusively established.

A similar pattern is observed in the case of the spatial autocorrelation indicator. The values obtained for all analyzed periods do not reveal any significant spatial dependency, suggesting that the distribution of parcel lockers is random.

Based on the results, it can be concluded that the number of parcel lockers is strongly correlated with the population of individual districts. In contrast, for the other examined variables, parcel lockers appear to be distributed relatively evenly. However, the absence of spatial autocorrelation in their placement indicates a dispersed, non-clustered distribution pattern.

Using QGIS software, the percentage of buildings in each district that is not within a 500 m walking distance of each parcel lockers was calculated. The results are presented in Table 7.

Table 7. Percentage of buildings outside the 500 m range of parcel lockers in districts

District	October 2023	April 2024	October 2024
Bogucice	1,71%	1,71%	1,71%
Brynów Część Wschodnia – Os. Zgrzebnioka	10,93%	10,73%	9,91%
Dąb	1,16%	1,10%	1,05%
Dąbrówka Mała	33,16%	26,67%	27,98%
Giszowiec	15,32%	13,32%	12,26%

Janów – Nikiszowiec	48,44%	33,83%	38,50%
Kostuchna	28,77%	27,16%	26,67%
Koszutka	15,77%	14,68%	15,77%
Ligota – Panewniki	13,09%	14,24%	10,85%
Murcki	41,13%	31,06%	31,13%
Os. Paderewskiego – Muchowiec	19,46%	14,07%	13,60%
Osiedle Tysiąclecia	3,52%	3,52%	3,52%
Osiedle Witosa	27,94%	27,94%	27,94%
Piotrowice – Ochojec	13,57%	9,97%	9,76%
Podlesie	49,26%	48,24%	45,79%
Szopienice – Burowiec	23,96%	22,99%	21,95%
Śródmieście	13,74%	11,56%	6,71%
Wełnowiec – Józefowiec	11,37%	14,75%	12,74%
Załęska Hałda - Brynów Część Zachodnia	26,21%	23,27%	23,22%
Załęże	46,39%	43,00%	44,91%
Zarzecze	47,56%	41,66%	41,66%
Zawodzie	24,62%	22,49%	27,03%
Katowice	23,23%	20,98%	20,23%

Source: own elaboration

In October 2023, 23.23% of Katowice's buildings were not within 500m of a parcel locker, in April 2024 the number of parcel lockers was the highest of the three surveyed periods, and in October 2024, despite a decrease in the number of machines compared to April 2024, the percentage of buildings out of reach dropped to 20.23%.

Comparing the data from Tables 3 and 7, it can be noted that the increase or decrease in the number of parcel lockers in a given district did not always lead to an improvement or deterioration in the availability of the service in question. In districts such as Bogucice, Osiedle Tysiąclecia and Osiedle Witosa, the percentage of buildings remaining out of reach remained at the same level in the three surveyed periods, despite the fact that the number of parcel machines was not constant (an increase in their number in April 2024 and a decrease in October 2024). Bogucice and Osiedle Tysiąclecia, this percentage of buildings is relatively small (1.71% and 3.52%, respectively). On the other hand, in the Osiedle Witosa, the percentage of buildings is almost 28%, and the lack of this change suggests that the parcel lockers were located in places already served by other operators.

On the other hand, it can be noted that in districts such as Kostuchna or Załęże, despite the increase in the number of parcel lockers by almost 90%, the percentage of buildings remaining out of reach of the isochrone remained almost unchanged (a decrease of about two percentage points). In Podlesie, the percentage of buildings remaining out of reach is the highest among all districts and the area with the greatest potential for the development of parcel machines.

In the Śródmieście district, a slight increase in parcel lockers (from 38 to 42) resulted in the percentage of buildings out of reach falling by 7 percentage points. In turn, the Wełnowiec – Józefowiec district is the only district where the increase in the number of parcel lockers between October 2023 and April 2024 worsened the availability of this service.

4. Conclusion and discussion

The selected variables and indicators did not reveal statistically significant relationships with the number of parcel lockers, apart from the district population size. This suggests that additional, unexamined factors may also influence the spatial distribution of lockers. Notably, parcel lockers operated by different companies are often located in close proximity to one another – for instance, within residential complexes or near commercial establishments. As a result, a higher number of lockers in a given district may reflect the presence of multiple operators rather than improved accessibility, as the effective walking distance to the nearest locker may remain unchanged.

Furthermore, the analysis was conducted at the district level, taking into account the total surface area of each district. However, it may be more appropriate to consider only actively inhabited areas – such as so-called potential transport service areas – excluding uninhabited zones such as green spaces or industrial lands.

It is also important to acknowledge that parcel lockers differ across operators, particularly in terms of the number and size of available compartments. These technical specifications may further influence decisions regarding locker deployment and placement strategy.

The issue of parcel locker distribution in urban areas has been examined in various international contexts, including Queensland (Australia) (Leung, Lachapelle, Burke, 2023), Poznań (Poland) (Sawik, Serrano-Hernandez, Muro, Faulin, 2022), czy Tianjin (China) (Ding, Ullah, Grigoryan, Hu, Song, 2023). The study conducted in Queensland focused on user behavior related to parcel collection. In Poznań, mathematical programming techniques were employed to determine the optimal placement of parcel lockers. The research in Tianjin analyzed the spatial distribution of lockers before and after the COVID-19 pandemic in order to identify factors influencing their deployment. To date, however, no such analysis has been conducted for Katowice. The approach adopted in this study differs from previous works by focusing specifically on population size and district area as key variables in assessing the distribution of parcel lockers.

The presented analysis of the change in the number of parcel lockers in the three examined periods in relation to the percentage of buildings in a given district that are beyond the 500 m walking distance parcel lockers demonstrates that the number of parcel lockers in a district alone is insufficient to assess service accessibility. A dynamic increase in the number of parcel lockers in districts can be noticed, but this does not always translate into a decrease in the percentage of buildings remaining outside the service coverage area. This suggests that a single parcel locker placed in a currently underserved location may contribute more effectively to improving accessibility than placing multiple lockers in areas already covered by existing infrastructure.

Summary

Future research could pursue a more granular analysis of parcel locker distribution by focusing on smaller spatial units, such as housing estates rather than broader administrative districts. Such an approach would enable a more detailed examination of the contextual characteristics of locker placement, including the type of area in which lockers are located (e.g., residential, commercial, recreational) as well as the immediate surroundings (e.g., accessibility or safety). However, several limitations must be acknowledged. These include challenges in defining consistent and accurate boundaries for the studied areas and categorizing them unequivocally, access to population data, the number of people using the lockers, or the dynamic nature of urban centers and parcel locker development itself. Further research could focus on a more detailed analysis of the types of buildings located outside the service coverage area, as well as an assessment of market concentration among parcel locker operators using indices such as the Herfindahl-Hirschman Index (HHI) (Hanusik, Gałęcka, 2026).

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CZASOWOPRZESTRZENNA ANALIZA ROZMIESZCZENIA AUTOMATÓW PACZKOWYCH W KATOWICACH

Abstract

Cel – Celem tego artykułu jest przedstawienie, jak zmieniała się liczba paczkomatów w poszczególnych dzielnicach Katowic, z uwzględnieniem pięciu największych operatorów tej formy dostawy.

Metody – W ramach realizacji celu badawczego zgromadzono dane dotyczące liczby paczkomatów w trzech przedziałach czasowych: październik 2023, kwiecień 2024 oraz październik 2024. Zebrano adresy urządzeń, a następnie przeprowadzono analizę zmian za pomocą wybranych miar statystycznych, takich jak współczynnik korelacji Pearsona, miary asymetrii (skośność) i spłaszczenia rozkładu (kurtoza), a także wskaźnik autokorelacji przestrzennej. Wykorzystano oprogramowanie GIS do wyznaczenia izochron 500 m dla ruchu pieszego od każdego automatu paczkowego oraz obliczenia odsetka budynków w poszczególnych dzielnicach pozostających poza ich zasięgiem.

Wnioski – Na podstawie współczynnika korelacji Pearsona wykazano silną dodatnią korelację pomiędzy liczbą paczkomatów a liczbą ludności w danej dzielnicy. Wskaźniki skośności i kurtozy nie ujawniły istotnych odchyżeń w rozkładzie liczby paczkomatów między poszczególnymi jednostkami przestrzennymi. Wartość globalnego wskaźnika I Morana nie wskazała na występowanie autokorelacji przestrzennej. Wykazano, że wzrost liczby automatów paczkowych w dzielnicy nie zawsze przekładał się na poprawę dostępności – w przypadku dzielnicy Wełnowiec-Józefowiec odnotowano pogorszenie dostępności pomimo wzrostu liczby automatów.

Słowa kluczowe: automaty paczkowe, e-commerce, lokalizacja

Klasyfikacja JEL: L87, R41, O30

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