SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 207

LOGISTICS ASPECTS IN THE QUALITY OF LIFE OF STUDENTS AS STAKEHOLDERS IN URBAN LOGISTICS IN UNIVERSITY CITIES

Marzena KRAMARZ

Silesian University of Technology; mkramarz@polsl.pl, ORCID: 0000-0003-0619-5809

Purpose: Research on smart cities and quality of life is advanced. However, there are few publications analyzing the logistical aspects of quality of life. In addition, publications conceptualize residents without considering segments within this stakeholder group. The purpose of this article is to evaluate the logistical aspects of students' quality of life in college towns.
Design/methodology/approach: The article compares three academic cities. The logistics systems of the cities were characterized according to attributes indicating intelligent and sustainable development of passenger transportation. Key solutions for integrated urban transportation, micromobility and intelligent transportation systems are identified. The next step discusses the results of a survey of students living in the surveyed cities. A customer satisfaction index was developed.
Findings: Recommendations have been identified for academic city managers in improving the flow of people in the city. Each case study also identified good practices that are highly appreciated by students.
Originality/value: Applying customer satisfaction characteristic methodology to evaluate logistics aspects affecting students' quality of life.
Keywords: smart city, quality of life, passenger transport, sustainable transport.
Category of the paper: research paper.

1. Introduction

Today's cities face many problems, not only in terms of transport accessibility, but also in terms of the environment. The ever-increasing volume of traffic contributes to transport congestion as well as generating an increase in emissions of harmful substances into the atmosphere. In addition, urbanisation and urban sprawl result in the loss of green spaces, which has a negative impact on the quality of life of residents and urban ecosystems. Consequently, solutions aimed at both improving transport accessibility and protecting the environment are becoming crucial for the sustainable development of modern urban areas.

A sustainable city logistics system is one of the attributes of a smart city. This seems quite obvious, however, research in this area is still underdeveloped. Many researchers recognise that the organisation of the movement of people and cargo in a city influences the quality of life of its inhabitants (Witkowski, Kiba-Janiak, 2012; Kelli de Oliveira 2019; Stec et al., 2020). The quality of life of the inhabitants, on the other hand, is crucial in assessing the level of intelligence of a city (Kramarz et al., 2022).

In this paper, I focus attention on those logistics aspects that support smart city development by building a high quality of life in the city. An important factor for such urban development is to work with stakeholders in the movement of people and cargo in a city to design solutions that are a compromise for different stakeholders. In this paper, I have limited my research to the key stakeholder of urban residents. I have focused my attention on academic cities and therefore it was interesting in the research context to purposely narrow down the general population to students living in the cities under study. The aim of the paper is to assess the satisfaction of students a with the logistical aspects that affect their quality of life in a university city.

In the cities surveyed, various higher education institutions, both public and private, provide their educational offerings. Among the population surveyed, I have included both students who are natives and those who have settled in the city for the duration of their studies. This issue is interesting from two perspectives. Firstly, students in the cities studied make up a significant proportion of the population and are therefore a group that is an important stakeholder in the city. The high quality of life in the city leads them to decide to stay and work in the region. A second perspective is the relationship between the quality of life in a city and the absorptive capacity of the higher education market. Of course, the key element that attracts students to the centres in question is the educational offer and the quality of education. As Dumitrascu and Serban (2013) note, for most students the most important factor in choosing a university is the specialisation of studies. Also, the reputation of the university, the high quality of teaching methods and excellent career opportunities play an important role in this decision. However, as these authors' research shows, the comfort of living also influences the desire to study in a particular city. This is an additional criterion that is taken into account when comparing educational offers in different cities. In order to assess the logistical aspects in the perception of quality of life in the city, I adopted the gap identification methodology known from the evaluation of logistical customer service. I focused my attention on gap 4, i.e. customer satisfaction. This gap is a comparison between the expectations of the respondents and the logistics service actually delivered. The customer in the sense of my research is the stakeholder in the city's logistics system - the student.

In the theoretical background section, the relationship between a smart and sustainable city as well as resident satisfaction and urban quality of life will be explained. Residents' satisfaction with logistics solutions is discussed through the theory of logistical customer service gaps. The consequence of this approach is the adopted interpretation of the logistical service of city

logistics stakeholders. At this stage, the question arose: how to integrate the residents' (students') satisfaction with aspects of city logistics into an assessment of their quality of life in the city? This is the overarching question in the research conducted. In part of the empirical research, it was detailed to the problem of students' quality of life in university cities.

Answering this main question required the design of a research investigation, which is presented in the methodology section. Gap four of logistical customer service, understood as student satisfaction with logistics solutions in the city, was assessed through the Customer Satisfaction Index (CSI). The developed methodology was verified in a case study involving a review of smart city solutions: Warsaw, Cracow and Poznan. The results of the study are discussed in the results and discussion section.

2. Logistics service as a determinant of smart city development

2.1. The Smart City concept

Smart cities are often understood through the prism of digital cities. This is not a valid interpretation. Undeniably, modern technologies, including Cloud Computing, Internet of Things, Intelligence Artefact, and many others, are solutions applicable to smart cities, however, they cannot be the only criterion for valuing a city's level of intelligence. A smart city is a city that has the capacity to support the development of all its inhabitants. There are many interpretations of the term Smart City. One of them is given by A. Caragliu et al. (2011), stating that a smart city is one in which the development of human and civic capital, as well as transport and ICT infrastructure, require sustainable economic growth and a high quality of life. Such a city is characterised by sound management of natural resources through resource sharing (Caragliu el al., 2011). Hollands (2008), on the other hand, emphasises that the smart city concept aims to develop infrastructure based on modern information and communication technologies. These technologies are intended to support both social and urban development through the involvement of citizens, the introduction of economic solutions and the improvement of management efficiency (Dembińska et al., 2019). A smart city, is also a concept that aims to reduce energy waste and greenhouse gas emissions, thus a city focused on sustainability (Kramarz et al., 2022). There are many related terms that refer to modern urban infrastructure and they are:

- digital city (Yovanof et al., 2009),
- creative city (Hall, 2000; Florida, 2002),
- knowledge city (Carlillo, 2004),
- green city (Zygiaris, 2013).

The aforementioned concepts have common features, but focus differently on technological, social and environmental issues. The concept of smart cities, became widespread in 2007 thanks to an initiative by the European Union, which incorporated it into its policies. It is worth noting that it is a key element of a strategy aimed at effectively tackling social problems such as social inequality, poverty or unemployment. The smart city refers to the comprehensive management of cities, integrating communication technology and knowledge infrastructure. Importantly, this is done while making rational use of natural resources, which coincides with the concept of sustainability(Korenik, 2017; Dembińska et al., 2019). The Smart City concept identifies its six dimensions, including: smart economy; smart mobility; smart environment; smart people; smart governance; and smart living conditions (Kramarz et al., 2022). The first dimension, smart economy, refers to an efficient and technologically advanced economy that emphasises innovative products and the efficient exchange of goods, services and knowledge. Smart mobility refers to the implementation of integrated transport systems within a functioning city logistics system, which are based on the concept of sustainable urban transport. The dimension relating to the environment refers to activities that protect natural assets, which is done, among other things, through the use of renewable energy sources. Smart people refers to high-quality social capital and smart living conditions to a lifestyle lived in a safe city with access to technology. Smart governance refers to the actions of government that enable communities to be involved in changing their environment, as well as creating spaces with a high degree of accessibility to public services.

The transformation of cities to become smart cities is commonly understood through concrete and often measurable economic, environmental and social outcomes that include sustainability goals, as smart city development and sustainability practices overlap (Ang-Tan, Ang, 2022; Baibarac-Duigan, de Lange, 2021; Blasi et al., 2022). A smart city should therefore serve the economic well-being of its inhabitants and the competitive position of the organisation in the market (economic smart outcome), meet the welfare requirements of urban residents (social smart outcome), and must establish a balance in which economic and social needs do not come at the expense of environmental quality, but preferably contribute to it (environmental smart outcome). Furthermore, transforming ordinary cities into smart cities requires investment in social capital and human resources to upgrade traditional technologies (e.g. transport systems) and to develop new and modern technologies (e.g. information and communication infrastructure) (Sakuma et al., 2021).

The mobility of residents, the elimination of traffic exclusion, are the elements of urban logistics that are most often indicated in publications dealing with the Smart City.

In the implemented transport policy of modern cities, the foundation of this concept is the optimisation of the movement of people and cargo within the urban space (Rześny-Cieplińska, 2018, 2020).

2.2. Logistics service versus quality of life in the city

Urban logistics deals with transport (both of people and cargo), storage, organisation of transport networks, municipal management and waste disposal. All these activities are integral to the daily life cycle of the city as an economic, social and cultural space. The definition proposed by the Council of Logistics Management defines urban logistics as the process of planning, executing and supervising flows in a city and takes into account: flows that are recorded within the urban area, flows that are initiated externally and directed to the city, flows that are recorded within the city itself, interacting both externally and internally (Kalbarczyk, 2019). Aspects of city logistics relate to four main areas, which M. Szymczak (2008) classified: storage of goods that constitute urban resources, transport of goods, transport of people, waste and waste disposal.

Logistics solutions in smart cities therefore include not only the use of ICT, data analytics, intelligent transport systems, but also environmentally adapted urban warehouses (eco-hubs), the adaptation of infrastructure to logistics needs, and cooperation between different actors to improve the quality of life by improving logistics solutions in the city. These solutions affect the quality of life of residents and need to be integrated into other smart solutions in the city. Improvements in quality of life as a result of logistics measures include, but are not limited to: efficient management of deliveries, reduction of congestion, reduction of environmental pollution, optimisation of routes, minimisation of delivery times, better use of vehicles and efficient planning of deliveries taking into account residents' preferences. Quality of life is a much broader construct and encompasses many non-logistical aspects of a person's daily life, such as living situation, place of residence, infrastructure, space, sense of security, leisure time, state of the environment, work and income, education and educational institutions. Historically, the concept of quality of life has been linked to ideas of social well-being, environmental quality, poverty, social inequality, social exclusion, social vulnerability and sustainability. Wesz et al. (2023) identify 7 categories of quality of life criteria (Tab. 1).

Table 1.
Quality of life areas and criteria

QoL Dimensions	Urban QoL Indicators
Urban services	Solid waste collection, Water supply, Electricity supply, Internet services, Health-related services (hospitals, health centres, etc.), Education services (schools, nurseries, universities, etc.).
Economy	Employment opportunities, Cost of living (expenses on housing, food, etc.), Existence of professional courses (computers, crafts, hairdressing, etc.), Access to credit (facilitated payment terms in shops and commerce), Variety of commercial and service establishments (markets, shops, restaurants, banks, post office, etc.), Existence of tourist activities.
Culture and reaction	Number of green areas and parks, Quality and maintenance of green areas and parks, Existence of places to take part in outdoor sports, Existence of places for cultural activities (artistic events, museums, theatres, cinemas), Opportunities to take part in free cultural and artistic events, Conservation of historical, artistic, and cultural heritage (buildings, houses, and public spaces).

Cont. table 1.

Urban mobility	Quality of public transport (comfort), Availability of public transport (number of lines and itineraries), Ease of going from one's house to other parts of the city (workplace, study, friends' houses, etc.), Ease of displacement on foot (to carry out daily activities), Quality and location of cycle paths Existence of tourist activities.
Conviviality	Conviviality and interaction with neighbours, Conviviality and interaction with homeless people, Opportunities to participate in the decisions of your own building, Opportunities to participate in community activities (associations, artistic and religious groups, etc.), Respect for cultural, sexual, religious, and political differences, Identification with the neighbourhood and people's pride in living in it.
Security	Feeling of security in public places (sidewalk, street, etc.), Feeling of security when accessing one's building during the day, Feeling of security when accessing one's building at night, Safety for children and teenagers to experience the neighbourhood (walking, playing, etc.), Quality of policing, Quality of public lighting (sidewalks, streets, parks, etc.).
Environmental comfort	Noise pollution, Air pollution (feeling when breathing), Existence of trees on the pavements and in the parks (climate comfort), Cleanliness of public spaces (pavements, streets, parks, etc.), Drainage and sewage system (floods/odours), View from one's apartment window to the outside space (street/courtyard).

Source: Wesz, Miron, Delsante, Tzortzopoulos, 2023, p. 56.

One of the key areas affecting quality of life is the ability to move around the city. It is determined by a number of factors, such as, for example, land use, terrain, prevailing activities (tourist city, industrial city) and many others. It is also important to share the transport linear infrastructure for the movement of people and the movement of goods in a city.

The logistics service of a city according to the theoretical considerations cited will be understood as the range of logistics services that are provided to the city. In contrast, the logistical service of city logistics stakeholders will be understood as the ability of the city's logistics system to respond to the needs of stakeholders in terms of time, reliability, communication and convenience. Thus, in developing the concept of evaluating the logistical service of residents (as key stakeholders of city logistics), I have used the theory of logistical service gaps in this paper.

2.3. Satisfaction as gap of the logistical service to residents

A high quality of life, characterised by satisfaction and positive feelings, is experienced when an individual's resources in this area are not compromised and their needs can be met. In contrast, a person experiences a poor quality of life, as a result of dissatisfaction and negative emotions, when needs and resources are insufficient. The feeling of dissatisfaction that accompanies such a person is associated with incurring psychological costs when one's own needs are met.12 Thus, it is legitimate to use knowledge from customer satisfaction theory to assess residents' satisfaction with the logistical aspects that shape quality of life in a city.

Logistical customer service can be defined as service covering the activities necessary from the receipt of the order from the customer, but also during the manufacture and delivery of the ordered goods. An important aspect is also the carrying out of activities that will eliminate or

preclude errors arising in the execution stages of the order (Sułkowski, Morawski, 2014). In logistical customer service, key elements are identified that form the basis for the description of the logistical customer service process and the selection of metrics for its evaluation. The logistical elements of the customer service process are of particular importance to customers, while the importance ascribed to them by the customer may change, depending on the market segment, the type of products, the forms and types of distribution or the intensity of competition. Customer service is characterised by the following logistical elements (Kramarz, 2014): time, reliability of the implemented processes (punctuality, completeness, fault-free implementation), communication between the service provider and the customer, availability of the offer at the time the customer needs it, convenience, flexibility in terms of time, size and type of offer in relation to the expectations set by the customer.

Customer satisfaction is influenced by many factors related to communication. Among these are the provision of information about the status of the logistics service, including access to information about the order in real time (Sułkowski, Morawski, 2014). Modern IT systems greatly support communication with the customer, making it possible to create analyses, transmit order information or create a current situation on the entire order process (Walasek, 2014). Differentiated modes of transmission improve the quality of service by adapting the way the customer places an order to the customer's preferences and capabilities. All these aspects, analysed so far in the logistics systems of manufacturing, trade, service companies and entire supply chains and networks, have not yet been comprehensively reflected in research on city logistics systems. In such systems, the customer is the city stakeholder. When thinking of citizens as key stakeholders in city logistics, the overriding aim is to take care of their satisfaction. Thus, both the delivery time of the logistics service, its availability, flexibility (understood as alternative and integrated transport systems) as well as reliability, communication and convenience are extremely important factors in city logistics. In the pre-transaction phase of the city logistics stakeholder service, it is necessary to carry out a stakeholder analysis (segmentation - assigning roles), identify stakeholder needs, determine the city's current and planned logistics solutions - policies, investments. Segmentation, which is highlighted as extremely important in the analysis of logistical customer service, can be mapped in the city's stakeholder needs survey. The different stakeholder groups are segments that can be grouped into macro-segments in terms of their roles in the city's smart city development (Kramarz et al., 2022) on the one hand and separated into micro-segments in terms of their detailed behaviours and needs on the other. Students are such a micro-segment in the resident segment. The post-transition phase is geared towards policy implementation, the implementation of solutions, the realisation of investments and, above all, towards meeting the current logistical needs of stakeholders. The post-transaction phase should include maintaining the infrastructure, monitoring stakeholder feedback and encouraging the use of the designed solutions. Given this understanding of the phases of city logistics stakeholder service, a gap assessment can be attempted.

Many authors tend to identify 4 key gaps in customer service, which are shown in Figure 1 (Kramarz, 2014). In the context of logistics, service quality depends on the degree of congruence between customer expectations and the actual parameters of the services provided.

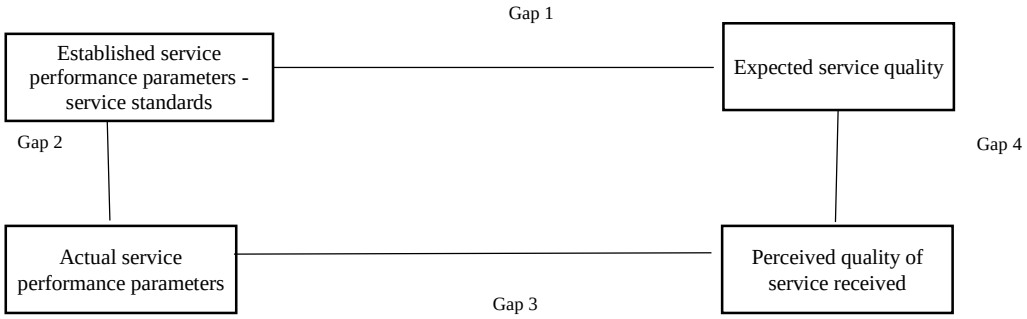

Figure 1. Gaps in customer service.

Source: Kramarz, 2014, pp. 48-50.

Gap 1 represents the difference between the customer's (stakeholder's) expected service quality and the specified service delivery parameters. In practice, this means that there is a gap between the customer's expectations of service quality and what has been planned for delivery. Gap 2 is the discrepancy that occurs at the service delivery stage. This gap is the result of deviations between the service standards set and the service actually delivered. In a city's logistics system, these include, for example, delays of buses, tram trains. The discrepancy between the customer's actual perception of the level of service and the company's perception of the level of service provided is represented by gap 3. Gap 4 describes the customer's satisfaction with the service performance process. The level of customer satisfaction is measured as the difference between the customer's expectations of service and the customer's actual perceived quality of the service provided.

In this paper, I have limited myself to interpreting and assessing the fourth gap due to the objective set.

3. Methodology

Conflicting goals in city logistics can be seen not only between different stakeholder groups, but even within one group, separate expectations can be seen. An example of this is the desire of cities to reduce external transport costs by reducing road transport in the city, with the aim of reducing pollution, noise, vibration and land occupancy. The benefits indicated are assessed by residents in the category of quality of life enhancing factors (clean air, safety) as beneficial and at the same time as negative, due to the reduction in mobility of residents. Due to these differences in the perception of logistical solutions, in this paper I adopted a methodology to adjust the rank of logistical criteria shaping quality of life by residents. The assessment of

logistical service gaps, according to the theory of logistical service gaps, requires the selection of an identification methodology for each gap separately. In the research presented in this paper, gap four was assessed.

In this paper, I analyse the impact of logistics solutions on the quality of life of residents (students). Logistics solutions have been assigned to three areas according to the assumptions in Table 2.

Table 2.
Factors examined in the characterisation of the city's logistics system

Area analysed	Factors in the area
1. Sustainable urban transport - ecology and tools to combat congestion	Characteristics of public transport: buses, trams, trains, cars Car sharing, Park&Ride solutions Micromobility: scooters, city bikes, mopeds Others - banning lorries from the city centre, paid parking, segregated zones, etc.
2. Infrastructure and safety improvements	Roads - technical condition Bus lanes Stops Freight routes Car parks
3. Communication, computerisation and automation of services	Information systems at bus stops Mobile applications e-tickets

Source: own work.

The areas indicated in Table 2 were analysed in three case studies. The case studies included:

- content and information analysis of intelligent transport systems operating in three selected cities,
- surveys targeting students living in the three selected cities. The survey questionnaire was the same in all cities. Respondents were asked to rate the elements indicated. First, they had to distribute a total of 100 points among all the elements, depending on their impact on the quality of life in the city. Respondents then rated each city on a five-degree Likert scale in terms of the established criteria.
- the calculation part involving the determination of the resident(student) satisfaction index for the logistical dimension of quality of life in the city. The calculation was based on a formula to determine the CSI% (3), which required the determination of the resident's satisfaction index CSI (1) and the maximum index CSImax (3). In accordance with the methodology for determining quality maps, which is a graphical deepening of the CSI, those elements were identified that significantly shape quality of life, but reach too low values in individual cities. The maps themselves are not included in the paper.

$$\text{CSI} = \sum_{i=1}^{n} W_i * C_i \quad (1) \quad \text{CSI} = = {}_{\max}\sum_{i=1}^{n} W_i * C_{max} \quad (2) \quad \text{CSI} = {}_{\%}\frac{CSI}{CSI_{max}} * 100 \quad (3)$$

where:

i – number of the element,

n – number of all elements,

w – weight of the element,

c – rating of the element.

The survey covered three cities: Warsaw, Cracow and Poznan. In Poland, there are 369 higher education institutions located in 97 cities. They have 1.3 million students, 235,500 of whom study in Warsaw alone. Analysts from the Polish Economic Institute developed an index of the academic nature of cities and on this basis indicated that, apart from the capital, the most academic cities in Poland are Cracow, Poznan and Wroclaw. The index is based on seven criteria: prestige, the situation of graduates on the labour market, innovation, scientific potential, scientific efficiency, study conditions and the internationalisation of universities. The model they built shows that academia influences the socio-economic development of cities by almost 80% (Raport: Po maturze). The analysts of the Polish Economic Institute also created a soft model examining the impact of the academisation of cities on socio-economic development, which was described using 17 indicators extracted from the Local Data Bank of the Central Statistical Office. These indicators referred both to the economic situation, demographics, living conditions or city resources. After a detailed analysis of all variables describing academic and socio-economic development, the model parameters were estimated, which showed that 78% of the socio-economic development of cities is determined by their academic performance. Among Polish cities, Warsaw tops the ranking, being at the same time the second city in Europe in terms of the number of students, with 235,000 people. It is ahead of Rome, Madrid and Barcelona, among others, and on a European scale, only Paris has more students. For this reason, I chose Warsaw for the study, as well as two cities from the leading Polish cities: Cracow and Poznan. The study involved 245 students from Warsaw universities, 238 students from Cracow universities and 233 students from Poznan universities. Thus, this is not a statistically significant sample, but it is a pilot study that indicates a certain trend that is worth analysing further in the future. The survey was conducted online.

4. Results and discussion

4.1. Characteristics of city logistics systems

In the three cities analysed, a number of activities are being implemented to improve the conditions of everyday life in the city. These initiatives are mainly investments in infrastructure development and the digital layer, which in effect translate into an increase in the quality of services provided by the city, including e-services. At the same time, this type of investment is accompanied by many activities aimed at building human and social capital, including involving citizens in co-governance.

Using innovative tools, these measures are improving the quality of life of the inhabitants, thus bringing the capital closer to a city that is developing intelligently. In 2024, the IMD ranked Warsaw 38th in the ranking (out of 142 cities included in the ranking), and it is worth noting that Warsaw is gradually gaining a higher position in the ranking. Varsovians rated their city highly in terms of access to timetables and online travel planning and the convenience of purchasing public transport tickets (as many as 71.1% of respondents rated this parameter positively). They were equally satisfied with public transport itself, with almost two-thirds of respondents giving this mark.

The public transport network in Warsaw is made up of buses, trams, underground and Rapid Urban Rail trains. In addition, it is possible to travel by Mazovia Railways and Warsaw Commuter Rail on the basis of WPT tickets, starting from daily tickets. Using Warsaw Public Transport (WPT), you can quickly and comfortably travel around the entire city and reach many of Warsaw's neighbouring towns and cities. The easiest way to plan your journey is by using the connection search engine. WPT vehicles can be used on the basis of tickets: time tickets (20-minute, single 75-minute, single 90-minute, group 75-minute), short-term tickets (daily, 3-day, weekend, weekend group) and long-term tickets (30- and 90-day). Temporary and short-term tickets come in the form of a cardboard box, while long-term tickets are encoded on the Warsaw City Card, among others. Micromobility is also developing intensively in Warsaw. Veturilo - is one of the largest urban bicycle systems in Europe. It constitutes an important element of Warsaw's transport ecosystem. Thanks to the development of bicycle paths, the network of which amounts to over 500 km in Warsaw, the system enables efficient access to various parts of the city, providing an alternative to means of public transport.

The complexity of the public transport structure in the metropolitan area poses challenges to the city administration. In order to minimise the likelihood of errors in the organisation of public transport, a separate entity called the Public Transport Authority (Zarząd Transportu Publicznego - ZTM) was established. It is a body superior to the city operators, whose task is to organise and supervise public transport in the Warsaw agglomeration area and neighbouring municipalities (ZTM, 2022). The Public Transport Authority (ZTM) sets the tasks for the modernisation change of the rolling stock owned by the transport operators and coordinates

them. Changes to the rolling stock occur quite slowly due to the course of tender competitions conducted in accordance with the Public Procurement Law (Journal of Laws 2019) and EU regulations. Urban buses are an example - only 9% are powered by environmentally friendly alternatives.

The Public Transport Authority of Cracow (ZTM) operates in Cracow. Passengers have the opportunity to purchase the Cracow City Card. Tickets can be purchased at PSPs (Passenger Service Point), in partner applications, mobile applications or ticket vending machines. From June 2022, Cracow residents can travel by hydrogen-powered bus. It is also worth mentioning Rapid Urban Transport and the "Feasibility study for fast, collision-free rail transport in Krakow". As a result of cooperation between ILF Consulting Engineers Poland and the Municipality of Cracow, a study was produced which recommends the Premetro project for Krakow. The Premetro, a type of public transport system that provides an intermediate solution between the traditional tram and underground. Construction of the tunnel is planned to start in 2029. In 2013, Cracow was the third most polluted city in Europe according to the European Environment Agency. However, since then the city has made ambitious efforts to improve air quality and reduce urban chaos. For the past two decades, Cracow has been working continuously to reduce pollution by modernising public transport and developing green spaces. In 2019, a ban on solid fuels was introduced as an important step in the fight against pollution. The city has become a leader in Europe with the introduction of the Clean Transport Zone and is part of the trend towards zero-emission public transport. Every space that has been reclaimed is now dedicated to pedestrians and cyclists, reflecting the vision of a city where air quality and public space are a priority. Cracow has 21,641 paid parking spaces.

The Public Transport Authority of Poznan (ZTM Poznan) plays a key role in the organisation and supervision of the city's public transport system. Public transport was used by 226.8 million passengers in 2022. The data shows that there is an upward trend in the aspect of the use of public transport by the inhabitants of this city. The city of Poznan is consistently developing its transport infrastructure with the aim of creating an efficient, comfortable and modern public transport system. It invests in new routes and the modernisation of existing ones, introducing innovative solutions such as quiet green tracks, bus lanes, two-way trams, hybrid buses and urban bicycle systems. The city has undertaken development activities based on the Smart City concept, creating the Smart City Poznan model. Smart City projects are subject to monitoring. To this end, a web-based platform with data is being developed, enabling the continuous presentation of indicators, dynamics and effectiveness of the innovations introduced. This will enable the city to track and evaluate the effectiveness of various solutions, which will allow it to continuously improve its infrastructure and services for residents. Poznan also sees a significant increase in the number of registered vehicles (by 9.3 thousand in 2022). Too many residents choose individual means of transport over public transport, which may be related to the need for greater mobility and convenience in travel. Therefore, there is a need to continuously improve and adapt the public transport offer in order to attract more passengers and encourage them to use this environmentally friendly mode of transport.

Table 3.
Characteristics of selected university cities in terms of smart urban logistics

Area analysed	Criterion characteristics	Warsaw	Cracow	Poznan
Students as stakeholders in city logistics	Number of universities (public and non-public) Number of students (including those living in dormitories, in private accommodation, living in the city, commuting to universities)	69 universities 235,500 students (academic year 2022/2023)	23 universities 129,360 students (academic year 2022/2023)	24 universities 112,000 (2024) students (academic year 2022/2023)
Sustainable urban transport - ecology and tools to combat congestion	Characteristics of public transport: buses, trams, trains, cars Car sharing, Park&Ride solutions Micromobility: scooters, city bikes, modpeds Others - paid car parks, segregated zones etc.	Integrated public transport - Public Transport Authority (ZTM) 58 electric buses, (25 are hydrogen fuel cell electric buses, Autosan Sancity 12 LFH tested, one of the greenest buses on the market), metro city bikes, electric bicycles, Park & Ride and Kiss & Ride systems	Integrated public transport - Public Transport Authority of Cracow Municipal Transport System Hydrogen-powered buses, Premetro rapid urban railway (plan 2029) Park & Ride system Clean Transport Zones long-term bike rental "LajkBajk", Park-e-Bike electric bike rental	Integrated public transport - Public Transport Authority (ZTM) Hybrid buses Hydrogen -powered buses (plan) Park & Ride system 337 Quiet, green tracks, city bikes, Hop&Go micromobility areas two-way trams, hybrid hire of electric bicycles (Bolt)
Infrastructure and safety improvements	Car parks Cycle paths Bus lanes	60,000 paid parking spaces 547.4 km of cycle paths 108.8 km of streets with contraflow (including 4.8 km of contraflow lanes) 78.6 km of footpaths and cycle paths 53.3 km of cycle lanes More than 68.5 km of dedicated lanes for public transport	The number of parking spaces has 21,641 paid parking spaces Cycle paths with separated cycling infrastructure of almost 250 km length More than 30 km of bus lanes	Number of parking spaces 14,201 spaces Number of parking meters 792 Cycle paths - nearly 400km 23 km of bus lanes

Cont. table 3.

Communication, computerisation and automation of services	Information systems at bus stops Mobile applications e-tickets	Personalised Warsaw City Card, Cycling map - Cycling Warsaw intelligent transport management systems, Passenger Information System SIP, mobile applications, intelligent street lighting, mobile application Warsaw 19115	Cracow City Card Intelligent Transport System (ITS), Cracow Municipal Transport Passenger Information System, DAROPLAN cycle map, Cracow Contact Centre application	PEKA (Poznan Electronic Agglomeration Card) Open data platform, Passenger Information Panel System (TIP) Intelligent Transport System (ITS) Interactive Cycling Map of Poznan, Smart Poznan Application

Source: own work.

All three cities are characterised by logistics solutions that fit into the Smart City concept. Warsaw has the most developed investments in this area. This applies to the availability of various means of urban transport, their integration, micromobility projects and the information sphere.

4.2. Identification of gap 4 – assessing differences in perception and evaluation of logistics elements in building student satisfaction with logistics service in the cities studied

Two assumptions were made in the research, taking into account the results of the literature. Assumption one, that the quality of life of residents is a key dimension of a smart city and assumption two, that logistical aspects significantly determine the quality of life. In line with these assumptions, a satisfaction survey was conducted on the logistical service elements of the residents (gap 4 of logistical service). The research was narrowed down to the problem of residents' mobility, which determine their mobility. In order to identify the gap 4 in logistical service for city residents, the same survey questionnaire was used in all case studies. As indicated in Table 3, all three cities have similar characteristics of the logistics system and are characterised by a metropolitan landscape. They are historic cities with a simultaneous role as an academic centre. It was therefore interesting in this context to compare the logistical elements shaping the quality of life of the inhabitants of these cities.

Table 4 shows the average results obtained in the survey conducted and the customer satisfaction index (CSI) determined from them.

Table 4.
Customer satisfaction index for logistics service elements in the Warsaw, Cracow, and Poznan

Elements	Warsaw			Cracow			Poznan		
	Average weight	**Average rating**	**Weighted rating**	**Average weight**	**Average rating**	**Weighted rating**	**Average weight**	**Average rating**	**Weighted rating**
Availability of alternative modes of transport	12,74	4,45	56,69	9,71	4,41	42,82	14,41	4,26	61,46
Travel safety	9,50	4,26	40,51	7,56	3,50	26,46	8,15	3,56	28,99
Travel time	12,47	3,74	**46,58**	11,68	3,35	**39,15**	13,85	3,79	**52,56**
Integration of transport systems	7,65	4,09	31,26	8,65	4,26	36,88	8,76	4,21	36,86
Pedestrian infrastructure	7,06	4,35	30,73	10,38	4,21	43,67	10,21	4,38	44,73
Communication, computerisation and automation of services	10,74	4,09	43,89	11,29	4,44	50,16	7,94	4,09	32,47
Cost of travel	6,74	3,32	22,38	10,56	4,18	44,10	7,68	4,29	32,96
Punctuality and regularity	13,09	3,53	**46,19**	13,38	3,03	**40,54**	12,62	2,94	**37,11**
Infrastructure for micro mobility	11,62	4,29	49,86	6,76	4,09	27,66	6,62	4,12	27,25
Environmental friendliness	8,41	4,29	27,96	7,74	3,74	28,89	6,82	4,29	29,30
CSI	396,053			380,318			383,695		
CSImax	500			500			500		
CSI%	79,21			76,06			76,74		

Source: own work.

The results obtained by the cities are good, however, they fall below 80%. In the table, bold italic text indicates results falling in the bottom right quadrant of the quality maps (the graphical version of which is not included in the paper), i.e. those which need to be improved in the cities in the first place due to their high importance for the respondents (average weighting above 10) and too low rating (below 4). Warsaw received the highest score and this is in line with Warsaw's position in both national and international rankings. Cracow and Poznan scored very similarly. When analysing the respondents' key preferences, it was assumed that for the number of elements analysed the indicated rank must be above average (a value above 10 was assumed). In Warsaw, these preferences included: Punctuality and regularity (13.09), Availability of alternative means of transport (12.74), Travel time (12.47). Infrastructure for micromobility (11.62), Communication, computerisation and automation of services (10.74), in Cracow: Punctuality and regularity (13.38), Travel time (11.68), Communication, computerisation and automation of services (11.29), Travel cost (10.56), Pedestrian infrastructure (10.38), while in Poznan: Availability of alternative means of transport (14.41), Travel time (13.85), Punctuality and regularity (12.62), Pedestrian infrastructure (10.21). Respondents in all three cities rated punctuality and regularity very low, in Warsaw (3.53), in Cracow 3.03), in Poznan only (2.94) and travel time: in Warsaw (3.74), in Cracow (.35) and in Poznan (3.79). These are results which, with the high importance of these two elements for the respondents, contribute to the low satisfaction rate with logistics services in the surveyed cities. In Warsaw, respondents rate the availability of alternative means of transport very high (4.45), which is also important to them, as well as the pedestrian

infrastructure (4.35), which, for students studying in Warsaw, was not shown to be an important factor in building their satisfaction (weighting only 7.05). The same respondents are clearly dissatisfied with the cost of travel (3.32) however, this factor is not a key factor for them either (weight of 6.74). In Cracow, respondents gave the highest rating (4.44) for communication, computerisation and automation, which is of high importance to them, and for the availability of alternative means of transport (4.41), which is of slightly lower importance. In addition to punctuality, respondents gave a low rating to Travel Safety (.5), which, however, is not a priority for them. In Poznan, respondents gave the highest rating (4.38) to pedestrian infrastructure, which is an important satisfaction factor for them. As in Cracow, Travel Safety was rated low (3.56) and is also not a priority for respondents.

The results obtained are interesting both on the level of recommendations for each city and in comparing similarities indicating general trends, expectations and direction for improving the logistics systems of other university cities.

Indicating recommendations for individual cities, according to the results marked in Table 3, all three cities should improve both travel times and punctuality and regularity. The second factor in particular is a major problem that discourages many people from using public transport. Due to the repetition of these two elements in the results obtained in all three case studies, it can be concluded that other academic cities should also improve these elements. From the point of view of the group of respondents selected for the study, the results in each city will depend on the degree of concentration of the city, the distance between the university(s) and the academies and other housing, the location of cultural, leisure and sports venues, the organisation of public space and the location of retail and service outlets. All three cities surveyed have dispersed development and large distances between the indicated points, meaning that public transport is more important than micromobility and pedestrian solutions. As the distance between these nodes decreases, the importance of the quality of pedestrian paths and micromobility solutions increases. All three cities surveyed are investing heavily in solutions to enhance sustainable mobility, as indicated in Table 2. The length of cycle paths is increasing every year. At the same time some cities, including Poznan (year 2021) are abandoning the urban bicycle system, which is being replaced by companies offering electric bicycle rentals. Such solutions are observed in all three cities. Micromobility and its development should also be looked at from a safety perspective. Studies carried out in 2022 show an increase in accidents involving cyclists in all three cities compared to 2021, however, analyses from 2018 onwards are not so clear (Table 5).

Table 5.
Number of accidents involving cyclists

	2018	2019	2020	2021	2022	Population	Number of accidents / 1,000 inhabitants
Warsaw	1019	961	917	887	917	1794166	0,51
Cracow	436	483	453	465	536	780796	0,69
Poznan	347	317	327	314	346	530464	0,65

Source: Study based on the Report Cities for Cyclists 2023: https://www.centrumrowerowe.pl/blog/miasta-dla-rowerzystow/?srsltid=AfmBOopBrxgzRF7hCO_iRIZaG25wEoa1PpNPkRfVWoXDf2BI8f9YgJen

Polish towns and cities undoubtedly aim at the creation of a cycling friendly and more widely for micromobility, which is indicated by an increase in funds devoted to development and maintenance of cycling infrastructure. The implemented projects underline not only the increase in cycling routes but also the improvement in safety in terms of broadly understood micromobility.

5. Conclusions

The sustainable development of urban flows translates into improved traffic flow, increased convenience for residents in terms of travel, and a higher standard of living in the urban area. It should be emphasised that it is also crucial to reduce emissions of air pollutants, reduce noise pollution, shorten travel times, increase road safety and limit the destruction of road infrastructure, which is an important part of the urban transport system. The development of urban logistics is inextricably linked to technological progress, which is influencing the evolution of the area. This understanding of sustainable urban flows fits in with the Smart City concept and is adopted in the paper as the leading one.

As pointed out in the research, a key stakeholder in city logistics is residents. In university cities, students play an important role in this stakeholder group. In order to assess the differences in students' perceptions of the elements of logistic customer service in the cities of Warsaw, Cracow and Poznan, a research procedure was applied in which respondents' opinions were collected using a survey questionnaire. The results obtained indicated two priority elements of logistic service, namely travel time and punctuality and regularity.

The research conducted is a pilot study. A limitation of the research conducted is the number of respondents. The results obtained point to directions for further research. It is certainly necessary to expand both the research sample and the cities included in the analysis. At the same time, the study of one group of stakeholders is also a limitation for inference. It is interesting to compare the logistical service needs of students with other resident segments and also the integral results obtained for the residents group with other stakeholder groups. Further studies will be dedicated to the other stakeholder groups. It is also a limitation that the

research focuses on gap four to the exclusion of the other gaps. Each of the gaps in the city's logistics service requires the shaping of a separate methodology. Further research will be directed towards developing a methodology to assess the remaining gaps.

References

1. Ang-Tan, R., Ang, S. (2022). Understanding the smart city race between Hong Kong and Singapore. *Public Money & Management, Vol. 42(4),* pp. 231-240.
2. Baibarac-Duignan, C., de Lange, M. (2021) Controversing the data filed smart city: Conceptualizing a 'making-controversial' approach to civic engagement. *Big Data & Society, Vol. 8(2),* pp. 230-252.
3. Blasi, S., Ganzaroli, A., De Noni, I. (2022). Smartening sustainable development in cities: Strengthening the theoretical linkage between smart cities and SDGs. *Sustainable Cities and Society, Vol. 80,* pp. 141-165.
4. Caragliu, C. Del Bo, Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology, Vol. 18(2),* pp. 112-138.
5. Carrillo, F.J. (2004). Capital Cities: A Taxonomy of Capital Accounts for Knowledge Cities. *Journal of Knowledge Management, vol. 8(5),* pp. 28-46.
6. Dembińska, I., Tundys, B., Frankowska, M., Malinowska, M.(2019). *Smart Logistics*. Edu-libri.
7. Dumitrscu, O., Serban, A. (2013). Present state of research regarding university choice and attractiveness of the study area. *Procedia Economics and Finance.* 6th International Economic Conference of Sibiu 2013 Post Crisis Economy: Challenges and Opportunities, IECS 2013, pp. 252-258
8. Florida, R. (2002). *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community, and Everyday Life*. New York: Basic Books.
9. Hall, P. (2000). Creative Cities and Economic Development. *Urban Studies, vol. 37(4),* pp. 639- 649.
10. Hollands, R.G. (2008). Will the Real Smart City Please Stand Up? *City: Analysis of Urban Trends, Culture, Theory, Policy, Action, Vol. 12(3),* pp. 110-115.
11. https://isportal.pl/smart-city-index-2024-inteligentny-transport-w-warszawie-doceniony/, 20.10.2024.
12. Kalbarczyk, M. (2019). City logistics as an element to improve the management of a city's logistics system. *Materials Management and Logistics, Vol. 10,* pp. 238-252.
13. Korenik, A. (2017). Smart City jako forma rozwoju miasta zrównoważonego i fundament zdrowych finansów miejskich. *Ekonomiczne Problemy Usług, Vol. 4*, pp. 166-178.

14. Kramarz, M. (2014). *Elementy logistyczne obsługi klienta w sieciach dystrybucji*. Warszawa: Difin.
15. Kramarz, M., Dohn, K., Przybylska, E., Jonek-Kowalska, I. (2022). *Urban Logistics in a Digital World. Smart Cities and Innovation*. Switzerland: Palgrave Macmillan.
16. Lebrument, N., Zumbo-Lebrument, C., Rochette, C., Roulet, T.J. (2021). Triggering participation in smart cities: Political efficacy, public administration satisfaction and sense of belonging as drivers of citizens' intention. *Technological Forecasting and Social Change, Vol. 171(4),* 120938, pp. 1-29.
17. Oliveira, L., Araujo, G., Kopperschmidt de Oliveira, I. (2019). How to explain the location of logistics warehouses from the urban quality-of-life index and the local supply index? *WSB Journal of Business and Finance, vol. 53(2),* pp. 15-21.
18. *Program zrównoważonej mobilności do 2026*, https://nowy.bip.um.warszawa.pl/web/prezydent/-/zarzadzenie-nr-621/2024-z-2024-03-27, 20.10.2024.
19. *Raport "Po maturze"*, https://www.pomaturze.pl/news/26+most+academic+cities+in+poland/1171/, 10.10.2024.
20. *Report Cities for Cyclists 2023*, https://www.centrumrowerowe.pl/blog/miasta-dla-rowerzystow/?srsltid=AfmBOopBrxgzRF7hCO_iRIZaG25wEoa1PpNPkRfVWoXDf2BI8f9YgJen, 12.10.2024.
21. Rześny-Cieplińska, J. (2018). Strategie logistyki miejskiej wobec koncepcji Smart City na przykładzie miast polskich i zachodnioeuropejskich. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, Vol. 505,* pp. 474-475.
22. Rześny-Cieplińska, J. (2020). Kierunki rozwoju logistyki miejskiej – aspekty organizacyjne. *Gospodarka Materiałowa i Logistyka, Tom. 5*, pp. 11-18.
23. Sakuma, N., Trencher, G., Yarime, M., Onuki, M. (2021). A comparison of smart city research and practice in Sweden and Japan: Trends and opportunities identified from a literature review and co-occurrence network analysis. *Sustainability Science, Vol. 16(6),* pp. 1777-1796.
24. *Smart City Poznań*, www.poznan.pl/smarcity, 8.10.2024.
25. Stec, S. (2020). The role of innovation in urban logistics on the example of Rzeszów. In: E. Szymańska, K. Michalski (eds.), *Economics and Organization of Logistics, Innovation in logistics, vol. 4(4),* pp. 77-89.
26. Sułkowski, Ł., Morawski, P. (2014). Obsługa Klienta W Procesach Zarządzania Logistycznego. *Przedsiębiorczość i Zarządzanie*. *Tom XV, zeszyt 5*. Łódź: Social Academy of Sciences, pp. 202-205.
27. Szymczak, M.(2008). *Logistyka miejska*. Poznań: Academy of Economics in Poznań.
28. Walasek, J. (2014). Logistyczna obsługa klienta na przykładzie operatora logistycznego. *Zeszyty Naukowe Politechniki Śląskiej, Seria Transport, z. 82,* pp. 281-282.
29. Wesz, J., Miron, L., Delsante, I., Tzortzopoulos, P. (2023). Urban Quality of Life: A Systematic Literature Review. *Urban Science, Vol. 7(2),* pp. 56-68.

30. Witkowski, J., Kiba-Janiak, M. (2012). Correlation between City Logistics and Quality of Life as assumption for referential model. *Procedia - Social and Behavioral Sciences, vol. 39,* pp. 568-581.
31. Yovanof, G.S., Hazapis, G.N. (2009). An Architectural Framework and Enabling Wireless Technologies for Digital Cities & Intelligent Urban Environments. *Wireless Personal Communications, vol. 49(3),* pp. 445-463.
32. *Zarząd Transportu Miejskiego w Warszawie*, https://www.ztm.waw.pl, 20.10.2024.
33. ztp.krakow.pl/transport-publiczny/komunikacja-miejska/buy-bilet-kmk, 7.10.2024.
34. Zygiaris, S. (2013). Smart City Reference Model: Assisting Planners to Conceptualize the Building of Smart City Innovation Ecosystems. *Journal of the Knowledge Economy, vol. 4(2),* pp. 220-221.