

## Article

# Multimodal Transport in the Context of Sustainable Development of a City

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**Abstract:** Multimodal freight transport in cities is a complex, valid, and vitally important problem. It is more seldom underlined in scientific studies and included in cities' strategies that devote more attention to passenger transport than freight transport. The increased utilization of multimodal transport matches current transport policy and at the same time, it is one of the most important challenges put before cities striving to achieve sustainable development. In this case, the paper embarks upon the problem of relations between multimodal transport development and the sustainable development of the cities. The objective of the paper is an analysis of the impact of the selected city of the Upper Silesian metropolis on the development of multimodal freight transport and an assessment of the impact of the development of multimodal transport on the sustainable development of the cities of the Upper Silesian metropolis. The authors developed three research questions in order to implement the adopted objective. The process of looking for the answer included four stages. Within the first and second stages, the literature studies and experts' research allowed for identifying key factors of the multimodal transport development that a city may have an impact on. In the third stage, the research was two-fold and was based on a questionnaire and scenario analysis. Due to the individual character of each of the cities, scenarios were developed for Katowice, being the main economic center of Upper Silesian and Zagłębie Metropolis. As a result of the research, factors have been identified that must be included in a strategy of a city that strives for sustainable development. The last stage of the research focused on the initial concept of the multimodal transport development impact assessment on sustainable development of the cities. Conclusions developed at individual stages allowed for answering the research questions.



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**Keywords:** multimodal transport; city's freight transport; sustainability; green city

## 1. Introduction

The idea of sustainable development based on taking into account not only economic, but also environmental and social aspects, is a very important factor shaping modern and future transport systems. This is the result of adopted guidelines recorded in the European and national strategic documents [1,2]. Freight transport is an area that is credited with a very large share in generating external transport costs [3]. Thus, in recent years, special attention has been paid to it as a problematic area, which is a great challenge and, at the same time, necessary to modify in terms of its sustainability. In particular, road transport is indicated as the aspect which has the largest share in the aforementioned costs, while in Poland it internalizes the external costs it creates in only 50% [4]. For comparison, in the case of rail transport, which generates significantly lower external costs, carriers paying in rates for access to infrastructure almost completely internalize their external transport costs [4]. One of the ways that fits well with the concept of sustainable development is the creation and development of multimodal freight transport chains.

Transport is a basic element of functioning, both on the national and city scale. The flow of goods in the city has attracted more attention, but still, when considering transport

problems in the city, the focus is on passenger transport. This may be a result of the belief that freight transport plays less important role in the whole transport system of a city [5]. However, although freight transport operations in the city account for only 20–30% of road traffic, they even account for 50% of the air pollution emissions in the city (depending on the considered pollution) [6]. If the urban flow of goods refers to the concept of multimodal transport, an even greater gap in this respect is visible. Freight transport in the cities is perceived from the standpoint of “the last mile” transport mostly; however, wider relationships between the multimodal transport and the sustainable development of the cities are recognized to a lesser extent. This problem is also underlined by other researchers engaged in urban logistics. Okyere, Yang, and Zhan attempted to reduce the cognitive gap by analyzing the impact of multimodal transport strategy concepts on the promotion of sustainable management of urban logistics [7]. However, De Sousa and Moreira link the problem of mobility in the cities with the problem of multimodal freight transport in their works. They sustain that new tools are needed to help the design of innovative business models and policies, and the change of habits and behaviors. They visualize urban logistics as a multi-stakeholder, multi-criteria, and multimodal mobility dynamic system [8]. Such perception of the urban logistics identifies new research directions, including the problem undertaken by the authors concerning the impact of the city on the development of multimodal transport and impact of the multimodal transport development on the sustainable development of the cities. Nemoto, Browne, Visser, and Castro also notice this two-fold dependence and create frameworks for future research related to intermodal transport in the context of urban logistics [9]. However, in their research assumptions, the authors do not engage with the problem of sustainable development of the cities. They show relatively low interest in the problem of freight transport by the policy of the cities comparing to strong emphasis put on this problem by the European Union (EU) policies. Multimodal transport, meaning transport of passengers or freight using two or more means of transportation [10], is equated with long-distance transport and mostly with out of town areas. However, for at least two reasons it can be concluded that there is a relationship between multimodal transport and the city and its sustainable development. First of all, it should be acknowledged that there are factors on the city side (apart from factors on a macro scale) that will affect the directions of development of the freight transport system in the city. Secondly, it should be noted that the aforementioned “last mile” transport can be a part of the entire multimodal transport chain. Additionally, the infrastructure used in the transport, both linear and point-to-point, also appears in urban areas. This relationship can also be indicated in the cited publications. Currently published studies do not answer the questions asked in the paper by the authors:

- How can the city influence the development of multimodal transport? (Q1)
- How does freight transport fit into the objectives and pillars of sustainable city development? (Q2)
- How to assess the impact of multimodal transport development on sustainable city development? (Q3)

The adopted concept of studying the city’s impact on the development of multimodal freight transport and, on the other hand, indicating the impact of the development of multimodal transport on the sustainable development of the city requires an analysis of both the objectives and scopes included in the pillars of sustainable development in terms of freight transport.

The authors adopted as the research objective an analysis of the impact of the selected city of the Upper Silesian metropolis on the development of multimodal freight transport and an assessment of the impact of the development of multimodal transport on the sustainable development of the cities of the Upper Silesian metropolis. Such a research problem develops current studies and shows a new approach that explores dependencies between assets of the sustainable development of the cities and the multimodal transport features. The authors have widened the research methodology adopted by Nemoto, Browne, Visser, and Castro [9]. The research process was multi-stage. The authors performed research in

280 Polish cities, and by using regression analysis and clustering, they identified the degree of inclusion of the freight transport problem, including multimodal transport, in the strategies of the cities, a fact which is related to the concept proposed by Nemoto, Browne, Visser and Castro [9]. Moreover, they developed multimodal transport development scenarios on the selected case study, i.e., Katowice. This part of the research was implemented using experts' methods.

Katowice is the largest city of the Silesian Province and its capital. It belongs to the Upper Silesian and Zagłębie Metropolis—the largest one in the country from the population standpoint. Katowice is one of 44 large urban centers in Poland that are especially endangered by the climate changes effects, where the conditions resulting from inherent city features, neighborhood, historical processes, and development dynamics may additionally escalate the threats. The city is located within nodal zone of the Upper Silesian Metropolitan Area, in the Katowice subregion (according to NUTS classification—Nomenclature of Territorial Units for Statistics). The area includes the node of the European transport corridors East–West and North–South (Corridor III: Berlin/Dresden–Katowice–Kiev and Corridor VI: Gdańsk–Katowice–Vienna/Bratislava). Moreover, Katowice is located along the axes of main international rail freight corridors (RFC): RFC5 Baltic–Adriatic, RFC 8 North Sea–Adriatic, and RFC 11 “Amber”. This all means that Katowice is identified as one of the map points that generate the most freight traffic and where this traffic is directed to. This significantly affects development of the city and also represents an important problem related to road throughput. Katowice also has dedicated International Airport Katowice-Pyrzowice that comes second in the freight transport in Poland. In the context of freight flow, the access to railway transport and inland navigation, due to proximity of the Silesian Logistic Centre and Gliwice port (15 km), is also important for the city. From this perspective, the geographical conditions, inclusion of the pillars of sustainable development into the city strategy, and the option to link different branches of transport make Katowice a basis on which to track the dependencies given in the research questions.

In the second section, the paper objective and research questions necessitated studies oriented at the identification of factors affecting multimodal transport development and pillars of the sustainable development of cities. In this context, inclusion of freight transport, including multimodal transport, in the strategies of cities was analyzed. The performed literature review strengthened the research gap presented in the introduction and is the premise upon which the research methodology discussed in Section 3 was developed. Section 4 presents the research results and discussion of the results obtained based on four stages given in the research methodology.

Identification of factors in individual perspectives of sustainable development, assessment of key factors and the concept of creating scenarios, and how to interpret them are stages that can be acknowledged as a universal procedure for testing the city's impact on the development of multimodal transport. The final test was conducted in the city of Katowice. This research idea results from seeking an answer to the question of what determinants of multimodal transport development should be included in the city's strategy, so that the city falls within the concept of sustainable development.

## 2. Theoretical Background

### 2.1. Pillars of Sustainable City Development

In recent years, cities became the subject of research for scientists representing various areas: geography, urban planning, sociology, economy, and logistics. This has resulted in a lack of an unambiguous definition of the city concept. The city is considered a complex system with its own economy, culture, infrastructure, resources, and relationships connecting various stakeholders [11]. The city is also defined as a large and permanent human ecosystem which provides a lot of services and opportunities to its citizens [12], or as a node (economic, political, administrative, communication) that connects diverse networks, thanks to which a modern society is functioning [13]. The city, in accordance

with an approach of the economic sciences, is also a place of conducting economic activity and a wide outlet market [14].

A city, as a unit composed of many different elements between which there are various types of relations functioning in a specific area, in a specific environment, should be treated as a dynamic, functional whole, and therefore as a system, and more specifically a territorial social system [15]. According to Szoltysek, a broad look at the concept of the city is evident in the definition presented in the European Charter for the Safeguarding of Human Rights in the City [16], according to which the city is a shared space, belonging to the community residing within it, having the right to guarantee its conditions of political, social and environmental fulfilment, while assuming solidarity duties [17]. However, according to Kiba-Janiak, this definition should be supplemented with a local government administration body and an auxiliary unit supporting it, whose task is to guarantee the city's community in the above-mentioned conditions [18]. Cities carry out their tasks based on a development strategy containing a mission, vision, and main long-term goals. The city's development strategy should holistically cover various urban spheres, so as to improve the city's quality of life and competitiveness as a result of its implementation.

The presented guidelines also apply to the broadly understood objectives resulting from the concept of sustainable development of the city. In its implementation, a significant role is assigned to public entities and local authorities, and to cooperation with other stakeholders of the city [19,20].

The concept of sustainable development, understood as a process aimed at satisfying the developmental aspirations of the present generation, in a way that enables these aspirations to be achieved by subsequent generations, is based on the main pillars, which, in literature, have been interpreted differently in recent years. You can usually find publications pointing to three strongly dependent pillars: economic (economic growth), environmental, and social [21]. The first attempt to operationalize the concept of sustainable development (assuming pillars such as economic growth and even distribution of benefits, protection of natural resources and the environment, and social development), presented in the report "Our Common Future" [22] in relation to the city, pointed to three areas of problems. The first results from the concept of needs, which is included in the pillars of sustainable development. In the city, it is difficult to precisely determine the needs of all participants in this system. Not only the type of stakeholder matters here (residents, local government units, enterprises, non-profit organisations), but even in the stratum of residents, the needs are very different and often contradictory. As regards the pillar of social justice (intra and intergenerational) [23,24] in particular, the problem of clarifying when the distribution of goods in the city can be acknowledged as fair is emphasized. The environmental pillar is strongly related to the "circular cities" idea defined as the cities using circular economy. They protect and reuse resources, promote and implement the principle of sharing, minimize the use of resources, and eliminate waste [11]. In terms of environmental restrictions, Chojnicki [25] pointed out the importance of carrying capacity, environmental space, and ecological footprint, requiring that the economy be run within the limits resulting from the quantity and quality of the environment, which is very difficult to implement in the reality of economic development of cities. Over 30 years have passed since the publication of the report, and taking action related to the economic development of the city (especially a large one) in relation to the limits imposed by its natural environment is still at odds. All these problems are a consequence of the high complexity of the city as a system. This complexity results from very different expectations of stakeholders and three types of relationships created in the city: relationships created as part of individual subsystems (social, economic, natural), relationships between individual subsystems, and relations between subsystems and the environment. The scope of shaping relations with the environment is limited. It is not subject to the interference of persons controlling a given territorial social system. As noted by Mierzejewska [15], sustainable development of the city is, therefore, about properly shaping all the aforementioned relationships, while taking into account the dynamic nature of the city system, which is certainly not easy.

In general terms, it is possible to divide sustainable development models and concepts into two groups. The first includes models and concepts that primarily refer to issues of the spatial form of the city, both locally (within the city's administrative boundaries) and regionally (in the urban functional region), including also the approaches combining both these aspects (local and regional), namely: eco-city, compact city, green city, redesigning a city, externally dependent city, fair shares city (equitable balance), MILU (multi-functional and intensive land use), new urbanism, and smart growth. The discussion in this area revolves around whether the compact or dispersed spatial and functional structure of the city is more balanced, and how to shape such a sustainable form. The second group is made up of those models and concepts that generally relate to issues of quality of life in the city, in particular in the context of social justice and sustainable urban economy, including, among others: self-reliant city, community garden, just city, and XXQ city (XXQuality—a city offering the highest quality of life) [15]. However, from the various concepts and models presented, goals can be separated that are generally part of the concept of sustainable development of the city (regardless of whether it is a compact city or a dispersed structure). Acknowledging this as part of its 2030 Agenda for Sustainable Development, the United Nations General Assembly established a set of 17 sustainable development goals (SDGs) in 2015 [26]. The 11th goal is to make cities inclusive, safe, resilient, and sustainable. Recognition of the central role of urbanization in sustainable development suggests that accomplishing the 11th SDG is vital for achieving other SDGs, such as fighting climate change (Goal 13), eradicating poverty (Goal 1), securing sources of safe water (Goal 6), clean energy (Goal 7), and increasing well-being (Goal 3) [27]. The SDGs, which emerged at the Rio+20 conference on sustainable development, aim to improve economic, social, and environment conditions, particularly in less developing countries [28]. The SDGs defend a triple bottom line approach to sustain human well-being, namely the economic development, environmental sustainability and social inclusion. In this context, the article considers the problem of freight transport in the city.

Considering the three currently identified pillars of sustainable development: economic, social, and environmental, the third pillar definitely has the strongest relationship with freight transport. These relationships are seen in the external costs of freight transport. At the same time, the city's economic development (economic pillar) requires an increased supply of goods to the city, as well as materials and primary commodity, which means that material flows are increasing. Thus support in the form of transport and logistics is also extremely important in this area.

While analyzing the goals of sustainable city development, which should be reflected in the city's strategy, one can notice an emphasis on environmental aspects, as well as improving the quality of life of the residents. The organization of freight transport in the city has a significant impact on both of these aspects. Freight transport in the city can, therefore, be considered an indispensable element of the city's economic growth. At the same time, the external costs of freight transport, such as exhaust emissions, accidents, congestion, land use, and noise indicate that ways of organising freight transport should be sought to enable the implementation of strategic goals [29]. The literature considers different variants that fit into the concept adopted in this way. In recent years, particular attention has been paid to the search for solutions in the area of last mile transport [30], including alternative sources of supply or changing the organization of supplies using microhubs [31], drones [32], time frames, etc. A separate problem is the organization of supplies to microhubs and the use of multimodal transport to reduce the negative impact of transport on the environment in the city. This direction of studying the impact of freight transport on the sustainable development of the city is poorly recognized in literature and is a cognitive challenge.

## 2.2. Freight Transport in the Sustainable Development of the City

Freight transport in the city plays an important role in meeting the needs of the citizens, and at the same time, it contributes to the generation of negative effects, especially for the



environment and society. It represents the last stage of the product flow in the supply chain (called the last mile transport) and generates significant cost in the whole delivery process and in external transport costs (meaning congestion on the roads, accident rate, noise, and air pollution). Thus, in the attempt to improve the last mile transport, one can benefit from reduction of the mentioned costs and correct operation of the whole chain. These aspects mean that the problem related to last mile transport, usually occurring within urban areas, should play an important role in the current undertakings [30,33–35].

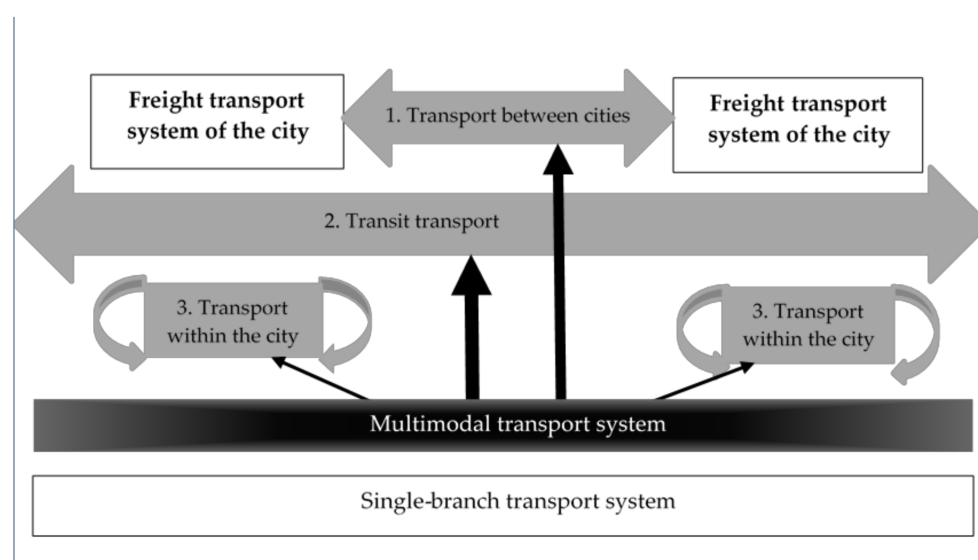
Fast development of freight urban transport is caused, among other things, by changes taking place within the supply chain. These include the expansion of e-commerce that is identified as the main current and future factor affecting the freight transport system in a city. This is related to the fact that B2C and C2C transactions are intensified, leading to more deliveries to individual recipients represented by inhabitants of the cities. E-commerce transactions are strongly related to dynamic development of parcel delivery companies that mostly use road transport in their deliveries. These two mentioned aspects contribute to a series of problems faced by contemporary cities. The constantly growing number of individual recipients and increasing number of freight means of transportation within cities significantly affect the conditions and quality of life and represent a threat for sustainable development of a city [33,36–39]. Despite the problem it creates, the freight transport system of a city is one of the most important factors determining its development. Its efficient functioning not only activates the economy of the city itself, but also of the whole country. This is due to the fact that interconnected urban transport systems are an important link in the country's transport system. Hence, striving for the functioning of the economy at the highest level, there is a need to properly shape these small links, so that they work properly and do not constitute a barrier to development [40]. Urban freight transport can be defined as the movement of materials and products within urban areas. It covers all freight movements that have their beginning or possibly end in cities, thus also indicating cargo movement between cities in metropolitan regions and transit movements in urban areas [41]. On this basis, Swamy and Baindur [5] classify urban freight movements in three areas:

1. flows between cities (external-internal or internal-external)—shipments that have the place of origin or destination outside the urban area,
2. external flows (external-external) are movements that have both the place of origin and destination outside the urban area (transit character of flows through the city), and
3. urban flows (internal-internal) include movements that have both the place of origin and destination in the urban area.

Actions to develop sustainable transport, including multimodal transport, can be implemented in each of these areas. However, it can be concluded that the greatest use of multi-branch transport takes place in the first area, then in the second, while in the third it is the smallest. Freight flows in the city, presented as part of the country's transport system, with an indication of the possibilities of multimodal flows, are shown in Figure 1 (in the figure, the thickness of the black arrows indicates the scale of the possibility of using multimodal transport in three distinguished areas of freight transport in the city).

Modern freight transport is mainly based on road transport, which generates as much as 40% of pollution in cities and increases the risk of accidents. In the face of such negative consequences, the proposal to use alternative solutions in the form of urban railway networks, subways, and trams not only for passengers but also for freight transport seems a reasonable alternative for transport organization. Moreover, it is also possible to combine freight and passenger transport within a single railway transport process [39,42]. Such a solution, as indicated by Ozturk and Patrick [42], is becoming increasingly popular in some European countries (e.g., in Paris, the Société Nationale des Chemins de Fer Français supplies part of the goods to the Monoprix retail network via suburban rail line D). The key element of this solution is the consolidation of the flow of goods in warehouses located on the outskirts of the city, then the goods are loaded onto a special freight train that uses public rail infrastructure and brings them to a transshipment hub in the city, from where

they are delivered to stores by road vehicles. In his research, Kordnejad [43] also analyzes the multimodal freight transport using rail from a city perspective. He conducts research on the possibility of using this type of solution and the conditions, in which it can be implemented. Among the necessary conditions, he indicates a stable flow of goods and transshipment in terminals, effective in terms of time and costs. The conducted analyses indicate a number of challenges facing this type of transport, but also many opportunities and benefits. The challenges mainly relate to organizational and physical coordination. The first one is associated with the adopted business model, based on local cooperation, in which local authorities play a significant role in creating the regulatory framework for this type of activity, based on sustainable development policy. Physical coordination is related to the technologies used (including their modernity). However, the main opportunities are associated with a lower level of environmental impact and a better use of infrastructure in the region. The meaning of the linear and point transport infrastructure in the development of a sustainable transport system is underlined by many researchers [33,34,44–47]. They underline a series of limitations it generates for sustainable transport related to both lack of or difficulties in access to part of the streets, separated loading bays or alternative branches, and means of transportation. Moreover, the fact of missing consolidation centers that serve the function of city hubs is underlined. The hubs might enable goods reloading operations using different branches of transport and delivering them to identified locations in the city center using delivery trucks (including electrical). Deliveries within city centers to a given address necessitate special loading stations (loading bays) in order to enable stopping and parking a delivery truck near a client to deliver goods (mostly by foot, manually, or using simple handling devices). In such a situation, to perform efficient delivery to a city center, it is necessary to determine an optimum number, throughput, and location of such stations, and their proper management [33,34,48]. An important aspect of planning the transport in a city in connection with the infrastructure condition is the necessity to cooperate with urban planners who have knowledge within the scope of land spatial development planning. Long-term and comprehensive plans of cities development that consider transport meeting the requirements of sustainable development are necessary [44,49,50]. Another aspect that must be taken into consideration is potential natural hazards that may be present within given areas [47]. Iwan draws an attention to the specificity of each city that necessitates an individual approach to designing transport systems, i.e., density of population, specificity of building development, traffic intensity, topology of road network, scope and scale of production or commercial operations, and expectations of different stakeholder groups [37].



**Figure 1.** Multimodal transport in city freight flows. Source: Own elaboration.

The freight transport system is an important part of the city. As emphasized by Schliwa, Armitage, Aziz, Evans, and Rhoades [51], an efficient and well-created freight transport system plays a key role in improving the competitiveness of the urban area and is an important element for the local economy in relation to employment and generated income. Paying attention to the modern concept of sustainable development, referring both to cities and transport, one can wonder what relation they have with each other. The question arises—can the transport system be sustainable and the city not? Is it possible that the city is developing in a sustainable way, but the transport system is unbalanced? There is currently no clear answer to these questions. However, the basic assumption is that the sustained development of transport represents an element of vision of sustainable city [52,53]. Such an approach requires special planning both within the social and economic as well as natural and spatial sphere. First of all, it should be remembered, that the planned activities should be included in the local development strategies. When creating this type of plan, cooperation between individual stakeholders of urban freight transport is necessary, e.g., in the form of public and private partnership [54]. At the same time, it is necessary to engage a public opinion identifying the benefits from a sustainable transport system [55].

Multimodal freight transport in the city is a complex issue and a big challenge for everyone involved in creating its vision. This is mainly due to the conflicting interest of different stakeholder groups. The following are the basic groups related to freight transport in the city:

- shippers of goods,
- recipients representing the demand for goods,
- providers of transport services (carriers, forwarders, logistics operators) and transshipment (managers and operators of transshipment terminals),
- other groups that are not directly involved in the flow of goods, but decisions in the area of transport can influence them indirectly (e.g., visitors and tourists).

All these groups, including transport decision makers, can be acknowledged as the key stakeholders for the development of freight transport in the city. Finding a balance between public and private goals is a particular challenge for public authorities. Essentially, this means maximizing the efficiency of goods distribution while minimizing the associated negative externalities of transport, as well as supporting sustainable development and ensuring good living conditions for residents [56]. Literature focuses a lot on the role of decision-makers in building sustainable freight flows, especially for multimodal transport in the city. These groups are designed to encourage, and sometimes even force shifts between modes of transport, through a series of decisions and initiatives. These groups include [57]:

- international bodies—e.g., decisions on permissible engine emissions standards,
- national authorities—e.g., decisions regarding taxes, fuel charges, and
- local or regional authorities—e.g., creation of land use plans, providing for the existence of consolidation or transshipment points and urban distribution centers, introduction of parking fees and regulations regarding loading and unloading, introduction of low emission zones, introduction of time limits for the transport of goods.

In an effort to shape sustainable urban transport systems, taking into account their multimodality, a special role is attributed to decision-makers, i.e., mainly local authorities, who are responsible for limiting city traffic. Kiba-Janiak [58] draws attention to the need to include freight transport in the strategic planning of the city, and then to implement the guidelines in accordance with the adopted plan. On this basis, she mentions the city's maturity in the planning and implementation of urban freight transport activities. Local authorities should be leaders and initiators of activities for a sustainable transport system, hence the assumptions about the flow of goods should find an important place in the city's strategic documents. Moreover, local authorities are required to consider the state-of-the-art technological achievements that may support transport processes in the cities. Additionally, attention is drawn to a necessary cooperation both with suppliers of such technologies



and transport contractors or scientists in order to design the best transport solutions in the cities [44].

It is also important that local authorities represent, and therefore take into account, the interests of different stakeholders. As there are conflicts between the expectations of individual groups, decision-makers should learn and consider all postulates, and then strive for compromise and choice of the optimal solution in a given situation. Moreover, as representatives of the local community, they should also ensure that the expectations of those stakeholders who have little impact, but whose interest in the transport system is significant, are met. Here are the next difficulties [37,59]. Urban transport is characterized by high heterogeneity and complexity, associated with the difficulty of indicating the common requirements of the various parties to this process. For example, people treat HGV (heavy goods vehicles) freight transport as a burdensome activity and a threat to all transport and the city. Residents report the need for lorries not to operate near residential homes to minimize noise, air pollution, etc. However, another group, the sellers, value goods delivered by lorries, but, at the same time, they regret the loading and unloading processes that take up space which can be used as parking for potential customers. The drivers themselves and the transport companies responsible for deliveries complain about the lack of parking spaces and heavy traffic, which increases the cost of car operation and causes delays in the delivery of products [41]. Yet another example of a different view on the development of freight transport concerns public authorities and companies involved in transport. The authorities strive to reduce transport, which is to generate benefits associated with increasing the attractiveness of the city for residents and visitors through environmental and social sustainability (e.g., reduction of congestion, pollution, or accidents). On the other hand, companies focus on reducing costs and improving the quality of services in order to satisfy the customer in a competitive market. Transport can help achieve these goals [51].

The struggle for sustainable freight urban transport necessitates adoption and implementation of urban strategy for freight transport that is nested in the concept of sustainable development; consultations with the interested parties in order to ensure transparency and acceptance of the proposed solutions; cooperation with stakeholders to ensure integration of various types of transport within the scope of common regional policy; ensuring qualified human resources with proper skills; and coordination of transport policies of different cities within the regions and taking common planning actions [6]. At the same time, it is necessary to notice and understand interactions taking place between a city and the multimodal freight transport implemented in it [45]. This impact will be reflected in the effects noticeable both for the city transport system and for the relationship between city sustainability and sustainability of transport within a city.

To sum up, one must emphasize the meaning of the undertaken problem related to the impact of a city on the directions of freight transport development. On the other hand, it is necessary to notice the shaping of the transport system as an element affecting the sustainable city development. Moreover, it is important to consider any types of stakeholders influence in the given dependence.

### 3. Methodology of the Study

Research questions became the basis for conducting the research, consisting of four main stages. They were included in Figure 2, which presents the methodology of the research.

Such methodology combines research concepts proposed in other papers within the field of freight transport in the cities. Analyzing the literature references concerning the scenario analysis in order to identify the freight transport development strategy, one may notice different approaches that are the result of the developed research questions and the level of research specificity. In the paper by [60], the authors focused their attention on the selected, very detailed issue in the area of transport, namely the development of bio-diesels. The authors assigned scenarios to the pillars of sustainable development, which is a direction that is also adopted by the authors of this paper. A different methodology

was adopted by Bäumler [61] who created 10-year long scenarios for smart transport systems related to road freight transport. In the first stage, the author identified scenario fields based on a literature review. As a consequence, he showed four areas where the issues related to development of smart transport systems are focused. Scenario analysis focusing on the question "How will digitization change road transport?" was performed by Pernestål, Engholm, Bemler, and Gidofalvi [62]. The authors built four scenarios and in each one of them investigated the impact of digitization on the road freight transport development, showing at the same time chances and barriers in achieving the sustainable transport development in each of the scenarios. They used an exploration scenario in the paper according to the basic assumption that the development of road freight transport digitization is unsure by its nature and there is no one determined future. There are rather a few probable futures that need investigating in order to prepare for future events. The exploration scenarios present various probable development trajectories; however, they are neither intended to present the most probable course of events (predictive scenarios) nor assess how the preferred scenario can be achieved [63]. Workshops with experts are an important part of the scenario-building process identified by Pernestål, Engholm, Bemler, and Gidofalvi [62]. Such approach to formulating scenarios is also adopted in this paper. However, the research focuses on predictive scenarios.

The authors performed the scenario analysis for the selected case study—Katowice city. The scenario analysis was complemented in the research by a regression analysis and an analysis of clustering the cities in Poland. This research array widens the so far proposed research methodologies related to freight transport in cities. It combines studies on a large research sample within the scope of including the freight transport aspects in Polish cities' strategies (according to the approach previously proposed by Nemoto, Browne, Visser, and Castro [9]) with the scenario analysis implemented at the stage of case study. The methodology of the scenario analysis is in conformity with the procedure proposed by Kramarz, Knop, Dohn, and Przybylska [64] to investigate freight transport development scenarios within cross-border areas. Due to a different research problem, the authors have proposed a methodology that allows for detailed scenario analysis for the selected city. The cluster analysis method was also used during the investigation of freight transport problems in the cities. The clustering, using city features in relation to the problem of the last mile transport organization, was also used among others by Ducret, Lemarie, and Roset [65]. The authors applied the clustering method to identify city models and urban logistics where similar solutions within the last mile transport can be proposed. Application of the clustering method to recognize city similarities from the standpoint of factors characterizing logistics aspects opens a new perspective for designing logistic solutions and directions of support for the cities in order to improve urban logistics. Castro, Merchaán, Lima, and Winkenbach [66] have drawn similar conclusions when showing features of the cities, including geographical conditions, population, and infrastructure, the combination of which allows for specifying a city model for which transport planning level solutions in the cities can be tailored. In the research proposed in this paper, the authors changed the perspective of using the clustering analysis and induced to the concept proposed by Nemoto, Browne, Visser, and Castro [9], and offered the determination of city templates based on the degree of freight transport consideration in the city policies. Anand, van Duin, Quak, and Tavasszy [67] comprehensively examine the problem of modeling urban logistics (in the meaning of freight transport in a city) and performed a literature review within the scope of the applied methods. The authors underline the popularity of statistical analysis methods, including the linear regression and clustering methods used by the authors. However, as they mention, according to current studies, these methods are not included in the research procedure in the way adopted by the authors. Therefore, based on known literature methods also used to solve problems within the area of freight transport in a city, a multi-stage methodology was proposed that binds various methods in order to answer three research questions.

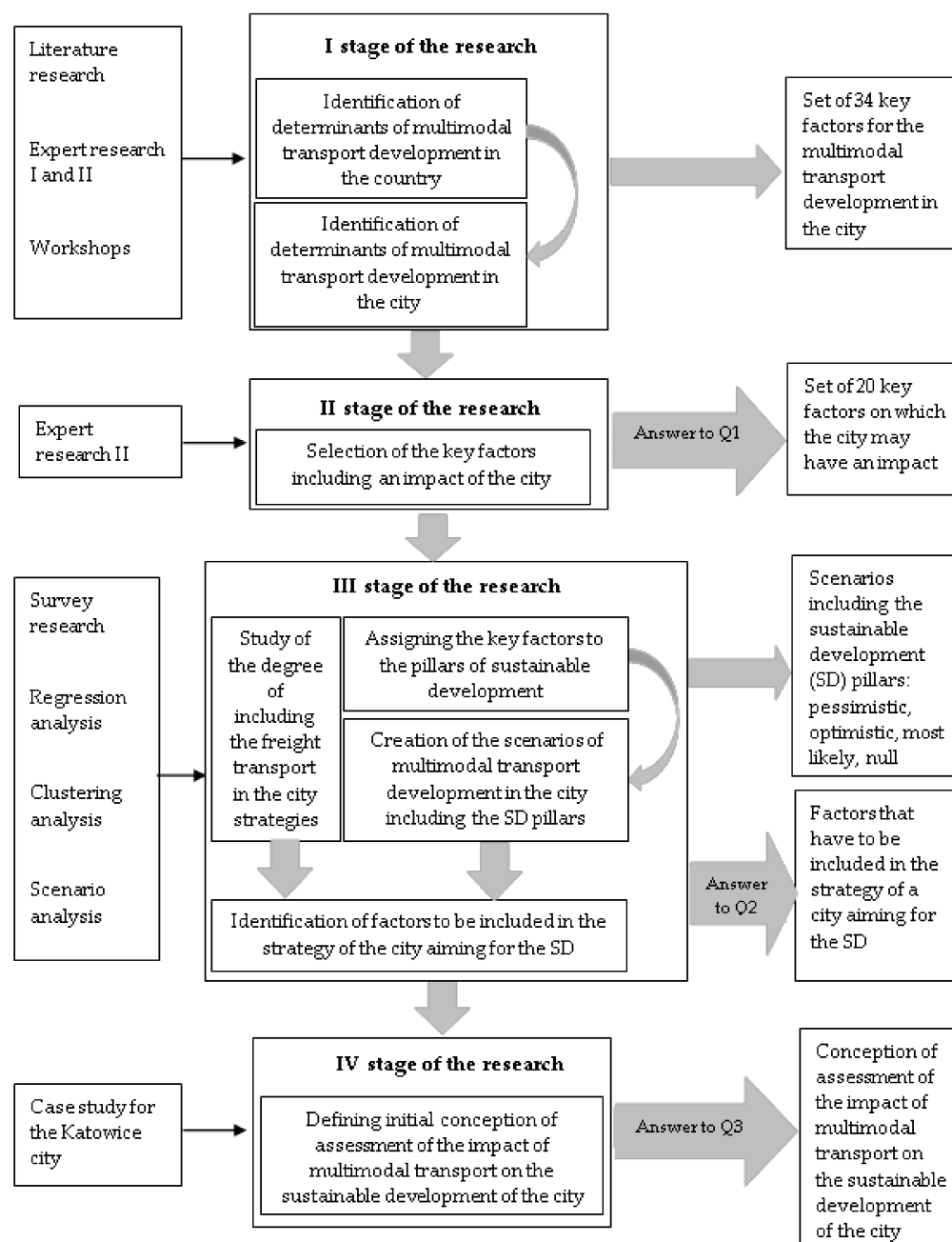


Figure 2. Methodology of the study. Source: Own elaboration.

#### Methodology of the study—I stage

The first stage of the research was connected with striving for identification of the key factors of multimodal transport in the city. Its starting point was the scenario studies of the multimodal transport development in Poland conducted by the authors in 2019 [68]. For this purpose, expert research was conducted, which allowed to indicate the key factors of the multimodal transport development in the city. The research was performed based on a survey questionnaire assigning weights to individual factors related to multimodal transport development. The questionnaire was filled out by 10 experts representing the field of economic science and practice. All persons were matched for the research with consideration of their competences in the field of an analyzed research question. The weight was assigned based on adopted assessment scale from 0 to 3, where 0—factor is not important; 1—factor is of little importance; 2—mean importance of the factor; and 3—decisive factor. In the paper, while adopting a different perspective of identification of

the multimodal transport development determinants—namely, the city—main research stages from 2019 were preserved. Conducted literature research allowed to indicate additional (apart from the ones formerly examined) potential determinants of the multimodal transport development in the city. In this way, the entire set of determinants subjected to an analysis included factors separated at the stage of research conducted in 2019, extended to determinants related to the impact of the city on the multimodal transport development. The full set of analyzed factors is presented in Table 1.

**Table 1.** List of researched factors.

Factors—Country/City	Factors—City
<p><b>Political and legal</b></p> <ul style="list-style-type: none"> <li>• Development of the TEN-T program</li> <li>• Degree of including multimodal freight in the country's transport policy</li> <li>• Formulated railway programs and their degree of implementation</li> <li>• Requirements of PKP PLK SA (PKP Polskie Linie Kolejowe SA) regarding the access of carriers to the railway linear infrastructure</li> <li>• Restrictions on the movement of freight by road</li> <li>• Development of the New Silk Road</li> <li>• Number of solutions included in the state transport policy promoting rail and multimodal transport</li> <li>• Level of international relation of individual countries and linear infrastructure managers</li> </ul> <p><b>Economical</b></p> <ul style="list-style-type: none"> <li>• Price level of competitive modes of transport (mainly by road)</li> <li>• Level of demand for rail transport</li> <li>• Level of intermodal relief</li> <li>• The existence of procedures and their stability in granting intermodal relief</li> <li>• Level of fees for carriers' access to railway linear infrastructure</li> <li>• Level of state expenditure on the development of linear infrastructure</li> <li>• Level of transit transport between western Europe and Asia</li> </ul> <p><b>Technological</b></p> <ul style="list-style-type: none"> <li>• Level of linking railway infrastructure with sea/river ports</li> <li>• Scale of adopting of linear infrastructure to service trains with a length of 750 m</li> <li>• Level of separation of freight linear infrastructure from passenger rail transport</li> <li>• Parameters of transshipment terminals</li> <li>• Network of multimodal transshipment terminals</li> <li>• Development of ro-la technology</li> <li>• Development of lo-lo technology</li> <li>• Development of ro-ro technology</li> <li>• Development of intermodal loading units</li> <li>• Level of rail system interoperability</li> </ul>	<p><b>Political and legal</b></p> <ul style="list-style-type: none"> <li>• Scope of aspects of freight transport included in the city's strategies</li> <li>• Scale of aspects of environmental protection in the city's strategy</li> <li>• Number of solutions included in the city's strategies promoting the development of multimodal freight transport in the city</li> </ul> <p><b>Economical</b></p> <ul style="list-style-type: none"> <li>• Level of city expenditure on the development of linear infrastructure</li> <li>• Level of industrialization of the city</li> <li>• Number of investments in freight transport in public-private agreement</li> <li>• Level of cooperation between cities in the region</li> <li>• The level of parking charges in the city</li> <li>• Level of city development</li> </ul> <p><b>Technological</b></p> <ul style="list-style-type: none"> <li>• Availability of parking and unloading places</li> <li>• Availability of areas intended for logistic support of the city</li> <li>• Level of city's cooperation with freight transport stakeholders</li> <li>• Level of innovation in the city</li> <li>• Length of railway linear infrastructure and navigable waterways in the city</li> <li>• Access to alternative linear infrastructure (rail transport-trams, bicycle freight transport)</li> <li>• Degree of compactness of the city</li> </ul> <p><b>Social and environmental</b></p> <ul style="list-style-type: none"> <li>• Level of awareness and attitude towards ecological aspects</li> <li>• Climate and surface features</li> <li>• Intensity of natural hazards (e.g., mining damage)</li> <li>• Population density and structure</li> <li>• Urbanization level</li> <li>• Level of external costs of transport</li> <li>• Population income level</li> <li>• E-commerce level</li> <li>• Activities of environmental organizations</li> </ul>

Source: Own elaboration.

At this point, it should be noticed that in previous research there were also determinants related to the regional impact and the impact of local government units, however, the set of these factors needed to be completed. The set of potential factors of multimodal transport development in the city created in such way was subjected to the II expert research that takes into account the importance of each factor (the rating scale did not change). At this stage of the research, the group of experts was increased from 10 to 15 (representatives of local government units were included in the group of experts, other experts remained unchanged). The whole group of experts participated in the workshops where the research problem was explained and the principles of filling out factors importance assessment questionnaire discussed. Also at this stage, the appointed experts could independently decide whether to start (or withdraw from) the research, while taking into account the self-assessment of their competences. At the same time, in order to exclude randomness of the importance assessment made by the experts, when assessing individual factors, the level of their conformity was investigated. For this purpose, the Krippendorff Alpha coefficient was used, determined in the Statistica program. This coefficient is a universal measure of experts' compatibility used for various measurement scales (nominal, interval, ordinal), and for large number of experts (more than two). This coefficient takes values from  $-1$  (complete incompatibility) to  $+1$  (complete compatibility), with  $0$  meaning compatibility at the level of chance. While taking into account the adopted assumptions, the coefficient of experts' compatibility for specific, analyzed factors was determined. For all analyzed factors, the Krippendorff Alpha coefficient was at least satisfactory (above  $0.4$ ). Therefore, all analyzed factors were included in further research.

#### Methodology of the study—II stage

At the second stage of the research, among the identified key factors of the multimodal transport development in the city, the factors on which the city can make an impact were distinguished. These factors were indicated based on the opinions of 15 formerly mentioned experts (apart from the assessment of the importance of factors, experts also indicated the factors which, in their opinion, the city has an influence on). In this way, the answer to the first research question put by the authors was obtained.

#### Methodology of the study—III stage

At the third stage, two groups of studies were conducted simultaneously. Their implementation allowed to indicate factors which should be included in the strategy of the city aiming for sustainable development. Firstly, scenarios for the development of multimodal transport in the city have been developed. They were constructed while including the sustainable development conception. For this purpose, all 34 identified key factors of the multimodal transport development in the city were assigned to the three pillars of sustainable development of the city (economic, environmental and social). Moreover, the fourth group of factors known as "others", which does not fit into the pillars of sustainable development, has been separated. For the four adopted perspectives, three scenarios have been formulated and compared: the most probable, optimistic, and pessimistic. The zero scenario has also been developed which meant a present state (in the scenario, it was assessed as the stabilization of each of the factors). Created scenarios were developed for the chosen Katowice city. The strategic analysis itself was chosen because of its advantages, pointed out both by theoreticians and practitioners. Scenarios are an effective tool of strategic management in conditions of high uncertainty for planning activities [69]. Scenarios are most useful when the external environment is complex and uncertain, and key decisions involve large investments or have long-term consequences. These assumptions are met in the problems of multimodal freight transport development [70]. Perhaps, here, the scenario analysis is important in helping us to begin to "think the unthinkable" and is increasingly being used in the transport field. There is extensive literature in terms of the general approach [71–75]. The dominant objectives are to develop more effective, strategic decision making, in view of uncertain trends, and to understand the potential for achieving breaks against dominant trends. A number of important difficulties become evident when undertaking scenario analysis:



- There is a fundamental problem with “indeterminacy”: developments in technologies, public policy, and awareness may not only affect exogenous policy variables, but may change “the rules of the whole game”, i.e., we do not really know what is likely to develop in future years [76,77].
- Policy makers often do not move beyond “satisfying”, they do not seek the “maximally beneficial” outcomes, but instead the “minimally acceptable” ones, avoiding the innovative options, that are perceived as risky [75,78]. This moves strategies away from the “technical optimum”, perhaps reflecting concerns over political and public deliverability. There are many examples here, like streetscape design and road pricing.
- “Inattentional blindness” [79] can often occur in strategy development. Here, important issues are often unnoticed, due to the focus on “the task in hand” and the lack of a wider perspective to decision-making. Perhaps the current focus on low CO<sub>2</sub> transport pathways will be an example of this, with the economic, social, health, and local environmental policy objectives given less significance.

The second group of research in the third stage was indicating the level of including the logistic aspects related to the freight transport in the strategies of Polish cities. It is connected to the fact that for the implementation of assumptions of the multimodal freight transport development in the cities, it is important for local self-government entities to notice the aspects not only directly related to freight transport, but also the ones that will influence the organization of this transport. These are: the localisation of manufacturing and trading companies and their way of communication, as well as the localization of the logistic centers and the distribution centers. Incorporation of the logistic aspects, especially those of such a broad sense and oriented on the freight transport, to the strategies of the cities in Poland is not a common practice. In order to indicate the level of including the formerly mentioned aspects in the strategies of Polish cities, the authors used the research conducted in 2020 at the Faculty of Organization and Management of the Silesian University of Technology. It was a questionnaire research dedicated to the concept of smart cities (including the logistic aspects in the strategies of cities was one of the elements of this research). As a part of the research, the results concerning 280 cities in Poland were collected. As formerly mentioned, the scope of including the aspects directly related to freight transport, localization of the manufacturing and trading companies, along with localization of the logistic centers and the distribution centers, in the strategies of the cities was analyzed. Each of these areas was assessed on a 5-point scale, where:

- 1—is not included,
- 2—will be included in the next strategic documents,
- 3—is included to a minimal extent,
- 4—is included on general level, and
- 5—is included in detail.

The questionnaires were filled out by people responsible for the strategy of the city. At the same time, the respondents indicated the characteristics of the city: income per capita, the number of citizens, and the region in which the city is located. The research results achieved this way were subjected by the authors to two analyses. The first one was linear regression analysis where attention was paid to the impact of per capita income on the scope of consideration of the logistic aspects in the city strategies. The other one was the analysis of concentrations that allowed for classifying the cities from the standpoint of logistic aspect consideration in their strategies.

Based on the research carried out in the third stage, the factors which have to be included in the strategy of the city aiming for the sustainable development were indicated (answer to the second research question).

#### Methodology of the study—IV stage

Indicated factors important for the multimodal transport development were analyzed in terms of legitimacy of their incorporation to the strategy of the city, in promotion, strategic projects, and operational funding from various sources, as well as in terms of necessity of the Transport and Logistics Observatory constituted in December 2019

monitoring them. Considering the fact that the proposed solutions require the extension of the concept to include the possibility of assessing the multimodal transport development for the sustainable development of the city, the fifth stage of the research was adopted, in which the authors proposed a formerly mentioned conception of assessment. Therefore, the third formulated research question has been answered.

#### 4. Results and Discussion

##### 4.1. Key Factors of Multimodal Transport Development in a City

As part of the research carried out by the authors in 2019 on the factors of development of multimodal transport in Poland, 25 factors determined as key ones, i.e., those of the greatest importance for the development of this transport, were identified [68,80]. The assessment scale included a range from 0 to 3 points; the key factors were those whose average significance was assessed by experts above 2.25 points. At the current research stage, the previously identified factors were compared with the key factors identified for the development of multimodal transport in the city. Table 2 presents those factors that are key determinants, both in the development of multimodal transport in the country and important in the case of the city. As the table shows, 15 such factors have been identified, constituting 60% of key determinants assigned to the country. Ten factors, which have been acknowledged by experts as very important for the development of multimodal transport in the country, are not of great importance in case of the city. These include the level of intermodal relief, the existence of procedures and their stability in granting intermodal relief, the level of transit transport between western Europe and Asia, the development of intermodal loading units, the development of lo-lo technology, the development of the New Silk Road, the development of the TEN-T program, level of international relations of individual countries and linear infrastructure managers, level of linking railway infrastructure with sea/river ports, and scale of adaptation of linear infrastructure to service trains with a length of 750 m.

**Table 2.** Key factors for the development of multimodal transport in the country and in the city.

Figure	Importance—Country	Importance—City
1. Level of state expenditure on the development of linear infrastructure	2.9	2.9
2. Level of fees for carriers' access to railway linear infrastructure	2.6	2.4
3. Level of demand for rail transport	2.5	2.4
4. Price level of competitive modes of transport (mainly by road)	2.6	2.8
5. Level of rail system interoperability	2.8	2.6
6. Development of ro-ro technology	2.4	2.5
7. Development of ro-la technology	2.3	2.3
8. Network of multimodal transshipment terminals	2.9	2.8
9. Parameters of transshipment terminals	2.8	2.3
10. Level of separation of freight linear infrastructure from passenger rail transport	2.4	2.5
11. Degree of including multimodal freight in the country's transport policy	2.4	2.4
12. Number of solutions included in the state transport policy promoting rail and multimodal transport	2.5	2.5
13. Requirements of PKP PLK SA regarding the access of carriers to the railway linear infrastructure	2.4	2.3
14. Formulated railway programmes and their degree of implementation	2.6	2.3
15. Restrictions on the movement of freight by road	2.5	2.5

Source: Own elaboration.

In addition to factors, that are important both in the country and the city, a group of factors has been identified, which were only indicated as key in case of the city (Table 3).

**Table 3.** Key factors for the development of multimodal transport services in the city.

Factors	Importance—City (Country)
1. Level of awareness and attitude towards ecological aspects	2.5 (1.9)
2. Intensity of natural hazards (e.g., mining damage)	2.3 (1.6)
3. Population density and structure	2.3 (1.2)
4. Urbanization level	2.4 (1.3)
5. Level of external costs of transport	2.7 (2.0)
6. E-commerce level	2.3 (1.5)
7. Level of city development (social capital, scientific and R&D facilities)	3.0
8. Level of city expenditure on the development of linear infrastructure	2.4
9. Availability of areas intended for logistic support of the city	2.6
10. Level of city's cooperation with freight transport stakeholders	3.0
11. Level of innovation in the city	2.4
12. Length of railway linear infrastructure and navigable waterways in the city	3.0
13. Scope of aspects of freight transport included in the city's strategies	2.6
14. Degree of compactness of the city	2.5
15. Scale of aspects of environmental protection in the city's strategy	2.5
16. Level of industrialization of the city	2.9
17. Number of solutions included in the city's strategies promoting the development of multimodal freight transport in the city	2.8
18. Level of cooperation between cities in the region	2.8
19. Access to alternative linear infrastructure (rail transport—trams, bicycle, freight transport)	2.9

Source: Own elaboration.

By analyzing the key factors listed in Table 3, they can be divided into two groups. The first (factors 1–6) are factors that, in the case of the development of multimodal transport in the country, were not acknowledged as key, while in the case of the city, their rank generally increased, which allowed them to be included as key factors. It is particularly characteristic that all these factors represent a group of socio-environmental determinants. In total, this group was acknowledged as the least important in the development of transport in the country, while its rank in the case of the city increased significantly. The second group of factors (factors 7–19) are determinants that are strictly related to the functioning of the city. They were not analyzed in the case of multimodal transport development in the country.

Of the 34 key factors for the city indicated in Tables 1 and 2, 20 were identified that could be influenced by the city through its activities. This is factor number 15 in Table 2 and all factors in Table 3. The research results allowed answering the first research question concerning the way a city can affect the multimodal transport development. The existence of as many as 20 such factors with a high level of importance indicates the great strength of the city in the development of multimodal transport. In further studies, this determination will allow to indicate the possibilities of supporting the management of the development of multimodal transport for the city.

#### 4.2. Logistic Factors in the Context of Strategy of a City Striving for Sustainable Development

##### 4.2.1. Logistic Aspects in the Strategies of Polish Cities

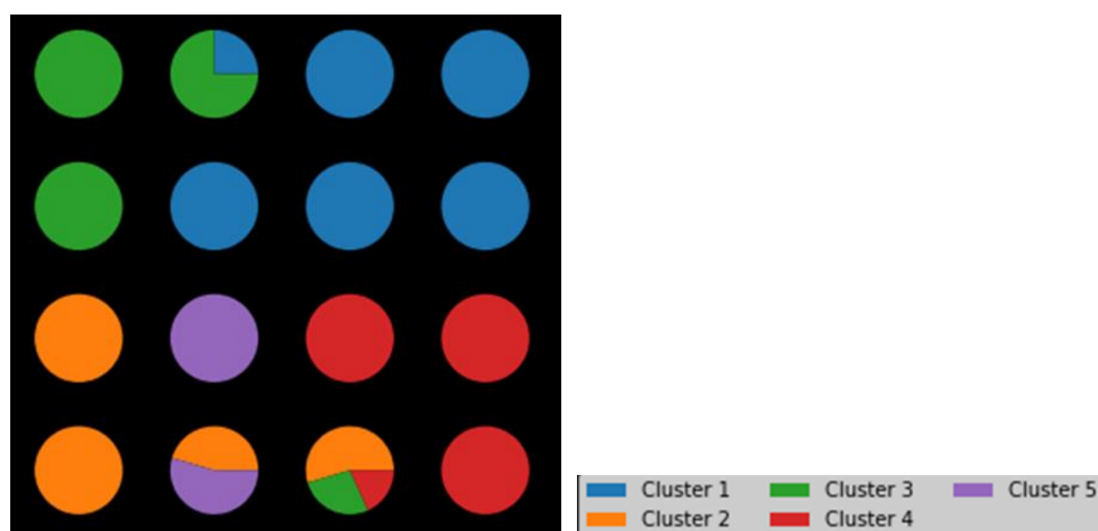
The results of the conducted questionnaire research on a group of 280 Polish cities allowed to perform two analyses devoted to the issue of including the logistic aspects in the strategies of the cities. The logistic aspects considered in the research were: freight transport issues, localization of the manufacturing and trading companies and their way of communication, localization of the distribution centers, and the logistic centers. The first conducted analysis was a linear regression analysis and the second analysis was a cluster analysis. Considering the fact that the Cronbach's Alpha coefficient totaled over 0.7, the collected data were recognized as acceptable for conducting the cluster analysis. The

regression analysis and cluster analysis were conducted with the use of the Python tool that allows for data processing.

The linear regression analysis indicated that an increase of an income per capita is not a factor that determines inclusion of the logistic aspects in the strategies of Polish cities. Whereas, the division of the cities considering the level of including the logistic aspects in the strategies of the cities as a criterion allowed for separating five clusters. Their short characteristics can be found below:

- Centroid 1 (3 pts.)—none of the three mentioned logistic aspects was included in the strategies of the cities. This group included 127 cities.
- Centroid 4 (6 pts.)—neither the freight transport nor the localization of the logistics and distribution centers were included in the strategies of the cities, whereas the last aspect was included in the strategies on a general level. This group included 47 cities.
- Centroid 3 (7 pts.)—freight transport was included in the strategies of the cities only on a general level, and localization of the logistics and distribution centers is planned to be included in the next strategic documents, whereas the distribution of trading and manufacturing companies and their way of communication were not included in the strategies of the cities. This group included 34 cities.
- Centroid 5 (9 pts.)—freight transport was not included in the strategies of the cities, whereas the localization of the logistics and distribution centers and the distribution of the trading and manufacturing companies, as well as their way of communication, were included in the strategies only on a general level. This group included only 19 cities.
- Centroid 2 (12 pts.)—all three considered logistics aspects were included in the strategies on a general level. This group included 53 cities.

The division into clusters was carried out using the K-means algorithm. Various values of the K-parameter, specifying the number of required clusters, were tested. As a result of the analysis, the value  $K = 5$  was selected. Then, the grouped city clusters were subjected to dimensionality reduction using the neuron network algorithm of the architecture of self-organizing map (SOM). This allowed obtaining two-dimensional data representation that is easy to visualize. Similarities of the features between the clusters are shown in Figure 3.



**Figure 3.** Results of the cluster analysis. Source: Own elaboration using Python tool.

Figure 3 has the form of  $4 \times 4$  grid that presents circle diagrams showing individual identified centroids. The SOM algorithm for the selected grid size automatically assigns a point on the grid to the records selected from the dataset, based on internal similarities. Each point (circle diagram) on the grid depicts cluster distribution of the records assigned

to it. For example, the diagram generated in this case shows a large difference between the first and second cluster elements, but the fifth and second are quite similar. This is manifested (in the first case) by clear separation of points on the grid to which examples belonging to cluster 1 and 2 were assigned and (in the second case) proximity of points that include examples from clusters 5 and 2 and presence of points to which a lot of examples belonging to both clusters (point 4 and 2 on the grid) were assigned.

The research has shown that none of the cities has indicated a level of detailed incorporation of the logistic aspects in their strategies. In the majority of the cities, the logistic issues related to the freight transport is not included in the strategies (centroid 1). The level of influence of the cities and regions on the multimodal transport development is minor. In this group, the cities from Wielkopolskie Province which constitute 15.7% of the cities in this group dominate. The cities of Dolnośląskie Province constitute 15%, and 10% are the cities of the Śląskie Province. In group 4, the conception of landscape planning is incorporated, including the localization of trading and manufacturing companies and their way of communication on general level. Although the freight transport aspects and those of the logistic support as the distribution centers and the logistic centers are not included here, the aspect of localization of manufacturing and trading companies itself allows for an impact in terms of the last mile transport. In this group, the cities of the Śląskie Province (17%) and the Lubuskie Province (10%) are dominating. In the third group of the cities, freight transport is included to a minimal extent (level 3). At the same time, the cities show that they plan to include the localization of the distribution centers and the logistic centers in the next strategic documents. However, they do not plan to include the aspects related to the localization of the manufacturing and trading companies. In the research, it was concluded that an awareness of the meaning of whichever aspect related to the freight flows, which results in the decision of its incorporation in the next strategic documents, is a positive tendency in the behavior of the cities; therefore, its rating was set on the level 2, that is between not including and including to a minimal extent. In this group, the cities of Podkarpackie Province (14.7%), the Dolnośląskie Province, and the Lubelskie Province and Warmińsko-Mazurskie Province (each 11.7%) were dominating. The logistic aspects are most strongly included in the strategies of the cities of groups 2 and 5. Group 5 covers, in particular, the aspects related to the landscape planning, and in this area both the problems of the localization of manufacturing and trading companies along with their communication and the aspects of the logistic support as the localization of the distribution and logistics centers are noticed. In this group, the cities of the Kujawsko-Pomorskie Province (15.8%), the Lubelskie Province (15.8%), the Mazowieckie Province (15%), Śląskie Province (15%), and Wielkopolskie Province (10.5%) are dominating. On the other hand, in group 2, both the aspects of freight transport and the aspects related to localization of the logistic centers, distribution centers, manufacturing and trading companies, and their way of communication are included on a general level. The cities of Śląskie Province represent 13%, whereas the cities of Łódzkie Province, the Mazowieckie Province, and Wielkopolskie Province constitute 9% each of the cities of this group. This group can be considered as the one having an advanced view on the strategic solutions for the freight transport along with the logistic support and spatial development.

Analyzing separated groups in terms of an income per capita, attention can be focused on the domination of the first group by the cities of an income from 222 EUR to 445 EUR per capita (37%). The same situation occurs in group 5 (36% of the cities). In the remaining groups, the distribution of the cities with an average per capita income is even.

In the research, the cities with a number of citizens from 10,001 to 25,000 are dominating, and these cities constitute the largest part of each identified group. In group 1, in which the logistic aspects are not included in the strategy, 28% is constituted by small cities of 10,000 citizens or less, whereas in the group of cities most strongly including the logistic aspects in the strategies of the cities (group 2), large cities of over 100,000 citizens (29%) are dominating.



#### 4.2.2. Scenarios of Multimodal Transport Development in a City Considering Sustainable Development Pillars

Scenarios for the development of multimodal freight transport were developed for the selected city of Katowice. It should be emphasized that the whole developed research methodology, identified key factors, and adopted assumptions and guidelines of the developed scenarios are universal and can be applied to any city. However, the same assessments of the strength of impact, trend, and probability of the identified key factors for the development of multimodal transport are prepared for the selected city, in this case for Katowice. This is necessary because each city has different characteristics and conditions in which it operates.

The city of Katowice is the capital of the Silesian province, located in the south of the country, bordering on the south with Slovakia and the Czech Republic, which means that it lies in the so-called cross-border region. This is an important feature because of the development of freight transport—the Czech Republic and Slovakia are the main directions of both export and import of goods. The province, headed by Katowice, took first place in the country in terms of investment attractiveness, which was mainly due to rich industrial traditions, a high degree of urbanization, and the thriving Katowice Special Economic Zone [81]. Katowice is the headquarters of the Upper Silesia-Zagłębie metropolis and the largest city in terms of population in the Upper Silesian conurbation. It ranks 11th in the country in terms of population, and 12th in terms of area. Katowice is one of the largest economic hubs in Poland (industrial, as well as commercial and service). The city is indicated as an important hub from the point of view of the development of transport and logistics activities. This is due to the fact that Katowice is located within the TEN-T transport corridor (Baltic-Adriatic); it is indicated as one of the main cities of the province in terms of supply and demand for modern warehouse space (the entire province is classified in this respect as second place in the country); and it has a well-developed entity structure of the transport and logistics industry. All of the above factors make the city an important hub, due to the development of freight transport, both in terms of goods transit and internal flows within the city or between the city and other neighboring cities. Thus, the organization of freight transport is a big challenge for the city, due to the need to create a freight transport system that will fully implement the tasks set for it, but, at the same time, will be a sustainable system. The answer to this is the need to develop multimodality in freight transport and, therefore, to undertake activities that will support this goal.

As previously indicated, the authors, taking into account the research methodology presented in Section 3, built scenarios for the development of multimodal freight transport for the city of Katowice. Four main scenarios were formulated: zero scenario (Z), optimistic (O), pessimistic (P), and most likely (ML) scenarios. The scenarios distinguish perspectives that are the pillars of sustainable development: social, environmental, and economic, as well as introduce a fourth group of factors referred to as “other”, which includes determinants that are not related to the previous three perspectives. Scenarios built in this way, broken down into perspectives, are presented in Tables 4–7.

The built-in scenarios were depicted as part of a graph showing the range of average impact strength for each scenario in each perspective (Figure 4).

The zero scenario indicates a moderately positive impact of the current conditions on the development of multimodal transport (social perspective 0.36; environmental perspective 0.13; economic perspective −0.5; other 0.09). Considering its spread, it can be seen that, in the social perspective, the separation of railway linear infrastructure (passenger and freight) is currently a strong inhibitory factor and it is this factor that determines the negative spread of this perspective. In the environmental perspective, such a factor is the intensity of natural hazards, and in the economic perspective, the level of the city's expenditure on the development of linear infrastructure. In the group of other factors, these are the number of solutions promoting the development of multimodal transport included in the city's strategy and the scope of aspects of freight transport included in the city's strategy. Considering only the factors that are controlled by the city in individual

perspectives, again, the average values of the zero scenario are close to neutral (social perspective 0.75, environmental perspective 0.13, economic perspective  $-0.5$ , and other 0.07). Thus, it can be seen that the social and environmental perspective have a slightly positive impact on the development of multimodal transport, the economic perspective has a slightly negative one, while the average of other factors is neutral. From the point of view of factors on which the city is influenced by social and environmental perspectives, they have a similar small and positive impact, while factors in the economic and “other” perspective are moderately negative, inhibiting the pursuit of multimodal transport. Among these factors, the scope of freight transport included in the city’s strategy and the number of solutions supporting the development of multimodal transport included in the city’s strategic documents have the most inhibitory effect. Therefore, the biggest problem that can be read from the zero scenario is the failure to recognize the importance of freight transport in the city, and thus not taking action related to the sustainable development of freight transport in the city. Indicated factors, inhibiting the development of multimodal transport in the city, are balanced by factors such as the level of cooperation of the city with other cities, access to alternative linear infrastructure (rail transport—trams, bicycle freight transport), length of railways and waterways, and level of city development (including social capital, scientific and R&D facilities)

**Table 4.** Summary of impact forces for individual scenarios in a social perspective.

Factor	Impact Strength in the Scenario:			
	Z	O	P	ML
E-commerce level	0.5	1.5	−1	1.5
Population density and structure	0.5	1.5	−0.5	0.5
Level of awareness and attitude towards ecological aspects	0.5	3	−3	3
Urbanization level	0.5	1.5	0	1.5
Level of city development (social capital, scientific and R&D facilities)	1.5	3	−2	3
Level of separation of freight linear infrastructure from passenger rail transport	−2	3	−3	−2
Access to alternative linear infrastructure (rail transport—trams, bicycle freight transport)	1	2.5	−2	2.5
Medium impact strength	0.36	2.29	−1.64	N: −2.0 P: 2.0

Z—zero scenario, O—optimistic scenario, P—pessimistic scenario, ML—the most likely scenario. Source: Own elaboration.

**Table 5.** Summary of impact forces for individual scenarios in an environmental perspective.

Factor	Impact Strength in the Scenario:			
	Z	O	P	ML
Intensity of natural hazards (e.g., mining damage)	−1	1	−2	−1
Level of external costs of transport	1	2.5	−2	2.5
Scale of aspects of environmental protection in the city’s strategy	0.5	3	−3	3
Restrictions on the movement of freight by road	0	3	−3	3
Medium impact strength	0.13	2.38	−2.5	N: −1.0 P: 2.83

Z—zero scenario, O—optimistic scenario, P—pessimistic scenario, ML—the most likely scenario. Source: Own elaboration.

**Table 6.** Summary of impact forces for individual scenarios in an economic perspective.

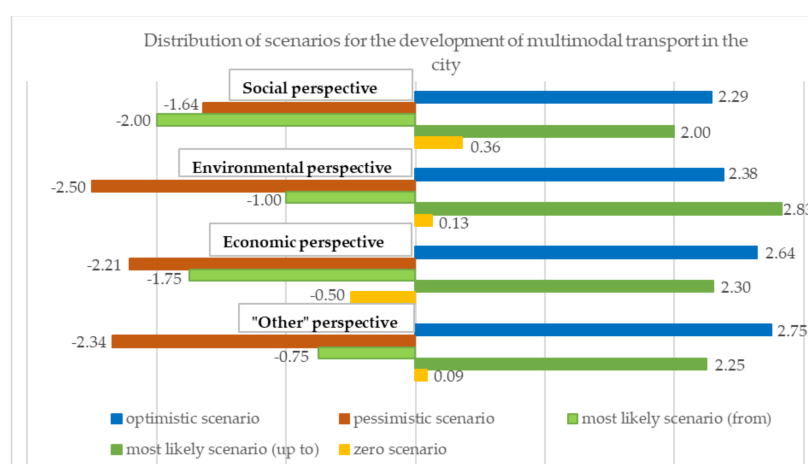
Factor	Impact Strength in the Scenario:			
	Z	O	P	ML
Level of state expenditure on the development of linear infrastructure	1	3	−2.5	3
Level of city expenditure on the development of linear infrastructure	−1.5	3	−2	−1.5
Level of industrialization of the city	0.5	2.5	−1.5	0.5
Level of innovation in the city	−0.5	3	−2.5	3
Level of demand for rail transport	−1	3	−2.5	3
Price level of competitive modes of transport (mainly by road)	−1	2	−2.5	2
Level of fees for carriers' access to railway linear infrastructure	−1	2	−2	−2
Medium impact strength N: negative, P: positive	−0.5	2.64	−2.21	N: −1.75 P: 2.30

Z—zero scenario, O—optimistic scenario, P—pessimistic scenario, ML—the most likely scenario. Source: Own elaboration.

**Table 7.** Summary of impact forces for individual scenarios in the “other” perspective.

Factor	Impact Strength in the Scenario:			
	Z	O	P	ML
Number of solutions included in the city's strategies promoting the development of multimodal freight transport in the city	−1.5	3	−3	3
Level of city's cooperation with freight transport stakeholders	−1	3	−2.5	−1
Degree of including multimodal freight in the country's transport policy	1	3	−2.5	3
Number of solutions included in the state transport policy promoting rail and multimodal transport	−1	3	−3	3
Requirements of PKP PLK SA regarding the access of carriers to the railway linear infrastructure	1	3	−2	1
Scope of aspects of freight transport included in the city's strategies	−1.5	3	−3	3
Parameters of transshipment terminals	1	3	−2	3
Development of ro-ro technology	−0.5	2	−2	−0.5
Development of ro-la technology	−0.5	1.5	−1.5	−0.5
Level of rail system interoperability	1	3	−2	1
Degree of compactness of the city	0.5	2.5	−2.5	0.5
Availability of areas intended for logistic support of the city	−1	3	−2.5	−1
Length of railway linear infrastructure and navigable waterways in the city	1.5	3	−2	1.5
Network of multimodal transshipment terminals	0	2.5	−2	2.5
Formulated railway programs and their degree of implementation	1	2.5	−2	2.5
Level of cooperation between cities in the region	1.5	3	−3	3
Medium impact strength N: negative, P: positive	0.09	2.75	−2.34	N: −0.75 P: 2.25

Z—zero scenario, O—optimistic scenario, P—pessimistic scenario, ML—the most likely scenario. Source: Own elaboration.



**Figure 4.** Distribution of scenarios for the development of multimodal transport in the city of Katowice. Source: Own elaboration.

Analyzing the most likely scenario, it can be seen that, in the social perspective, as many as 5 out of 7 factors are likely to change in a positive direction for the development of multimodal transport. These are development of the e-commerce market, increase of awareness and focus on ecological aspects, increase in the level of urbanization, increase in the level of development of the city, and increase in access to alternative linear infrastructure (including rail transport, bicycle freight, etc.). These highly probable changes in factors are the result of the observed gradual change in society awareness, but also the increasing awareness of local government units regarding broadly understood issues affecting the quality of life of residents. In the environmental perspective, four factors (all acknowledged as dependent on the decisions of local government units) are likely to change in a direction conducive to the development of multimodal transport. These are an increase in the external costs of transport, an increase in solutions (activities, undertakings) included in the city's strategy in the field of environmental protection, and an increase in restrictions and legal regulations in the field of freight traffic in the city. The increase in external transport costs is always an impulse to look for other alternative transport solutions, and such a solution is multimodal transport. Similarly, you can explain the relationship between restrictions on freight traffic in the city—they are aimed at reducing car transport in the city, but, at the same time, they are an opportunity for alternative transport solutions, especially in the area of the last mile. These factors are consistent with the social perspective, in which, at the same time, one can notice a high probability of e-commerce trade growth, which further strengthens the impact of both external costs and regulations in the field of freight transport in the city. Certainly, the environmental perspective emphasizes the important role of the city in creating conditions conducive to improving the negative impact of freight transport in the city and on the environment, and thus creating solutions that enable the development of alternative freight transport solutions in the city, including multimodal transport. The economic perspective only has three out of seven factors that depend on the city itself. Four out of seven factors were assessed as likely directions of change, supporting the development of multimodal transport. Of these four factors, only one depends on the city: an increase in the city's level of innovation. The other three are an increase in the level of state expenditure on the development of linear infrastructure, an increase in the level of demand for rail freight, and an increase in the level of prices in road transport. The economic zone perspective is the least conducive for the development of multimodal transport and, in this area, it is necessary to look for opportunities to acquire various sources of financing for investments supporting sustainable development. At the same time, in this perspective, factors have been noticed that may be classified as risk factors, their probability is not high (between 0.15 to 0.2), however, the negative impact is very high (between  $-2.5$  and  $-3$ ). This group includes a decrease in state

expenditure on the development of linear infrastructure, a decrease in innovation in the city, a decrease in demand for rail freight, and a decrease in prices in road transport. A particularly noteworthy factor is the level of innovation in the city. Depending on the changes of this factor (which in the zero scenario is basically neutral:  $-0.5$ ), it may either have a strong inhibitory or stimulating effect on the development of multimodal transport. This factor depends, among others, on the focus on financial resources for innovative solutions that fit into the concept of a smart city. Thus, taking into account this currently very clear tendency to co-finance from various sources of smart city solutions, it is worth including this factor on the side of significant design assumptions for the city. The greatest turbulence can be seen in the perspective of other factors that do not result from the concept of sustainable development. In this group, out of 16 factors (including 7 controlled by the city), 7 were assessed as likely changes that will have a positive impact on the development of multimodal transport (including only 3 on the city side). These factors are an increase in solutions promoting the development of multimodal transport in the region in the city's strategies, an increase in the degree of including multimodal freight in the country's transport policy, an increase in solutions promoting multimodal freight in national policy, an increase in solutions in the field of multimodal freight included in the city's strategy, an increase in quality parameters of transshipment terminals, an increase in the density of multimodal transshipment terminal networks, an increase in the number of railway programs and the degree of their implementation, and an increase in the level of cooperation between cities in the region. The group of factors included in the "other" perspective includes such factors that may have a strong negative impact (the probability of such events varies from 0.05 to 0.25). These factors should be included in the risk map, among them the factor with the highest probability is the decrease in access to areas designated for the city's logistics support.

#### 4.2.3. Discussion Concerning Logistic Factors in the Context of Strategy of a City Striving for Sustainable Development

Research performed at the first stage of the adopted methodology showed a group of 34 factors that affect the multimodal freight transport development in a city. From among them, 20 factors have been identified as those that a city may have an impact on (the second stage of research in the adopted methodology, an answer to the first research question). All 34 factors have been assigned to three perspectives of sustainable development and one perspective not related to the mentioned concept ("other"). They were included in the built scenarios of multimodal transport development in a city. This allowed for identifying:

- within social perspective—6 out of 7 factors were related to a city,
- within environmental perspective—all factors are dependent on a city,
- within economic perspective—only 3 out of 7 factors were related to a city,
- within perspective identified as "other"—only 7 out of 16 factors are dependent on a city.

Diversity of identified factors related to a city and their relationship with individual perspectives shows the validity of division of these elements that may and should be reflected in the city strategies, those that require funding and implementation of strategic and operational projects, and those that should be continuously monitored both at the level of a country and city.

A proposal for such a set of factors for the city of Katowice is presented in Table 8. These factors have been assigned to individual pillars of sustainable development: social (1), environmental (2), and economic perspective (3). Factors representing the "other" perspective were marked as 0, i.e., those that are not assigned to the pillars of sustainable development. The organization that should undertake to monitor these factors is the Transport and Logistics Observatory (OTL), which was established in 2019 in the province of Silesia.

As mentioned in Table 7, as many as 18 factors dependent on a city should be continuously monitored. Therefore, the proposal is to include this task in the established Transport



and Logistic Observatory organization. Four factors should be subjected to promotional activities and five factors need funding within the scope of the initiated operational programs. Over half of the identified factors dependent on the cities (10 factors) should be directly included in the formulated city strategy striving for sustainable development.

**Table 8.** Supporting the management of the development of multimodal transport for the city.

Factors	Pillars of Sustainable Development	City Strategy	Promotion	Operational Programs	Monitoring—Role of the OTL
Level of awareness and attitude towards ecological aspects	1		+		
Scale of occurrence of natural hazards (e.g., mining damage)	2				+
Population density and structure	1				+
Urbanization level	1				+
Level of external costs of transport	2	+		+	+
E-commerce level	1				+
Level of city development (social capital, scientific and R&D facilities)	1	+			+
Level of city expenditure on the development of linear infrastructure	3	+			
Availability of areas intended for logistic support of the city	0			+	+
Level of city's cooperation with freight transport stakeholders	0	+	+		+
Level of innovation in the city	3			+	+
Length of railway linear infrastructure and navigable waterways in the city	0			+	+
Scope of aspects of freight transport included in the city's strategies	0	+			+
Degree of compactness of the city	0				+
Scale of aspects of environmental protection in the city's strategy	2	+			+
Level of industrialization of the city	3				+
Number of solutions included in the city's strategies promoting the development of multimodal freight transport in the city	0	+	+		+
Level of cooperation between cities in the region	0	+	+		+
Access to alternative linear infrastructure (rail transport—trams, bicycle freight transport)	1	+		+	+
Restrictions on the movement of freight by road	2	+			+

Source: Own elaboration.

#### 4.3. Concept of Assessment of the Impact of Multimodal Transport on the Sustainable Development of the City

Identifying the factors that should be considered in a city strategy and proposal of the organization (Transport and Logistic Observatory) that should monitor them necessitate widening of the research by the opportunity to assess the multimodal transport development for sustainable development of a city. Table 9 indicates the initial concept of such an assessment.

**Table 9.** The concept of assessing the impact of the development of multimodal transport on the sustainable development of the city.

Pillar of Sustainable Development	What Should Be Assessed?	How Should It Be Assessed?
Social perspective	Quality of life of residents Access of residents to the linear infrastructure (separation of the linear infrastructure for passenger and freight transport) Logistics customer service using e-commerce CO <sub>2</sub> emissions Noise	Surveys, descriptive analysis, customer satisfaction index
Environmental perspective	Land use for logistics and transport infrastructure Congestion Land use for point infrastructure (transshipment hubs)	Monitoring system of indicated quantities/ratio analysis
Economic perspective	Economic development of the city City expenditure on modernization of the linear infrastructure	Available static data/ratio analysis

Source: Own elaboration.

The table presents the initial list of measures for individual sustainable development perspectives. Therefore, it answers the third research question asked by the authors.

## 5. Conclusions

In the article, an important and current problem regarding freight transport in cities is addressed. The presented research and its results are part of a wider work carried out on the concept of the development of freight transport, including the desire for its sustainability. This problem is part of the Polish and EU transport policy guidelines, which aim to relieve road transport, develop multimodal transport, and thus reduce the external costs of transport. The adopted concept of research on the development of multimodal transport in the city was based on three formulated questions, which the research sought to answer.

The authors in the conducted research identified a group of 34 key factors that are important for the development of multimodal transport. Of this group, 20 factors are determinants that the city has an impact on through its actions. Thus, there is a significant possibility of the city's impact on the development of freight transport, that it implements. Thus, the first research question was answered.

Research (using regression analysis and cluster analysis) performed at the next stages led to noticing that Polish cities are missing detailed considerations of logistics aspects in the strategies (45% of the studied cities do not consider the identified logistics aspects even at the general level). Thus, a large gap in perceiving the logistics problem related to freight transport by the city administrators is noticeable. This indicates the need to take actions

oriented at inclusion of the logistics aspects into designing or modifying city strategies. The next aspect of the research was performed in the form of a case study for Katowice. It should be emphasized that the whole research methodology adopted by the authors is versatile and can be applied in every city. However, results of the following research stages are directly and specifically related to the studied city. This necessitates their replication for each and every city separately. This is some sort of limitation of the proposed methodology. This also creates a premise for future research within the scope of using the methodology in other cities and for comparison of their results. The research performed using the scenario analysis allowed answering the second research question. The authors proposed classifying the factors into four groups: factors that should be included in the city strategy, factors that require funding and implementation of strategic and operational projects, factors that require promotion, and factors that should be continuously monitored both at the country and city levels. The organization named Transport and Logistic Observatory was delegated to implement the tasks related to monitoring. Its operations will be studied by the authors in the near future. The identified proposals represent a set of managerial recommendations for the territorial self-government units in Katowice. At the same time, they point to an important cooperation problem of production, trade, and logistic service companies with the territorial self-government units. This is a challenge for the mentioned stakeholders of freight transport in the city. It is especially important in the age of increasing e-commerce flows and the last mile transport problems that generate too high external costs of transport. The model of cooperation with the freight transport stakeholders in the city is the area of the next research by the authors. The proposal of support within the scope of monitoring the factors affecting the multimodal transport in the city in the form of the Transport and Logistic Observatory organization is extremely important. The identified proposals must be treated as different managerial implications.

The third research question was the biggest challenge, because it is difficult to find such concepts in previous studies and, at the same time, there are no examples of well-developed multimodal transport systems in cities. Individual indicators should, however, be related to the three perspectives indicated. In the social perspective, it is important to build measures in terms of the quality of life of residents, in particular, expanded to include factors related to the separation of passenger and freight infrastructure, as well as the degree of satisfaction of logistics needs in the area of e-commerce. In the environmental perspective, it is proposed to build a system for assessing the external costs of transport. The impact assessment of the development of multimodal transport on the economic perspective relates to stimulating the economic development of the city by providing logistical support to enterprises in this city, as well as improving the flow between the city and other regions.

The research problem presented in the paper represents an important aspect of functioning of the cities. At the same time, in the age of developing e-commerce, it will necessitate paying more attention to it. These aspects will be included in the next research by the authors.

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