

Review

Defining and Measuring the Relevance of Criteria for the Evaluation of the Inflow of Goods in City Centers

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Abstract: The aim of this paper is to define and measure the relevance of the criteria for the evaluation of the inflow of goods in city centers, in order to improve delivery activities within city centers. The development of the city center leads to the grouping of numerous business operators, which results in the increase of the quantity of goods entering the city center, causing additional traffic congestion, higher levels of noise and emissions of harmful gases. In the long term, this leads to major dissatisfaction with the quality of life among city residents. Therefore, the planning of goods delivery must be in line with the sustainable development of city logistics, while at the same time considering the interests of relevant stakeholders. However, in the existing literature the criteria for evaluating delivery flows have not been comprehensively identified or evaluated by the stakeholders of city centers. In order to fill the research gap, the authors have defined four groups of criteria: technical-technological, economic-financial, organizational and social criteria. To determine the relevance of these criteria, it was necessary to use the questionnaire method to collect data from the stakeholder groups defined by the literature review. Regarding the relevant stakeholders (carriers, delivery recipients, residents and urban policy makers), the results have pointed out that the technical-technological and organizational criteria groups are considered the most relevant by the stakeholders regarding the inflow of goods in city centers.

Keywords: city logistics; delivery flows; interest groups; evaluation criteria



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1. Introduction

Urban development is one of the key issues of the modern age. Every day there is an increase in migration of people from rural to urban areas, most often for economic and social reasons. More than 50% of the global population lives in cities, and by 2050 the percentage is projected to increase to 70% [1]. A growing number of inhabitants place a heavy burden on cities, which represent the social and economic backbone, and are also the center of social, economic and cultural activities.

Modern urban development moves in two interrelated directions: the direction of sustainable development that provides a framework for shaping policies and strategies for continuous economic and social progress based on available resources, without (or with minimal) damage to the environment and natural resources relevant to human activities in the future, and the direction for the development of smart cities that focuses on residents who use energy, materials, services and finance to catalyze sustainable development and ensure high quality of life by combining technology, architecture and renewable energy sources. As part of the smart city concept, what can be highlighted is the planning of sustainable cities through more efficient, innovative and safer transport systems, the development of reliable transport networks and the reduction of environmental pollution, and other similar impacts [2].

Delivery of goods significantly affects the sustainable development of the city center. As the population of people gravitating to city centers grows, the challenges of delivering

necessary goods in an appropriate manner are increasing. Numerous flows of goods from and within the city center increase the level of congestion in city centers, which are already congested by public transport and cars. High emissions of harmful gases occur due to the rising turnover of goods and due to the fact that conventional trucks equipped with outdated technology are used for transport [3].

Stakeholders of the city center are interested in making decisions or achieving goals that seek to improve the existing delivery situation [4]. Each stakeholder group strives to pursue its interests, but the only correct decision is the one that will consider the opinions of all stakeholders but without explicit policy leadership there is a danger that certain institutional stakeholder priorities will be imposed over others by the most powerful without adequate dialogue [5]. Each stakeholder group has its own interests and perception of problems related to delivery activities, which increases the complexity in finding the optimal solution. Therefore, mutual interaction is necessary. Non-compliance with the interests of stakeholders can have major consequences for the sustainability of the urban logistics system [6]. The question is how to organize and structure the decision-making process so that all stakeholders contribute to the potential decision [7].

Delivery of goods is important for the functioning of the economy within the city center, such as the need to replenish stocks of food and other retail goods in stores, delivery of documents, office supplies, etc. Although delivery of goods plays an important role in the economic development of the city center, it also has a number of negative effects [8]:

- traffic congestion: delivery vehicles make up between 5% and 10% of the total flow of vehicles in city centers. However, when parked outside designated delivery points, they obstruct roads and contribute to congestion;
- reduction of air quality: almost all delivery vehicles have a diesel engine which results in the emission of harmful gases that directly affect human health;
- greenhouse gas emissions: delivery vehicles are a significant greenhouse gas generator; although this may be of less interest to city authorities, this issue must be addressed by the European Union directives;
- noise: sleep disturbance of residents, especially in early morning and evening deliveries;
- reduced safety: city authorities consider delivery vehicles to be dangerous for both pedestrians and cyclists because of their size, especially near buildings in the city center where streets are too narrow.

Inefficient distribution leads to additional costs for the carrier and is ultimately borne by the end user. City logistics has the task of developing and implementing measures to achieve an efficient and environmentally friendly urban transport system [9]. Customers expect that carriers will provide a better transport service within Just-In-Time delivery [10]. For this reason, most carriers have their headquarters near city centers. This results in an inefficient use of delivery vehicles, which use their capacities inadequately, all because of customer satisfaction in terms of speed of delivery [10,11]. The entry of heavy goods vehicles (HGVs) into city centers disrupts the quality of life of its residents. However, these same vehicles bring the goods the residents need [12]. Certainly, the goals of urban transport management include reducing transport costs and setting a higher level of quality of logistics services to make the urban area “cleaner” and “quieter”, which would have a positive impact on the quality of life of residents [12]. Planning the delivery of goods in the city center without theoretical and scientific support, as well as without practical application of the principles of sustainable and smart development, and without taking into account the interests of city stakeholders, has a negative impact on the sustainable development of the city center. This fact motivated the authors for this research to try to give a framework for improving delivery activities, all for the purpose of sustainable development of the city center. Thus, there is a need to define and evaluate the criteria for the inflow of goods to the city center, with the aim of improving sustainable logistics of the city.

Anand et al. [13] provide an overview of the ways of modeling city logistics with regard to its importance and role in society and try to identify the shortcomings of mod-

eling urban transport. They emphasize that the development of the model requires a multidimensional and multidisciplinary approach where all stakeholders who are a part of the city center must be considered. Tamagawi et al. [14] developed a model according to which the customer determines the time of the earliest and latest delivery in which the order must be delivered. The results of the model indicate that the ban on trucks entering the city center directly affects the sustainability of the city area, which leads to an acceptable environment for all stakeholder groups, both for residents and the reduction of delivery times. Koster et al. [15] emphasize the importance of the organization of postal and parcel services. One of the most relevant criteria is travel time to the end customer. They point out that travel time is very difficult to predict, given that the number of vehicles in traffic differs during the day, i.e., traffic jams are created. They emphasize that all stakeholders, including local residents, carriers, administrators and delivery recipients, must be involved in decision making. Gonzales-Feliu [16] emphasizes that stakeholders should have a direct influence on decision-making related to urban logistics. The author recognizes several stakeholder groups, such as public administration, which has both a legislative and technical role, passenger transport, delivery people, locals and users of public transport and delivery services. Neghabadi et al. [17] emphasize the importance of urban logistics planning, especially the part related to sustainable development. Such planning requires the interaction between all stakeholders, suppliers, retailers, consumers and local authorities in order to find the optimal solution for the development of urban logistics. Morfoulaki et al. [18] point out that the goal of urban logistics is to optimally plan, manage and control cargo movement within the logistics network in the urban area with regard to integration and coordination between the stakeholders involved. The consequences of such planning are expected to reduce noise pollution, air pollution, congestion and carbon emissions; it also implies measures and methods of assessment. They note that the main interest groups are freight carriers, local authorities and residents (consumers). Munda [19] believes that issues related to the sustainability of the city center are characterized by a high degree of possible conflicts between stakeholders. The paper emphasizes the criteria related to sustainability, which are economic, environmental and technological.

Berbe et al. [20] emphasize the importance of proper selection of criteria related to the observed issues. They point out that it is necessary to include defined interest groups in making any decisions. Deluka-Tibljias et al. [21] present the issue of decision-making on transport infrastructure. The authors analyze the constraints of decision-making in which several stakeholders participate, indicating the importance of involving stakeholders in decision-making in the planning, design, maintenance and reconstruction of transport infrastructure in urban areas. They emphasized that when choosing the criteria, it is necessary to pay the most attention to the criteria related to the sustainability of the urban area. Jaeger et al. [22] present a literature review that identifies green supply chain challenges in multi-tier supply chains. The purpose of the paper is to identify operational bottlenecks in the multi-tier supply chain to guide organizations towards where they should focus their efforts to address their supply chain environmental challenges. The applicability of the model is demonstrated by identifying environmental bottlenecks in a healthcare supply chain that support decisions about which challenges a green supply chain strategy should address. Watrobski et al. [4] point out the problems of harmful gas emissions in urban areas and emphasize that the biggest polluters of the city center are HGVs. Given the growing interest in the use of vehicles on alternative fuels, the authors have selected the criteria related to the use of electric vehicles such as speed, capacity, battery charging time, price, etc.

Zanella A. et al. [23] provide an overview of the technologies, protocols and architectures provided by Internet of Things technology. They conclude that the new technology will greatly facilitate the planning and organization of the delivery of goods to the city center, but also the lives of the residents of the city center in general. Tijan et al. [24] present a comprehensive overview of the current and rising trends in the use of blockchain technology in logistics and supply chain management. They emphasize that this technology

can facilitate logistics tasks: It can be used to track orders, order changes and freight documents, and it can help in sharing information about the manufacturing process and delivery. Upadhyay et al. [25] explored the challenges and opportunities of adopting blockchain technology from the lens of the technological–organizational–environmental framework (TOE) for operational excellence in the UK automotive industry context. The authors present significant theoretical and managerial implications and deep understanding for companies seeking to understand the challenges and opportunities of blockchain adoption for their operational excellence.

As can be seen from the papers in general, the authors showed the impact of a single/multiple criteria on city centers. None of the papers included a whole range of criteria related to city center delivery activities at once. We also recognized that articles related to new technologies emphasize the possibility of accelerating business processes, i.e. better planning of business activities.

According to the literature review, the authors conclude that numerous stakeholders are involved in the decision-making process. One stakeholder group is always related to public policy (local, regional, national or European level). The other stakeholder groups depend on the research topic (residents, industries, freight forwarders, carriers, etc.) [20,26].

Decision makers always strive to decide based on an optimal solution. Unfortunately, the optimal solution exists only in the case of one criterion; in real situations, almost every decision involves conflicts and dissatisfaction [21,27]. The decision-making process that results in choosing the best solution provides a solution in which positive results outweigh possible losses [19]. The goals of the decision-making process are to effectively generate necessary information for decision-making from available data, to efficiently generate solutions, and to understand potential decision-making problems [4].

Based on a review of the literature and theoretical determinants of the development of city logistics, the aim of this paper is to define and measure the relevance of the criteria for the evaluation of the inflow of goods in city centers. In the paper authors have defined four possible groups criteria which are tested by identified stakeholders through survey questionnaire.

In the first section, Research Methodology, we explain the selection of criteria and the method of data collection used to determine the relevance of selected criteria. The second section analyzes in detail the theoretical results for the evaluation of the inflow of goods in city centers. The third section focuses on the results of empirical research. The article finishes with concluding remarks.

2. Research Methodology

The lack of scientific and professional research related to the delivery of goods to city centers, was the main factor that led us define and measure the criteria to determine guidelines for improving delivery activities. The application of the methodology will be used mostly for urban policy makers who, with the help of other relevant stakeholders, will be able to make decisions for the benefit of the entire community. To define and measure the relevance of criteria for the evaluation of the inflow of goods in the city center, it was necessary to identify the stakeholder groups and select the evaluation criteria. When identifying stakeholders, it was necessary to determine the scope of the research in order to determine the boundaries of the defined problem [28]. With regard to sustainability issues in the context of mobility and transport, special attention must be paid to how the decision made will affect individual stakeholders.

In this paper, we applied the methodology to define and measure the relevance of criteria for evaluating the inflow of goods in city centers according to the following steps:

- step 1; identify stakeholders,
- step 2; define criteria for evaluation,
- step 3; conduct a survey questionnaire,
- step 4; set guidelines for improving delivery activities.

Based on a review of the literature related to urban logistics [13–16], the authors have singled out four stakeholder groups relevant to the evaluation of the inflow of goods in city centers: carriers who transport the goods into the city centers, delivery recipients who receive the said goods, urban policy makers (or regulators/supervisors) and residents which is the first step of this research.

Carriers and delivery recipients are directly involved in delivery activities, while urban policy makers and residents are not directly involved, but are significantly affected by the way delivery service is handled [29]. After the stakeholder groups have been defined, it is necessary to define the evaluation criteria with regard to the researched problem of delivery activities within the city center. The definition of criteria is primarily based on determining the goals of stakeholders, and the fact that the interests of all stakeholders must be considered in order to make a good decision.

In selecting the criteria, the authors considered those related to the general development of the city center, such as greenhouse gas emissions, noise levels, investment in new/existing technologies, etc. [4,17–21] and criteria related to the organization of delivery activities. The authors have divided the criteria for evaluating the inflow flow of goods in city centers into four groups: technical-technological criteria group, economic-financial criteria group, organizational criteria group and social criteria group. This represents the second step of this research.

As stated before, an assessment of the relevance of the criteria by stakeholders is necessary to set guidelines for improving delivery activities. The research was conducted to define the criteria and their relevance for the inflow of goods to the city center. In accordance with their opinions, the respondents rated the criteria on a scale from 1 to 5, with grade 1 assigned to a criterion that was considered completely irrelevant and grade 5 assigned to a criterion of the utmost relevance for the inflow of goods in city centers. Conducting a questionnaire is the third step of this research. By analyzing the questionnaire, the authors propose guidelines for improving delivery activities, which is the fourth step of this research.

3. Application of Research Methodology

This chapter provides an overview of the stakeholder groups and the defined criteria related to inflow of goods in city centers. The criteria and stakeholders were defined based on the methodology explained in the previous chapter. This chapter will theoretically explain step 1: the identified stakeholder groups and step 2: the defined criteria for evaluation.

3.1. Stakeholder Groups

Stakeholder engagement is increasingly recognized as an important part of every decision-making process. Cities that have established constructive networking with stakeholders have been more successful in designing new transport solutions and setting up new management rules [30]. Conflicts between different stakeholder groups inevitably arise, especially between residents and carriers in the city center itself. Urban policy makers are trying to find the balance between the demands of stakeholders who must protect the interests of residents, and at the same time support the economic sector [8].

Successful cooperation between stakeholders leads to the development of strategies that contribute to the development of city logistics. In order to make the right decisions, it is necessary to involve and encourage all stakeholders from the planning stage [31].

3.1.1. Urban Policy Makers

Urban policy makers should protect the interests of both residents and businesses. The goal of public administration is to provide residents with a quality life with as few (or no) greenhouse gas emissions as possible, noise reduction and optimal use of infrastructure to meet the needs of all stakeholders in the city center. Urban policy makers must be neutral and should play a major role in resolving any conflicts between urban logistics

stakeholders [12]. Their task is to coordinate interest groups and facilitate the development of city logistics. Urban policy makers are increasingly embracing the fact that an efficient delivery service has an important impact on the city's economy [32]. Given the potential conflict between interest groups, it is necessary to find balance in making any decisions that must strive to minimize economic costs.

3.1.2. Carriers

The main goal of carriers is to reduce costs by increasing the efficiency of delivery of goods to recipients, i.e., to minimize the costs associated with the collection and delivery of goods to customers in order to increase profits. A pressure from customers to improve the quality of service with lower transportation costs is present, which is especially true when the carrier is required to deliver goods to customers within a certain period [30]. Carriers often face difficulties in transporting on city roads, mostly due to traffic jams, bottlenecks, but also due to inadequate delivery points. This leads to an inefficient use of delivery vehicles, where a small number of consignments/goods are transported and delivery vehicles are often forced to wait near the delivery location [33]. Carriers are limited by determinants set by others, such as store opening hours or the inability to pick up shipments/goods at certain hours.

3.1.3. Delivery Recipients

Delivery recipients are located in urban areas and are the end point of the supply chain. This category includes shops, offices, construction sites, residents, etc. Recipients are often not responsible for city delivery because shipments are organized and paid for by the sender (the price of transportation is included in the price of ordered goods). In many cases, recipients do not realize that they can influence city delivery, for example, by setting the time of possible deliveries [33]. Recipients are located in the city itself and for this reason can better identify delivery problems than carriers, who are usually active in a larger geographical area.

3.1.4. Residents

Residents are a very important interest group and they are extremely interested in sustainable development practices. They oppose the idea of HGVs inside the city center regardless of the fact that they deliver the goods people order. They agree that traffic congestion, noise, greenhouse gas emissions and the number of traffic accidents near residential or retail areas should be reduced. In shopping districts of urban areas, stores want to receive goods at a convenient time, which can sometimes lead to conflict with the interests of residents who want calm and safe conditions on local roads [17].

3.2. Evaluation Criteria

After identifying the stakeholder groups related to delivery activities within the city center, it is necessary to pinpoint the criteria related to the defined stakeholder groups. The defined criteria are based on determining the goals of the stakeholders of the observed research area. The defined criteria are divided into four groups of criteria as shown in Figure 1.

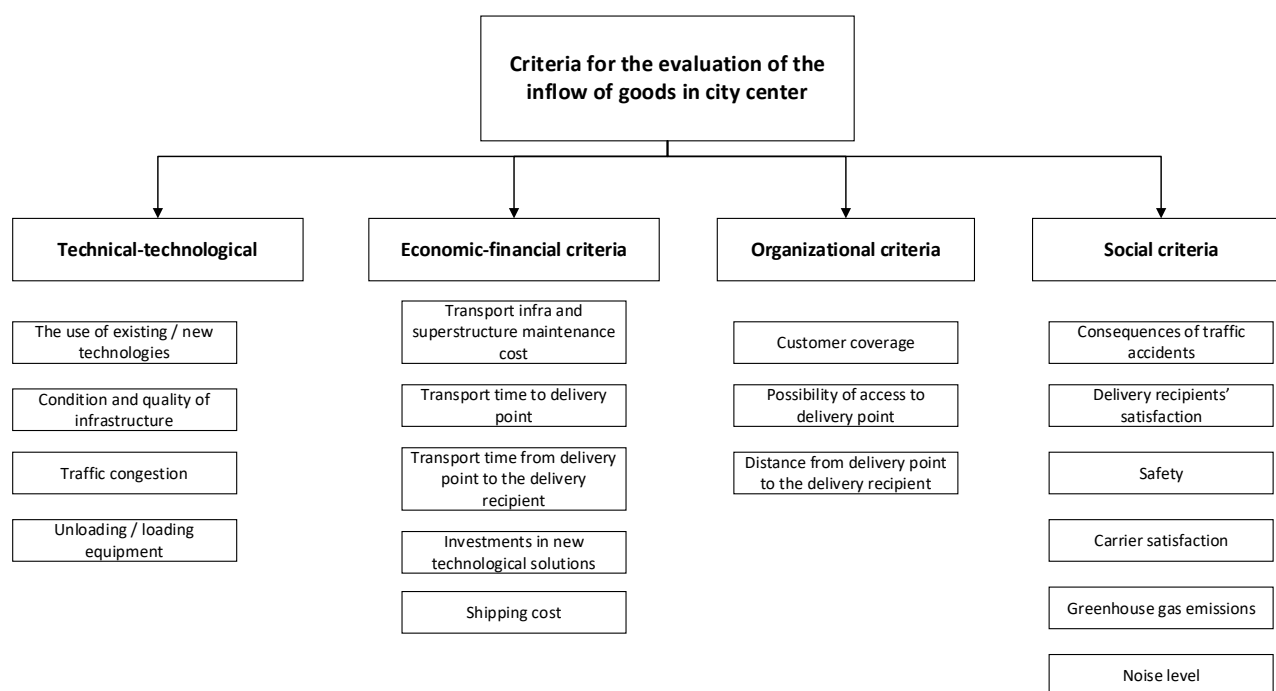


Figure 1. Evaluation criteria. Source: authors.

3.2.1. Technical-Technological Criteria

Technical-technological criteria influence the improvement of delivery activities within the city center through better synchronization of all stakeholders of the city center, and especially between carriers and delivery recipients [34]. In the following part, the authors singled out several criteria related to technical and technological development:

The use of existing/new technologies—with the challenges of delivering goods to city centers and tracking packages in real time, there is a need for innovation and affordable technology. The use of modern technologies, primarily the Internet of Things, RFID (radio frequency identification), artificial intelligence and environmentally friendly vehicles, both in transport and in warehouses and distribution centers, ensures cost reduction. It also reduces operating time and frustration for consumers, as well as supply chain operators [35]. Using the devices, which have the ability to communicate with each other, increases business flexibility. Used in combination, these technologies help delivery recipients and carriers to accelerate business processes [23].

Condition and quality of infrastructure—the future of cities is inconceivable without efficient infrastructure for business activities and the organization of delivery without the use of new technologies and innovations. The main purpose of developing such a system is to use alternative vehicles such as electric cars to reduce greenhouse gas emissions. High quality infrastructure is a prerequisite for the provision of efficient transport services for freight transport, which in turn supports basic economic activities [36].

Traffic congestion—due to rapid economic development and growing urban population, the number of vehicles gravitating to the city center has increased dramatically. Demands on the city's transport infrastructure are increasing due to the growing number of traffic jams and bottlenecks. Traffic congestion seriously affects daily activities of residents, causing environmental pollution and waste of resources [37].

Unloading/loading equipment—the equipment used by delivery vehicles for loading/unloading of goods should minimize the transfer time of goods from delivery points to the premises of delivery recipients. When planning unloading/loading, the characteristics of goods such as weight, nature (size, shape, stability) and the method of fastening/separating the lifting equipment must be considered. Delivery is usually done

manually, by carts and forklifts. The method of unloading usually depends on the distance from the delivery point to the premises of delivery recipients [38].

3.2.2. Economic-Financial Criteria

The economic-financial group of criteria encompasses several criteria that significantly affect the efficiency and quality of the delivery service. The selected economic and financial criteria are:

Transport infra and superstructure maintenance cost—the maintenance of transport infra and superstructure includes the costs of maintaining the existing transport network. It covers those expenditures that are most often financed by public and local governments [15].

Transport time to delivery point—is the time required for the delivery of goods from the place of departure to the place of delivery. In addition, it is necessary to consider the time for organizing the shipment of goods, which includes the collection and packaging of goods for a particular place of delivery [10].

Transport time from delivery point to the delivery recipient—represents the time required for the transfer of goods from the delivery point to the premises of delivery recipients. This is significantly affected by the distance between the place of delivery and the premises of delivery recipient [9].

Investments in new technological solutions—investments in modern technology (mentioned in the criterion “The use of existing/new technologies”) can result in reduced costs and improved profitability. The strong growth of e-commerce fuels consumer expectations for faster and more flexible delivery. Modern technological solutions enable intelligent consolidation of orders, enabling delivery by vehicles which are optimally loaded, which affects business efficiency [39]. Business synergy is needed, along with technological solutions that will unite the interests of all stakeholders.

Shipping cost—refers to the costs incurred by carriers in providing the delivery service. The largest costs that carriers have are the maintenance of the vehicle fleet (own delivery vehicles, rent or leasing, insurance, tires, vehicle registration, repairs, annual services, etc.), labor costs (drivers) and fuel. The goal of carriers is to try to avoid traffic congestion in order to make delivery service more efficient, and thus reduce costs [40].

3.2.3. Organizational Criteria

The criteria from the organizational group are related to the possibility of adequate use of the delivery point and the distance from the delivery point to the delivery recipient. When planning delivery points, it is necessary to analyze the locations and needs of delivery recipients so they are adequately covered by the appropriate number of delivery points [31].

Possibility of access to delivery point—refers to the possibility of parking a delivery vehicle in the place prescribed and marked for delivery. It is often the case that the prescribed and marked parking place for delivery is occupied, and the carrier is forced to make a delivery against the rules by parking on the road, at a bus station, blocking another vehicle or parking on the sidewalk. Respecting the communal order is required, but often not respected [41].

Distance from delivery point to the delivery recipient—refers to the distance from the place of unloading to the premises of the delivery recipient, or to the place where the delivery service must be performed. The criterion of unloading/loading equipment is related to this criterion [41].

Customer coverage—refers to the number of entities that use delivery services in relation to the number of delivery points in the observed area, i.e., how many delivery recipients are served from one delivery point [42].

3.2.4. Social Criteria

Social criteria relate to the quality of life within the city center. Social criteria significantly affect the sustainable development of the observed area, whether it is quality and efficient delivery services or quality of life [43].

Delivery recipients' satisfaction is the judgment of whether a product or service has provided an adequate level of fulfillment. Delivery recipients' satisfaction is influenced by the most common expectations: quality of service and customer preferences. It is an important condition in providing high quality products and services. One of the most important elements of delivery recipients' satisfaction is the delivery of goods on time and in good condition [42].

Greenhouse gas emissions—cities are big polluters and thus significantly affect climate change. Cities consume more than two-thirds of the world's energy and account for more than 70% of global CO₂ emissions. More than 90% of the world's urban areas are located on the coast, and therefore at high risk from the devastating effects of climate change, such as rising sea levels and strong coastal storms. Cities also play a leading role in launching global action to combat climate change [44].

Noise level—city dwellers are regularly exposed to noise of more than 85 decibels from sources such as traffic, subway, industrial activity and airports. Life in the city maintains an average noise level of more than 60 decibels, which contributes to increases in blood pressure and faster heart rate, causes stress, loss of concentration and loss of sleep. Sirens are a particularly extreme example of noise inflicted on people on a daily basis at a level of 120 decibels (a level that corresponds to the pain threshold in humans, according to the World Health Organization). The idea of quiet zones is part of urban planning. The first zoning laws took noise into account by denoting residential areas separate from trade and industry zones [45].

Consequences of traffic accidents—traffic accidents cause economic and social costs for the community. Human activity is the main cause of traffic accidents, which are also affected by external factors such as rain, light levels, etc. It is necessary to identify critical points in order to organize alternative routes for vehicle movement [46].

Safety—in smaller or older cities, delivery vehicles can occupy a narrow street during working hours, leaving a congested passage on both sides for pedestrians, cyclists, people transporting groceries, people pushing wheelchairs or prams. These situations are dangerous for residents and disturbing for delivery truck drivers who often have to pass through a narrow street (or even wait) in order to legally park and deliver goods [47].

Carrier satisfaction—refers mostly to the organization of delivery activities. If the delivery organization is done in such a way that the truck driver has the possibility to park safely at the prescribed delivery point, and delivers the goods to customers or unloads at the agreed delivery time, then it is to the mutual satisfaction of both carriers and customers [41].

4. Results

This chapter shows the third methodological step, i.e., the results of the survey query. In the chapter, authors will also provide guidelines for improving the delivery activities as the final step of this research.

The survey questionnaire was sent to 650 e-mail addresses. Cumulatively, the survey was completed by 239 respondents. The survey sample consisted of carriers, delivery recipients, representatives of the residents and urban policy makers. Within the stakeholder group "urban policy makers", several faculties related to transport, public authorities and urban planners participated in the questionnaire. The stakeholder group "Delivery recipients" consisted of stakeholders who receive delivery service in the city center: cafes, shops, restaurants, etc. The group "Resident representatives" consisted of representatives of buildings in the city center (one representative represents approximately 20 tenants). Respondents were also carefully selected with regard to the observed research. Only respondents who have contact with the delivery service were considered. The data was collected in the first quartile of 2020. The questionnaire was carried out in Southeast Europe.

The criteria for evaluating the inflow of goods in the city center are divided into four main groups, which has already been explained in the previous chapter. The obtained data were analyzed with regard to the average assessment of the relevance of the criteria from the point of view of all stakeholders and from the point of view of each stakeholder group separately. Respondents rated the relevance of the criteria on a scale of 1 to 5.

Table 1 shows the results of the relevance of the criteria assessed by all stakeholder groups (delivery recipients, carriers, residents and urban policy makers).

Table 1. Relevance of the criteria evaluated by all stakeholders.

| CRITERIA | | DELIVERY RECIPIENTS | | URBAN POLICY MAKERS | | RESIDENTS | | CARRIERS | |
|------------------------------|--|---------------------|------|---------------------|------|-----------|------|----------|------|
| | TECHNICAL-TECHNOLOGICAL CRITERION | Mean | Sd | Mean | Sd | Mean | Sd | Mean | Sd |
| T1 | The use of existing/new technologies | 3.19 | 1.36 | 2.86 | 1.36 | 2.84 | 1.35 | 2.87 | 1.34 |
| T2 | Condition and quality of infrastructure | 3.2 | 1.16 | 2.89 | 1.16 | 2.92 | 1.19 | 2.88 | 1.18 |
| T3 | Traffic congestion | 3.27 | 1.43 | 2.67 | 1.41 | 2.75 | 1.45 | 2.66 | 1.39 |
| T4 | Unloading/loading equipment | 3.18 | 1.21 | 2.92 | 1.13 | 2.96 | 1.17 | 2.93 | 1.11 |
| ECONOMIC-FINANCIAL CRITERION | | | | | | | | | |
| E1 | Transport infra and superstructure maintenance cost | 3.2 | 1.03 | 2.73 | 1.02 | 2.77 | 1.04 | 2.73 | 1.02 |
| E2 | Transport time to delivery point | 2.88 | 1.02 | 2.65 | 1.03 | 2.66 | 1.02 | 2.65 | 1.03 |
| E3 | Transport time from delivery point to the delivery recipient | 2.87 | 1.13 | 2.7 | 0.94 | 2.7 | 0.94 | 2.72 | 0.93 |
| E4 | Investments in new technological solutions | 3.08 | 1.19 | 2.63 | 1.23 | 2.64 | 1.23 | 2.63 | 1.21 |
| E5 | Shipping cost | 2.98 | 1.02 | 2.75 | 0.98 | 2.77 | 0.96 | 2.75 | 1.02 |
| SOCIAL CRITERIA | | | | | | | | | |
| S1 | Delivery recipient's satisfaction | 2.48 | 1.12 | 2.65 | 1.05 | 2.57 | 1.07 | 2.62 | 1.06 |
| S2 | Greenhouse gas emissions | 3.07 | 1.2 | 2.98 | 1.26 | 2.97 | 1.23 | 2.94 | 1.25 |
| S3 | Noise level | 3.01 | 1.11 | 2.93 | 1.1 | 2.92 | 1.08 | 2.91 | 1.09 |
| S4 | Consequences of traffic accidents | 3.09 | 1.21 | 2.95 | 1.2 | 2.93 | 1.2 | 2.94 | 1.22 |
| S5 | Safety | 2.84 | 1.22 | 2.55 | 1.09 | 2.54 | 1.08 | 2.54 | 1.08 |
| S6 | Carrier satisfaction | 2.64 | 1.14 | 2.64 | 1.05 | 2.57 | 1.05 | 2.63 | 1.05 |
| ORGANIZATIONAL CRITERIA | | | | | | | | | |
| O1 | Possibility of access to delivery point | 3.13 | 1.36 | 2.89 | 1.22 | 2.84 | 1.27 | 2.85 | 1.18 |
| O2 | Distance from delivery point to the delivery recipient | 3 | 1.22 | 2.85 | 1.02 | 2.84 | 1.05 | 2.85 | 1.04 |
| O3 | Customer coverage | 3.1 | 1.38 | 2.83 | 1.18 | 2.84 | 1.21 | 2.8 | 1.14 |

Based on the data from Table 1, in Figure 2 is shown a radar chart.

Table 1 and Figure 2 show that the criteria from the technical-technological and social groups were rated as the most relevant by all stakeholders. Delivery rated these criteria above average. The criteria of traffic congestion and investments in new technological solutions are especially emphasized here. Interestingly, the criterion of delivery service satisfaction was rated as the least relevant criterion. Carriers, on the other hand, rated the traffic congestion criterion as one of the least relevant. Surprisingly, carriers rated the criteria from the social group as the most relevant, and in addition to consequences of traffic accidents, the criteria of greenhouse gas emissions and noise levels stand out. Carriers are obviously aware of the fact that they have to invest in the vehicle fleet, that

is, make the transition to environmentally friendly operations. Residents, as expected, highlighted the criteria from the social group as the most relevant, and the criterion of greenhouse gas emissions particularly stands out. They also assessed the organizational criteria group as more relevant, especially the possibility of access to delivery point. Surprisingly, they evaluated the safety criterion as the least relevant. Urban policy makers are the drivers of decision-making and the creators of sustainability policies related to the city center. As expected, urban policy makers rated the criteria from the social group as the most relevant. They assessed the technical-technological criteria group as very relevant; unloading/loading equipment and condition and quality of infrastructure stand out.



Figure 2. Average assessment of the relevance of the criteria according to all stakeholders. Source: authors.

Looking at the average ratings of the criteria relevance by all stakeholder groups (Table 2), it is surprising that the criteria of safety and cost of delivery are rated among the least relevant. The most relevant are the criteria related to the sustainability of the city center, i.e., the social criteria group and the technical-technological criteria group.

Based on the results or the respondents' assessment, it can be concluded that investment in new/existing technology can significantly affect the improvement of delivery activities in the city center. It has been shown through a review of the literature that the implementation of such technology accelerates business processes, which is mostly reflected in the income of the service provider, but also in the impact on the satisfaction of the end user.

Table 2. Average ratings of the relevance of the criteria by all stakeholders.

| | Criteria | Average Rating | Standard Deviation |
|----|--|----------------|--------------------|
| T2 | Condition and quality of infrastructure | 3.07 | 1.18 |
| T4 | Unloading/loading equipment | 3.05 | 1.17 |
| T1 | The use of existing/new technologies | 3.03 | 1.34 |
| S2 | Greenhouse gas emissions | 3.03 | 1.21 |
| S4 | Consequences of traffic accidents | 3.02 | 1.20 |
| O1 | Possibility of access to delivery point | 3.00 | 1.27 |
| E1 | Transport infra and superstructure maintenance cost | 2.99 | 1.06 |
| T3 | Traffic congestion | 2.99 | 1.45 |
| S3 | Noise level | 2.96 | 1.11 |
| O3 | Customer coverage | 2.96 | 1.25 |
| O2 | Distance from delivery point to the delivery recipient | 2.92 | 1.15 |
| E5 | Shipping cost | 2.90 | 1.01 |
| E4 | Investments in new technological solutions | 2.87 | 1.22 |
| E3 | Transport time from delivery point to the delivery recipient | 2.79 | 1.04 |
| E2 | Transport time to delivery point | 2.77 | 1.05 |
| S5 | Safety | 2.70 | 1.16 |
| S6 | Carrier satisfaction | 2.64 | 1.09 |
| S1 | Delivery recipients' satisfaction | 2.56 | 1.08 |

Source: authors.

According to the average assessment of the criteria relevance, there is a clear difference in the opinion of the stakeholder groups, which will be proven by applying the ANOVA analysis of variance. ANOVA is a technique of using differences between sample averages in concluding whether the difference exists between the population averages. To perform the ANOVA test, it is necessary to test the null hypothesis and the alternative hypothesis (Equation (1)).

$$H_0 = \bar{x}_1 = \bar{x}_2 = \bar{x}_3 = \dots = x_n, H_1 = \bar{x}_1 \neq \bar{x}_2 \neq \bar{x}_3 \neq \dots \neq \bar{x}_n \quad (1)$$

The null hypothesis states that the averages within the stakeholder groups are equal, while the alternative hypothesis states that the averages within the stakeholder groups differ.

The results show a significant difference in the average relevance of the criteria of the respondents with a reliability of 95%. As can be seen in Table 3, the null hypothesis was rejected; the calculated F (10.1413) is significantly higher than the tabular F crit (2.739502) and it is concluded that there is a disproportion in the ratings evaluated by stakeholders.

Table 3. Application of ANOVA test according to stakeholders.

| Stakeholder Groups | Count | Sum | Average | Variance | |
|----------------------------|---|-------|---------|----------|----------|
| DELIVERY RECIPIENTS | 18 | 54.21 | 3.01 | 0.04 | |
| URBAN POLICY MAKERS | 18 | 50.08 | 2.78 | 0.02 | |
| RESIDENTS | 18 | 50.03 | 2.78 | 0.02 | |
| CARRIERS | 18 | 49.90 | 2.77 | 0.02 | |
| ANOVA | | | | | |
| Source of variation | SS | df | MS | F | F crit |
| Between stakeholder groups | 0.74 | 3 | 0.25 | 10.1413 | 2.739502 |
| Within stakeholder groups | 1.65 | 68 | 0.02 | | |
| Total | 2.38 | 71 | | | |
| Decision Rule: | Reject the Null Hypothesis if F Statistic > 2.7395 or p -Value < 0.05 | | | | |
| Conclusion: | Reject the Null Hypothesis | | | | |

5. Conclusions

City logistics is a recent research area whose purpose is the sustainable development of city centers to the general satisfaction of all stakeholders. Urban population growth, alongside the increasing number of vehicles and the need for delivery services results in the creation of bottlenecks, increased greenhouse gas emissions and delays in goods delivery.

For a successful implementation of delivery of goods within the city center, it was necessary to consider and analyze the relevance of criteria assessed by all stakeholders, so that a decision can be made to the satisfaction of all stakeholders in the city center. The authors have singled out four stakeholder groups relevant to the evaluation of the inflow of goods in city centers: carriers who transport the goods into the city centers, delivery recipients who receive the said goods, urban policy makers (or regulators/supervisors) and residents.

The authors have then selected the criteria that relate to the general development of the city center such as greenhouse gas emissions, noise levels, investments in new/existing technologies, etc. and criteria that relate to the organization of delivery activities. The defined criteria were divided into four groups for evaluating the inflow of goods in city centers, namely: technical-technological group, economic-financial group, organizational group and social group. A survey questionnaire was used to determine the relevance of the criteria. The evaluation of the criteria was done by the stakeholders belonging to the predefined groups: carriers, delivery recipients, urban policy makers and residents, and the results were analyzed.

The data obtained from the survey questionnaire were analyzed with regard to the average assessment of the criteria relevance from the point of view of all stakeholders and from the point of view of each stakeholder group separately. The results of the research indicate a discrepancy in the assessments of criteria relevance between the stakeholders. For example, delivery recipients assessed traffic congestion as the most relevant, while carriers assessed it as the least relevant criterion. It is interesting that both delivery recipients and carriers rated delivery service satisfaction and carrier satisfaction as the least relevant criteria, while they assessed the criteria from the social and technical-technological group as the most relevant. The authors emphasize that it is desirable to involve all stakeholders when making any decisions related to delivery activities within the city center.

The results of the research have justified the main goal of the paper; following the steps of methodological research it is possible to determine the guidelines for the development of delivery activities, all based on the assessment of the relevance of the criteria. The paper did not consider the delivery of smaller packages and the postal service. It is a delivery of goods that can be delivered by motorcycle, bicycle, etc.

This research presents the basis for further research of optimizing the inflow of goods in city centers by applying the multi-actor multi-criteria analysis, based on the criteria identified and measured in this paper. Such an analysis allows the consideration of different scenarios of selected city centers, which can later be verified by simulation tools.

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