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Strategic Optimization of Parcel Distribution in E-Commerce: A Comprehensive Analysis of Logistic Flows and Vehicle Selection Using SWARA-WASPAS Methods

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Abstract: In recent years, e-commerce has emerged as a dominant sales channel, with an increasing number of large-scale companies exclusively operating online. The substantial growth of e-commerce has been paralleled by the growing importance of efficient logistics, as the flow of goods in international trade demands sophisticated planning and execution. Following the purchase stage, logistics plays a pivotal role in ensuring timely delivery to end customers, with final distribution being one of the most critical aspects. The optimization of the distribution process is particularly challenging due to the complexities involved in the selection of transport modes, optimal routing, and the appropriate types of vehicles. This study investigates the parcel distribution process in the Serbian logistics sector, providing a comprehensive analysis of e-commerce flows during the initial stages of goods movement. A decision-making model based on the Stepwise Weight Assessment Ratio Analysis (SWARA) and Weighted Aggregated Sum Product Assessment (WASPAS) methods is proposed to optimize vehicle selection for parcel distribution. The model evaluates ten vehicle alternatives across nine distinct criteria: delivery volume (C_1), average number of parcels per delivery (C_2), vehicle fleet size (C_3), payload capacity (C_4), number of customer complaints (C_5), cargo volume (C_6), incidence of damaged shipments (C_7), loss of shipments (C_8), and vehicle height limitations (C_9). Sensitivity analysis is conducted to test the robustness and stability of the proposed model, ensuring that the selected vehicle configurations are resilient under varying operational conditions. The findings contribute to the broader understanding of logistics optimization in e-commerce, offering insights into the effective selection of transport vehicles that can enhance the efficiency and reliability of the final distribution phase.

Keywords: Distribution; E-commerce; Logistics; Stepwise Weight Assessment Ratio Analysis (SWARA); Weighted Aggregated Sum Product Assessment (WASPAS)

1 Introduction

At the end of the last century, electronic commerce (e-commerce) emerged as a highly relevant phenomenon. This form of trade has been evolving rapidly and has the potential to significantly transform not only business operations but also lifestyles and society as a whole. As e-commerce continues to expand, logistics challenges are increasing at all levels, making this field crucial for logistics service providers [1]. The growth of online shopping is directly linked to the increasing volume of home deliveries, and future expansion in this area is associated with trends such as the rising prevalence of home-based online shopping, the declining number of household members, and the shortening of product life cycles, indicating a growing tendency among consumers to replace products more frequently [1, 2]. The expansion of e-commerce and home shopping impacts both passenger and freight transport in urban environments. Studies have shown that the net effect of fewer passenger car trips and the increased number of delivery vehicle trips could result in a 70-80% reduction in total vehicle kilometers within cities [1, 3, 4]. For example, in Cologne, Germany, over a three-year period, e-commerce contributed to a 14% reduction in passenger car traffic, while freight traffic increased by 3% [1, 5]. However, despite its convenience, e-commerce is still associated with customer dissatisfaction, primarily regarding delivery services [1, 6].

In e-commerce operations, it is crucial to differentiate between customer-facing activities, such as order reception, sales, and marketing (the so-called "front end" of e-commerce), and activities related to order fulfillment and delivery

(the so-called "back end"). The latter involves physical distribution, encompassing the planning, organization, and execution of goods flows to meet customer demands. Most innovations in e-commerce focus on the "front end", particularly the ordering process. However, the "back end" of the B2C (Business-to-Consumer) e-commerce supply chain has undergone only minor improvements. Even the most prominent online retailers have often overlooked the importance of physical distribution, leading to increased costs and significant logistical challenges [1, 7].

In fact, last-mile logistics (LML) represents the most challenging segment of any supply chain (SC), as urban consumers have high expectations regarding the fulfillment of their demands in the shortest possible time, at the lowest possible cost, with no delays or errors. Due to increased traffic congestion, limited parking spaces, and the necessity of complying with increasingly stringent environmental regulations, LML in densely populated urban areas faces significant difficulties. Given the challenges faced by logistics companies in delivering goods and shipments to end customers, a substantial portion of the demand is fulfilled by courier and postal services [8].

The principles underlying the organization of modern postal logistics, such as service accessibility, security, speed of e-commerce parcel distribution, and continuous quality improvement, enable postal operators and logistics providers to respond to the increasingly complex demands of the modern market and environment. A critical role in the provision of postal services is played by the organization of work across all phases of e-commerce parcel distribution (including reception, dispatch, transport, and final delivery), as well as the efficient utilization of all available technical resources [9]. This paper focuses on transport as one of the key phases in the e-commerce parcel distribution process. The primary objective of this study is to emphasize how the complexity of various activities, circumstances, and challenges can make e-commerce parcel distribution highly demanding. The paper analyzes e-commerce parcel distribution based on data and insights provided by Provider 1. Apart from the introduction and conclusion, the paper is structured as follows. The second section provides an overview of the problem and a literature review, highlighting the importance of efficient e-commerce parcel distribution and its impact on enhancing last-mile logistics. The third section analyzes goods flows (e-commerce parcel flows) within the municipalities of Belgrade, aiming to identify patterns and trends in customer ordering behavior. The fourth and fifth sections focus on methodology and the development of a model for evaluating and selecting the optimal type of vehicle for e-commerce parcel distribution, along with an overview of selection criteria, vehicle characteristics, and the implementation results.

2 Problem Description and Literature Review

The e-commerce parcel distribution process begins with the receipt of an order from the customer and concludes with the transportation and delivery of parcels to customers, i.e., the end consumer. The very fact that the distribution process encompasses a large number of activities and participants highlights its significance for every company. Through the distribution process, a company establishes direct contact with consumers, making logistics a key factor in competitiveness [10]. The distribution process is further complicated by the demands that arise within e-commerce. In recent years, e-commerce has become an increasingly important sales channel for products and services. It is estimated that e-commerce accounts for 20-25% of total retail sales worldwide, with online sales expected to grow by approximately 10% annually in the coming years. E-commerce enables consumers to purchase products from around the world with minimal costs, time, and effort. Additionally, the advantages of e-commerce are numerous, including 24/7 availability of products on a global market and the speed and convenience of shopping with a single click from the comfort of home. However, what cannot be achieved as quickly and conveniently is the delivery of parcels, which often leads to customer dissatisfaction. Products ordered online must physically pass through highly complex logistics systems, where logistical processes require time, generate costs, engage various resources, and face numerous risks and disruptions.

E-commerce constantly presents new challenges and demands for logistics, such as reliable product delivery in the shortest possible time, affordable delivery prices and conditions, high product and service quality, frequent deliveries of smaller shipments, product returns, etc. It is rightly stated that logistics and product delivery are crucial and critical factors for successful e-commerce. Online retailers seek various solutions to efficiently deliver products and meet increasing customer expectations. Companies have two options: to handle distribution with their own resources or to outsource it to logistics service providers. The latter option is often more favorable for retailers, as it involves hiring a logistics provider with the necessary knowledge, experience, and resources, qualified to offer comprehensive logistics services in terms of designing, planning, and managing logistics systems and parcel deliveries [10].

The current market landscape among leading e-commerce retailers reflects these challenges. For example, Amazon, which sells a vast range of products online, guarantees fast delivery to customers' addresses. This is why Amazon continually strives to implement (new) business models to enhance delivery efficiency and profitability. When Amazon handles deliveries in-house, it employs full-time couriers. However, to increase delivery volume and reduce costs, the company introduced the Delivery Service Partner (DSP) program, which, along with Amazon Flex, allows for more flexible delivery execution. Amazon Flex is closely associated with crowd logistics. It allows

individuals (whether private persons or legal entities, such as startups) to earn additional income by delivering e-commerce parcels using their own vehicles. Essentially, these individuals act as intermediaries between Amazon and end consumers. Amazon Flex can be considered a type of crowdsourcing platform where "independent couriers" can register to pick up and deliver parcels to customers. The platform offers a wide range of features, from scanning packages at the distribution center and determining delivery routes to final delivery confirmation, including taking a photo of the delivered package at the recipient's address. However, all fuel and other costs associated with the job are borne by the vehicle owner [11].

In addition to Amazon Flex, supplier partner programs are also highly popular. These programs assist entrepreneurs in starting and operating small courier businesses that fulfill orders placed on Amazon's website. Amazon collaborates with entrepreneurs (known as delivery service partners) and compensates them for parcel delivery services while offering discounts on vehicles, uniforms, fuel, insurance, etc. Deliveries are carried out using branded Mercedes-Benz vans, and all drivers are required to wear standardized uniforms and use a uniform fleet of up to 40 vehicles, with a workforce not exceeding 100 employees. Deliveries can take place in the presence or absence of the customer, either at their address or at an alternative location [11, 12]. One convenient solution for parcel delivery in the absence of the customer is the use of lockers, such as Amazon Locker and The Hub. These lockers allow customers to collect their parcels at a time that suits them best. To use these lockers, customers must have an account on the e-commerce platform. The lockers, also referred to as "pickup points," are located near customers' addresses in high-traffic areas such as stores and pharmacies, ensuring cost-effective delivery. Couriers deposit the package into a designated locker drawer, and customers can retrieve their parcels within a specified time frame, typically three days. If the package is not collected within this period, it is returned, and the customer receives a refund [11].

Among the e-commerce platforms that have rapidly gained popularity is Temu, launched in September 2022. It is now one of the most visited e-commerce platforms. Temu's standard delivery time is approximately two weeks from the date of purchase, distinguishing it from platforms such as AliExpress, where delivery times can be unpredictable. Moreover, Temu offers free shipping, which raises questions about whether this is a short-term strategy to gather customer data or a long-term approach. Regardless, it is an effective way to attract customers by eliminating concerns about shipping costs [13, 14]. Furthermore, various studies analyze the digital marketing strategies applied by Temu to expand its business. Some of the most notable studies include [14–17]. These studies indicate that the emergence of Temu has significantly complicated e-commerce parcel distribution, highlighting the complexity of logistical challenges in the sector. On the other hand, Vasić et al. [18] studied the satisfaction of users of logistics services in e-commerce. A model for selecting the e-commerce distribution channel using the FAHP (Fuzzy Analytic Hierarchy Process) and MOOSRA (Multi-objective Optimization on the basis of Simple Ratio Analysis) methods was developed by Vasić et al. [19].

3 The Analysis of Goods Flows in Serbia

In today's rapidly evolving world of online retail, brands face significant competition in gaining popularity. Distinctive branding, social media advertisements, and offers that enable affordable purchases of a wide variety of items make them recognizable. E-retailers continuously develop and enhance their platforms to provide users with the most "comfortable" shopping experience [16]. In most cases, e-retailers succeed in attracting customers by guaranteeing delivery within the time frame specified on the platform at checkout. If delivery is not completed within that period, customers are offered credits that can be used for future orders. These deliveries typically take about two weeks from the moment of ordering. Additionally, various studies show that e-retailers are often compared based on delivery speed. As their business expands, e-retailers' solutions for home delivery include outsourcing to logistics providers, organizing in-house logistics, or opening logistics centers to speed up deliveries [13, 14].

The fact that e-retailers have managed to attract customers from Belgrade municipalities is confirmed by the data presented in Figure 1. According to data obtained from Provider 1, the average daily number of e-commerce shipments in Belgrade municipalities in June was 10,202. In July and August, the numbers increased to 13,101 and 16,125, respectively. A significant increase in customer demand in Belgrade municipalities was observed in September and October, with recorded figures of 19,851 and 25,200 e-commerce shipments. Data from Provider 1 also show a further increase in November, with 37,582 shipments. It is important to note that November will be considered the reference month, and all subsequent tables (Table 1, Table 2, Table 3, Table 4, Table 5, Table 6, Table 7 and Table 8) will refer to this period. The fast and flexible delivery offered by e-retailers has attracted many customers, but logistical challenges, such as collaboration with Serbian Post, may pose problems. Moreover, it is crucial to establish specific patterns in customer demand (what customers are ordering, in what quantities, how frequently, etc.) to ensure efficient shipment distribution. In other words, market segmentation is of particular interest (from both the perspective of the e-retailer and Provider 1).

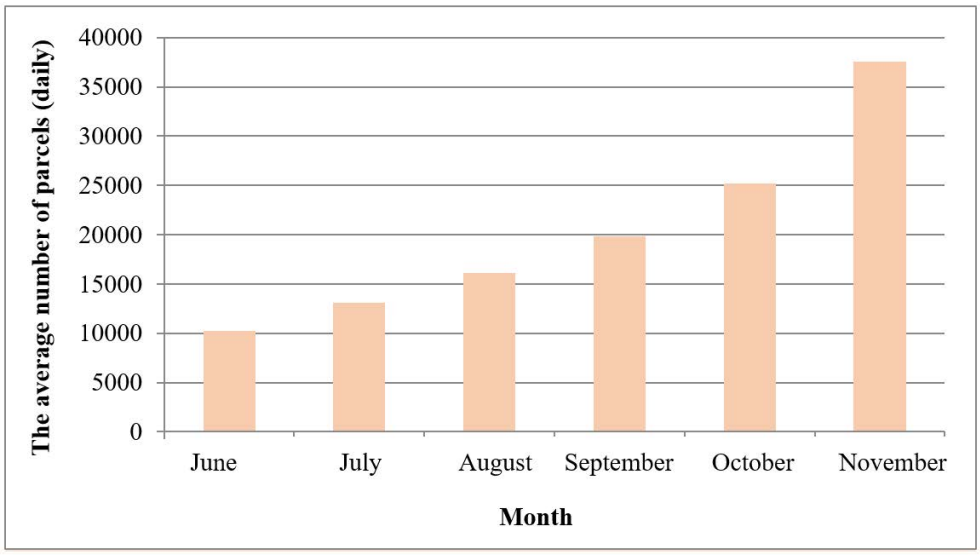

Figure 1. E-commerce parcels per month [20]

Market segmentation is the process of dividing a market into distinct groups of customers with similar needs and characteristics that drive them to respond in a similar manner to a particular product offering or marketing program [21–23], along with Jovanović [21] emphasize that a market segment is a group of customers within a market who share specific characteristics essential for shaping marketing strategies. Effective segmentation enhances profit opportunities by enabling businesses to address different customer groups with tailored economic or psychological value propositions. Variations in product preferences, demand size and growth, and competitive structures influence the differences in customer responses to market offerings. Markets are intricate entities that can be defined in multiple ways. A critical challenge is to establish an appropriate segmentation that facilitates targeting, positioning, and the development of a successful marketing strategy and program [21]. Key motivations for market segmentation include the following [21–23]:

• Enhanced alignment with customer needs – creating tailored offerings for each segment;

• Increased profitability – customers exhibit varying price sensitivities, enabling marketers to optimize pricing through segmentation;

• Growth opportunities – segmentation can drive sales growth by enabling companies to offer higher-margin products to targeted customers;

• Focused communication – delivering clear and targeted messages is easier within a homogeneous market segment than across a broad, undifferentiated market;

• Encouragement of innovation – segmentation provides a clearer understanding of diverse customer needs and economic values across the market;

• Market segment dominance – smaller companies can achieve leadership positions within selected market segments, even if they cannot dominate the entire market.

The market segmentation process involves three crucial steps [21, 22]. The first one is identifying homogeneous segments that differ from others. This step involves pinpointing one or more groups of potential customers who share common needs, desires, and likely responses to different elements of the marketing mix. The second one is defining the criteria that characterize the segment. These criteria should enable clear identification and accessibility of segment members, allowing marketers to determine whether potential customers belong to the target market and reach them effectively through marketing communication tools. Finally, the third step is assessing segment size and potential. Estimating these factors is crucial for prioritizing the segments to be pursued. On the other hand, key criteria for successful market segmentation include [21, 24]:

• Measurability – understanding the size, needs, characteristics, and behavioral patterns of customers. Without measurable success indicators, it becomes challenging to choose between segments and create offerings that deliver superior value;

• Accessibility – the feasibility of reaching the segment through appropriate distribution and communication channels;

• Sustainability – ensuring that the segment is profitable enough to warrant separate servicing;

• Operability – the company's capability to develop a competitive offering that meets the specific needs of the segment.

It is evident that market segmentation significantly enhances the logistics of e-commerce shipment distribution. In this context, consumer behavior in Belgrade municipalities regarding online ordering and purchasing has been analyzed. Various indicators could be considered; however, this study focuses on the type of goods and the average weight of e-commerce shipments.

3.1 Analysis of Goods Flows by Product Type

The following section analyzes the purchasing and ordering behavior of users from Belgrade's municipalities when using e-commerce platforms. The type of goods has been selected as the key variable for analysis. This study aims to facilitate more efficient planning of transport vehicle capacities, assess the need for providing additional shipment insurance services for e-commerce, and similar considerations. The quantities of goods ordered by municipality are presented in Figure 2.

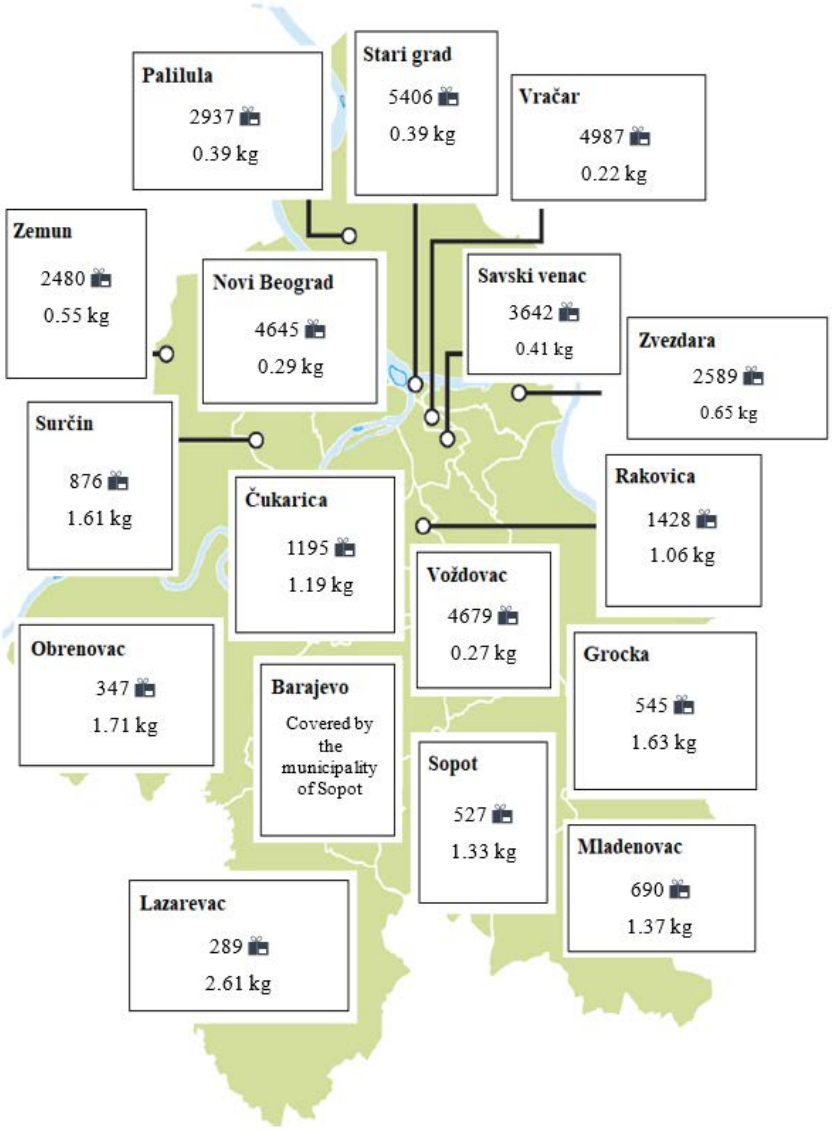

Figure 2. The number of parcels and average weight per shipment across Belgrade municipalities [20]

As shown in Table 1, the majority of shipments that were insured (I) at the municipal level contained jewelry, watches, cameras, gold, clothing, footwear, sports equipment, and leather goods. On the other hand, the least insured shipments (NI) primarily contained soaps and cleaning products, followed by shipments of essential oils, perfumery, and toiletry items. Regarding the municipality of Stari Grad, users requested additional insurance for shipments of books, school supplies, office supplies, and art materials, as well as furniture and parts (bed linen, mattresses, pillows). When it came to the ordering and purchasing of sanitary devices and equipment, as well as lighting, heating, and cooling devices, in most cases, users did not opt for shipment insurance. For the municipality of Vračar, insured shipments included baby strollers, toys, and lighting, heating, and cooling devices. In contrast, users did not

choose to insure shipments of medical devices, aids, or furniture and parts (bed linen, mattresses, pillows). For the municipality of Savski Venac, users requested additional insurance for shipments of electronics and lighting, heating, and cooling devices. However, when ordering and purchasing medical devices and aids, as well as sanitary devices and equipment, most users did not opt for shipment insurance. For the municipality of Zvezdara, insured shipments included electronics and medical devices and aids. In contrast, in most cases, users did not select insurance for shipments of jewelry, watches, cameras, gold, books, school supplies, office supplies, and art materials.

Table 1. Representation of product types in e-commerce shipments (1/4) [20]

E-Commerce Parcels (Daily)								
Municipality	**Stari Grad**		**Vračar**		**Sauski Venac**		**Zvezdara**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	2	235	25	164	58	287	5	156
Essential oils, perfumery, and toiletry products	18	371	47	155	77	576	10	279
Medical devices, aids, and similar items	211	65	149	173	98	76	147	34
Clothing, footwear, sports equipment, leather goods, and similar items	1065	81	704	282	351	49	112	45
Lighting, heating, and cooling devices, and similar items	127	51	323	128	235	31	114	24
Electronics	249	21	427	111	349	41	145	27
Sanitary devices and equipment	55	86	46	119	182	71	5	31
Furniture and parts; bed linen, mattresses, pillows	339	42	301	121	173	71	73	105
Jewelry, watches, cameras, gold, and similar items	1546	49	775	115	501	63	678	291
Baby strollers, toys, and similar items	234	37	323	16	155	48	79	50
Books, school supplies, office supplies, and art materials, and similar items	479	43	155	20	79	71	56	123

Table 2. Representation of product types in e-commerce shipments (2/4) [20]

E-Commerce Parcels (Daily)								
Municipality	**Rakoxica**		**Surccin**		**Grocka**		**Obrenovac**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	6	97	2	86	3	64	2	75
Essential oils, perfumery, and toiletry products	11	105	5	76	3	45	1	121
Medical devices, aids, and similar items	25	87	10	31	1	21	3	5
Clothing, footwear, sports equipment, leather goods, and similar items	83	91	45	45	18	29	10	6
Lighting, heating, and cooling devices, and similar items	13	82	35	56	15	38	2	17
Electronics	22	56	12	78	18	31	3	19
Sanitary devices and equipment	10	77	11	21	9	29	5	23
Furniture and parts; bed linen, mattresses, pillows	125	55	19	12	10	22	7	17
Jewelry, watches, cameras, gold, and similar items	215	41	110	46	32	38	12	4
Baby strollers, toys, and similar items	69	41	23	87	17	31	5	3
Books, school supplies, office supplies, and art materials, and similar items	78	39	35	31	16	55	6	1

As shown in Table 2, the shipments that were insured in the highest number of cases at the municipal level contained jewelry, watches, cameras and gold, as well as clothing, footwear, sports equipment, and leather goods. On the other hand, the least insured shipments contained soaps, cleaning products, essential oils, perfumery, and toiletry products, as well as baby strollers, toys, and electronics. Regarding the municipality of Rakovica, users requested additional insurance for shipments of furniture and parts (bed linen, mattresses, pillows) and books, school supplies, office supplies, and art materials (this is also observed in the case of users from the municipality of Grocka). However, when ordering and purchasing medical devices, aids, and lighting, heating, and cooling devices, the majority of users did not opt for shipment insurance. For the municipality of Surčin, insured shipments included lighting, heating, and cooling devices (which were also part of the uninsured shipments) and books, school supplies, office supplies, and art materials. In contrast, users did not opt for insurance for shipments of medical devices and aids. When ordering and purchasing lighting, heating, and cooling devices, as well as books, school supplies,

office supplies, and art materials, most users in the municipality of Grocka did not choose shipment insurance. For the municipality of Obrenovac, insured shipments arrived in significantly lower numbers compared to uninsured shipments (both types of shipments were similarly insured). In contrast, the majority of users did not opt for insurance for shipments of sanitary devices and equipment, or furniture and parts (bed linen, mattresses, pillows).

Table 3. Representation of product types in e-commerce shipments (3/4) [20]

E-Commerce Parcels (Daily)								
Municipality	**Lazareyac**		**Voždovac**		**Novi Beograd**		**Paliluta**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	1	65	10	137	12	282	11	110
Essential oils, perfumery, and toiletry products	2	43	24	246	51	173	25	235
Medical devices, aids, and similar items	1	24	38	125	82	74	31	83
Clothing, footwear, sports equipment, leather goods, and similar items	5	13	434	19	677	47	241	189
Lighting, heating, and cooling devices, and similar items	3	24	1002	18	328	61	328	87
Electronics	2	17	571	55	345	38	239	75
Sanitary devices and equipment	1	19	331	62	208	57	142	73
Furniture and parts; bed linen, mattresses, pillows	5	21	273	51	319	92	109	50
Jewelry, watches, cameras, gold, and similar items	5	9	682	28	605	85	389	49
Baby strollers, toys, and similar items	3	10	239	74	227	272	123	57
Books, school supplies, office supplies, and art materials, and similar items	1	15	136	432	119	491	124	167

Table 4. Representation of product types in e-commerce shipments (4/4) [20]

E-Commerce Parcels (Daily)								
Municipality	**Zemun**		**Čukarica**		**Mladenovac**		**Sopot**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	5	287	4	105	3	102	1	8
Essential oils, perfumery, and toiletry products	6	209	7	97	1	98	4	2
Medical devices, aids, and similar items	15	89	12	43	7	21	3	37
Clothing, footwear, sports equipment, leather goods, and similar items	128	85	75	65	37	23	11	46
Lighting, heating, and cooling devices, and similar items	121	61	56	87	18	31	7	31
Electronics	135	66	47	56	14	44	6	17
Sanitary devices and equipment	19	121	11	64	11	27	1	19
Furniture and parts; bed linen, mattresses, pillows	102	97	20	55	36	18	4	21
Jewelry, watches, cameras, gold, and similar items	551	108	113	41	47	26	33	22
Baby strollers, toys, and similar items	83	60	57	59	21	29	19	98
Books, school supplies, office supplies, and art materials, and similar items	75	57	88	33	19	57	16	121

As shown in Table 3, the shipments that were insured in the highest number of cases at the municipal level contained lighting, heating, and cooling devices, as well as jewelry, watches, cameras, and gold. On the other hand, the least insured shipments included books, school supplies, office supplies, and art materials, followed by shipments of essential oils, perfumery, and toiletry products. Regarding the municipality of Lazarevac, insured shipments arrived in significantly lower numbers compared to uninsured shipments (both types of shipments were similarly insured). However, when ordering and purchasing soaps, cleaning products, and medical devices and aids, the majority of users did not opt for shipment insurance. For the municipality of Voždovac, insured shipments primarily included electronics, as well as clothing, footwear, sports equipment, and leather goods (this trend is also observed among users in the municipalities of Novi Beograd and Palilula). In contrast, users did not choose to insure shipments of soaps, cleaning products, or medical devices and aids. When ordering and purchasing soaps, cleaning products, and baby strollers and toys, most users in the municipality of Novi Beograd did not opt for shipment

insurance. Similarly, in the municipality of Palilula, the majority of users did not choose to insure shipments of clothing, footwear, sports equipment and leather goods, as well as soaps and cleaning products.

As shown in Table 4, the shipments that were insured in the highest number of cases at the municipal level contained jewelry, watches, cameras, and gold, as well as books, school supplies, office supplies, and art materials. On the other hand, the least insured shipments included soaps and cleaning products, followed by shipments of essential oils, perfumery, and toiletry products. Regarding the municipality of Zemun, users requested additional insurance for shipments of electronics, as well as clothing, footwear, sports equipment, and leather goods. However, when ordering and purchasing sanitary devices and equipment, as well as furniture and parts (bed linen, mattresses, pillows), most users did not opt for shipment insurance. For the municipality of Čukarica, insured shipments included clothing, footwear, sports equipment, and leather goods (which were also prominent among uninsured shipments), as well as baby strollers and toys (a trend also observed among insured shipments in the municipality of Sopot). In contrast, most users did not opt for insurance when ordering and purchasing lighting, heating, and cooling devices. In the municipality of Mladenovac, the majority of users requested additional insurance for shipments of clothing, footwear, sports equipment, leather goods, and furniture and parts (bed linen, mattresses, pillows). However, when it came to electronics and baby strollers and toys, users generally did not opt for shipment insurance. For the municipality of Sopot, insured shipments arrived in significantly lower numbers compared to uninsured shipments (both types of shipments were similarly insured).

3.2 Analysis of Goods Flows Based on Average Shipment Weight

This section analyzes the purchasing and ordering behavior of users from Belgrade municipalities on e-commerce platforms, with a particular focus on the average shipment weight as the key indicator under consideration. As previously suggested, the analysis aims to facilitate more efficient planning of transport capacity, the need for additional e-commerce shipment insurance services, and similar logistical requirements. As shown in Table 5, the highest average shipment weight is observed for insured shipments at the municipal level, which primarily included furniture and parts (bed linen, mattresses, pillows), as well as sanitary devices and equipment. On the other hand, the lowest average shipment weight is observed in the case of uninsured shipments, which mainly included soaps, cleaning products, essential oils, perfumery, and toiletry products. Regarding the municipality of Stari Grad, a higher average weight is noted in insured shipments containing electronics and lighting, heating, and cooling devices. In the case of uninsured shipments, a lower average weight is observed among users ordering and purchasing medical devices, aids, clothing, footwear, sports equipment, and leather goods. In the municipality of Vračar, insured shipments of medical devices, aids, clothing, footwear, sports equipment, and leather goods had a lower average weight. In contrast, uninsured shipments of baby strollers, toys, jewelry, watches, cameras, and gold exhibited a higher average weight. For the municipality of Savski Venac, a higher average weight is observed in insured shipments of medical devices, aids, jewelry, watches, cameras, and gold (which also appeared among the lower-weight uninsured shipments). Uninsured shipments with lower average weight were primarily related to books, school supplies, office supplies, and art materials. In the municipality of Zvezdara, insured shipments containing books, school supplies, office supplies, and art materials (which stood out among the higher-weight uninsured shipments), as well as jewelry, watches, cameras, and gold, had a lower average weight. Conversely, uninsured shipments of baby strollers and toys showed a higher average weight.

The data in Table 6 show that insured shipments had the highest average weight in the specified municipalities. This mainly included furniture and parts like bedding, mattresses, and pillows, as well as soaps and cleaning products. On the other hand, the lowest average weight is noted in the case of uninsured shipments that consisted of sanitary devices and equipment, as well as lighting, heating, and cooling devices. In the case of the Rakovica municipality, a higher average weight is observed in insured shipments containing medical devices and aids, as well as essential oils, perfumery, and toiletry products (which stood out among uninsured shipments of lower weight). For uninsured shipments, a lower average weight is observed among users who ordered and purchased jewelry, watches, cameras, and gold. In the Surčin municipality, the average weight of insured and uninsured shipments is approximately equal across all product categories. Regarding Grocka, a higher average weight is observed in insured shipments of jewelry, watches, cameras, and gold, as well as clothing, footwear, sports equipment, and leather goods (which were identified among uninsured shipments of lower weight). For uninsured shipments, a lower average weight is observed among users who ordered and purchased books, school supplies, office supplies, and art materials. In the Obrenovac municipality, a lower average weight is observed for insured shipments that included books, school supplies, office supplies, and art materials (which stood out among uninsured shipments of greater weight), as well as jewelry, watches, cameras, and gold. The previously mentioned trends also apply to uninsured shipments of greater average weight.

Table 5. Average weight of e-commerce shipments by product type (1/4) [20]

E-Commerce Parcels (Daily)– Average Weight (kg)								
Municipality	**Stari Grad**		**Vračar**		**Savski Venac**		**Zvezdara**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	0.539	0.023	0.083	0.234	0.495	0.470	0.413	0.673
Essential oils, perfumery, and toiletry products	1.078	0.036	0.084	0.235	0.496	0.473	0.415	0.675
Medical devices, aids, etc.	0.548	0.039	0.085	0.237	0.498	0.474	0.417	0.679
Clothing, footwear, sports equipment, leather goods, etc.	0.583	0.049	0.089	0.239	0.500	0.475	1.008	0.485
Lighting, heating, cooling devices, etc.	0.610	0.050	0.095	0.29	0.085	0.701	1.010	0.487
Electronics	0.751	0.052	0.096	0.294	0.089	0.702	1.015	0.104
Sanitary devices and equipment	1.110	0.060	0.262	0.295	0.237	0.704	1.018	0.105
Furniture and parts; bed linen, mattresses, pillows	1.410	0.064	0.264	0.299	0.239	0.705	0.697	0.929
Jewelry, watches, cameras, gold, etc.	0.445	0.067	0.269	0.300	0.245	0.358	0.698	0.930
Baby strollers, toys, etc.	0.514	0.074	0.270	0.305	0.247	0.359	0.699	0.931
Books, school supplies, office supplies, art materials, etc.	0.520	0.079	0.271	0.310	0.136	0.196	0.039	0.935

Table 6. Average weight of e-commerce shipments by product type (2/4) [20]

E-Commerce Parcels (Daily)– Average Weight (kg)								
Municipality	**Rakovica**		**Surčin**		**Grocka**		**Obrenovac**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	1.515	0.850	1.720	1.058	0.823	2.317	2.104	1.034
Essential oils, perfumery, and toiletry products	1.487	1.226	1.746	1.520	1.549	2.320	2.110	1.496
Medical devices, aids, etc.	1.490	1.227	1.817	1.527	1.552	2.327	2.120	1.510
Clothing, footwear, sports equipment, leather goods, etc.	1.496	1.230	1.837	1.535	1.553	0.950	1.189	1.515
Lighting, heating, cooling devices, etc.	1.510	1.158	1.840	1.223	1.565	0.952	1.190	1.246
Electronics	0.380	1.159	1.858	1.225	1.567	0.957	2.335	1.249
Sanitary devices and equipment	0.384	0.701	1.415	1.883	2.508	1.620	2.366	2.250
Furniture and parts; bed linen, mattresses, pillows	0.385	0.702	1.416	1.888	2.686	1.640	2.371	2.266
Jewelry, watches, cameras, gold, etc.	0.387	0.704	1.425	1.925	2.799	1.650	1.084	2.267
Baby strollers, toys, etc.	1.362	1.315	1.315	1.931	1.024	1.665	1.085	1.665
Books, school supplies, office supplies, art materials, etc.	1.365	1.319	1.319	1.945	1.025	0.825	1.090	1.675

The data in Table 7 show that insured shipments in the listed municipalities have the highest average weight. This mainly includes medical devices, aids, and electronics. On the other hand, the lowest average weight is noted in the case of uninsured shipments that consisted of soaps, cleaning products, essential oils, perfumery, and toiletry products. In the case of the Lazarevac municipality, a higher average weight is observed in insured shipments containing furniture and parts (bedding, mattresses, pillows), as well as sanitary devices and equipment. For uninsured shipments, a lower average weight is noted among users who ordered and purchased medical devices, aids, clothing, footwear, sports equipment, and leather goods. In the Voždovac municipality, the average weight of insured and uninsured shipments is approximately equal across all product categories. Regarding Novi Beograd, a higher average weight is observed in insured shipments of lighting, heating, and cooling devices, as well as clothing, footwear, sports equipment, and leather goods. For uninsured shipments, a lower average weight is noted among users who ordered and purchased sanitary devices and equipment, as well as furniture and parts (bedding, mattresses, and pillows), which were identified among insured shipments of lower weight in the Palilula municipality. In the Palilula municipality, a higher average weight is observed in uninsured shipments that included furniture and parts (bedding, mattresses, pillows), as well as jewelry, watches, cameras, and gold.

From the provided data in Table 8, it can be observed that the highest average weight is recorded for insured shipments at the level of the given municipalities, which primarily included furniture and parts (bedding, mattresses, pillows), as well as children's strollers and toys. On the other hand, the lowest average weight is noted in the case of uninsured shipments that consisted of children's strollers and toys, as well as jewelry, watches, cameras, and gold. In the case of the Zemun municipality, a higher average weight is observed in insured shipments containing books, school, office, and art supplies, as well as sanitary devices and equipment. For uninsured shipments, a lower average

weight is noted among users who ordered and purchased soaps, cleaning products, essential oils, perfumery, and toiletry products. In the Čukarica municipality, a lower average weight is observed in insured shipments of lighting, heating, and cooling devices, as well as electronics (which were identified among uninsured shipments of higher weight). Regarding Mladenovac, a higher average weight is observed in insured shipments of medical devices and aids, as well as essential oils, perfumery, and toiletry products. For uninsured shipments, a lower average weight is noted among users who ordered and purchased books, school, office, and art supplies. In the Sopot municipality, a lower average weight is observed in insured shipments that included clothing, footwear, sports equipment, and leather goods, as well as lighting, heating, and cooling devices. For uninsured shipments, a higher average weight is noted for soaps, cleaning products, and books, school, office, and art supplies.

Table 7. Average weight of e-commerce shipments by product type (3/4) [20]

E-Commerce Parcels (Daily)– Average Weight (kg)								
Municipality	**Lazarevac**		**Voždovac**		**Novi Beograd**		**Palilula**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	1.518	2.131	0.225	0.129	0.514	0.384	0.514	0.096
Essential oils, perfumery, and toiletry products	4.180	2.152	0.228	0.133	0.517	0.385	0.517	0.100
Medical devices, aids, etc.	4.263	2.155	0.234	0.135	0.518	0.095	0.518	0.102
Clothing, footwear, sports equipment, leather goods, etc.	1.840	2.055	0.563	0.136	0.519	0.096	0.519	0.118
Lighting, heating, cooling devices, etc.	1.858	2.065	0.442	0.143	0.520	0.100	0.731	0.119
Electronics	3.235	2.070	0.443	0.145	0.083	0.102	0.337	0.121
Sanitary devices and equipment	3.415	2.371	0.445	0.147	0.084	0.228	0.340	0.122
Furniture and parts; bed linen, mattresses, pillows	3.631	2.440	0.446	0.168	0.085	0.234	0.341	0.721
Jewelry, watches, cameras, gold, etc.	2.310	2.445	0.448	0.169	0.089	0.235	0.345	0.724
Baby strollers, toys, etc.	2.317	2.467	0.417	0.171	0.421	0.436	0.555	0.592
Books, school supplies, office supplies, art materials, etc.	2.320	4.116	0.420	0.173	0.423	0.438	0.556	0.593

Table 8. Average weight of e-commerce shipments by product type (4/4) [20]

E-Commerce Parcels (Daily)– Average Weight (kg)								
Municipality	**Zemun**		**Čukarica**		**Mladenovac**		**Sopot**	
Product Type	**I**	**NI**	**I**	**NI**	**I**	**NI**	**I**	**NI**
Soaps, cleaning products	0.225	0.095	1.117	1.245	1.883	1.025	1.817	2.266
Essential oils, perfumery, and toiletry products	0.228	0.096	1.120	1.246	1.888	1.026	1.837	1.129
Medical devices, aids, etc.	0.234	0.363	1.125	1.249	1.925	1.030	1.840	1.130
Clothing, footwear, sports equipment, leather goods, etc.	0.524	0.365	1.117	1.251	0.493	1.032	0.863	1.132
Lighting, heating, cooling devices, etc.	0.525	0.367	0.889	1.315	1.018	1.407	0.867	1.200
Electronics	0.527	0.424	0.890	1.319	1.019	1.410	0.868	1.205
Sanitary devices and equipment	1.075	0.425	0.895	1.320	1.020	1.413	0.870	1.209
Furniture and parts; bed linen, mattresses, pillows	1.078	0.428	1.171	0.908	1.022	2.110	1.473	1.000
Jewelry, watches, cameras, gold, etc.	1.079	0.430	1.172	0.909	1.518	2.120	1.475	1.003
Baby strollers, toys, etc.	1.082	0.432	1.174	0.910	1.520	2.131	1.480	1.004
Books, school supplies, office supplies, art materials, etc.	1.084	1.056	1.225	1.045	1.527	0.519	1.875	1.888

4 Methodology

The observed e-retailer has gained significant popularity among customers/users; however, this has further complicated the logistics of shipment distribution. In response to this, the following section will address the problem of e-commerce shipment distribution as provided by Provider 1 (Figure 3). The problem description is as follows: Customers have placed orders with the e-retailer, and these shipments need to be delivered. Provider 1 independently delivers a portion of these shipments, while the remaining portion is outsourced to courier services. Both Provider 1 and the courier services own a fleet of vehicles. However, there are several constraints that must be considered when selecting the type of vehicle for distribution (these criteria and alternatives are described later in this paper).

In line with the defined objective, the model is based on the SWARA and WASPAS methods. The following sections provide a description of these methods, along with a step-by-step explanation of their application.

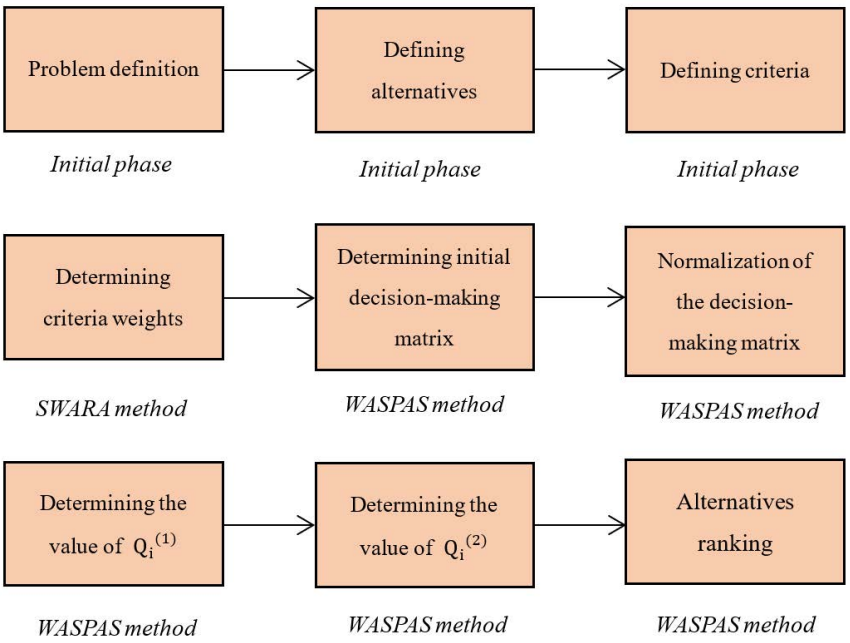

Figure 3. Methodology of the paper

4.1 SWARA Method

The SWARA method is one of the many multi-criteria decision-making methods that assist decision-makers in selecting the best solution or alternative. Additionally, the SWARA method is practical for decision-making at all levels, particularly at the highest level of decision-making. It is applied when comparing criteria whose values are given using a linguistic scale. The main advantage of the SWARA method lies in its simplicity of application. Specifically, it involves comparing two criteria (the next and the previous ones). The following outlines the steps for applying the SWARA method [25–28].

Step 1. Ranking Criteria by Importance. In this step, experts rank the defined criteria according to their significance. The most important criteria are placed at the top, while less important criteria are ranked lower.

Step 2. Determining the Significance of Criteria (S_j). Starting from the second-ranked criterion, the relative importance of each criterion (C_j) compared to the next criterion ($C_j + 1$) is assessed.

$$S_j \leftrightarrow j+1 = \sum_{k=1}^{r} C_j \leftrightarrow j + \frac{1}{r} \tag{1}$$

Step 3. Calculating the value of the coefficient K_j.

$$K_j = \begin{cases} 1 & j = 1 \\ S_j + 1 & j > 1 \end{cases} \tag{2}$$

Step 4. Calculating the values of q_j.

$$q_j = \begin{cases} 1 & j = 1 \\ q_j - \frac{1}{qK_j} & j > 1 \end{cases} \tag{3}$$

Step 5. Calculating the relative criteria weight (W_j).

$$W_j = \frac{q_j}{\sum_{k=1}^{m} q_j} \tag{4}$$

4.2 WASPAS Method

The WASPAS method is one of many multi-criteria decision-making methods, designed by Zavadskas et al. [29]. The WASPAS method is unique in that it combines two multi-criteria decision-making methods: WSM (Weighted Sum Model) and WPM (Weighted Product Model). Some studies that have explored the practical application of the WASPAS method include [30–33]. Specifically, the WSM method determines the overall result of an alternative as the weighted sum of the criteria values, while the WPM method determines the result of an alternative as the product of each criterion's evaluation raised to the power corresponding to the weight of the given criterion. Additionally, the WASPAS method aims to achieve the highest accuracy in assessment by optimizing the weighted aggregated function. Furthermore, in the WASPAS method, it is assumed that there is a set of m feasible alternatives, A_i (i = 1, 2, . . . , m) and n criteria C_j (j = 1, 2, . . . , n). The steps for applying this method are outlined below [34–36].

Step 1. Formation of the decision matrix X, in which the values of alternatives are presented relative to the criteria.

Step 2. Normalization of the values within the decision matrix. Normalization is performed using the following equations.

$$x_{ij}^{*} = \frac{x_{ij}}{\max_i (x_{ij})} \quad i = 1, 2, \ldots, m; j = 1, 2, \ldots, n \tag{5}$$

$$x_{ij}^{*} = \frac{\min_i (x_{ij})}{x_{ij}} \quad i = 1, 2, \ldots, m; j = 1, 2, \ldots, n \tag{6}$$

where, $x_{ij}{}^{*}$ represents the normalized value of i^{th} alternative in accordance to the j^{th} criterion.

Step 3. Determining the relative importance of i^{th} alternative using the WSM method.

$$Q_i^{(1)} = \sum_{j=1}^{n} x_{ij}^{*} w_j \tag{7}$$

Step 4. Determining the relative importance of i^{th} alternative using the WPM method.

$$Q_i^{(2)} = \prod_{j=1}^{n} x_{ij}^{*w_j} \tag{8}$$

Step 5. Determining the relative importance of alternatives (Q_i).

$$Q_i = \lambda Q_i^{(1)} + (1 - \lambda) Q_i^{(2)} \tag{9}$$

where, λ can take the following values: $\lambda \in [0; 1]$.

Finally, the alternatives are ranked based on the value of Q_i. The alternative with the highest value of Q_i represents the best-ranked alternative. It is worth mentioning the following [29]:

- λ = 0, transformation of the WASPAS method into the WPM method;
- λ = 1, transformation of the WASPAS method into the WSM method.

5 Case Study

5.1 Criteria and Alternative Description

As mentioned at the beginning of this section, customers place orders with e-retailers, and these orders need to be delivered. Provider 1 handles a portion of these deliveries independently, while outsourcing the remaining shipments to courier services. Both Provider 1 and the courier services operate their own vehicle fleets, whose characteristics are outlined below. The vehicles serve as alternatives, while their attributes represent the evaluation criteria. It is important to note that the first four vehicles belong to the fleet of Courier 1, the next four to the fleet of Courier 2, and the remaining two vehicles (A_9 and A_{10}) to Provider 1.

Alternative 1 $(\mathbf{A_1})$ is a vehicle with the following specifications: a maximum height of 1800 mm, a cargo volume of 3.9 m^3, and a payload capacity of 802 kg. The fleet includes 22 vehicles of this type.

Alternative 2 $(\mathbf{A_2})$ has a maximum height of 1,205 mm, a cargo volume of 2.8 m^3, and a payload capacity of 495 kg. There are 16 such vehicles available.

Alternative 3 $(\mathbf{A_3})$ features a maximum height of 1,662 mm, a cargo volume of 8 m^3, and a payload capacity of 1,445 kg, with 14 units in the fleet.

Alternative 4 $(\mathbf{A_4})$ offers a maximum height of 1,932 mm, a cargo volume of 13 m^3, and a payload capacity of 1,290 kg, with 8 units available.

Alternative 5 ($\mathbf{A_5}$) is a vehicle with a maximum height of 1,196 mm, a cargo volume of 3.3 m^3, and a payload capacity of 768 kg. The fleet consists of 27 such vehicles.

Alternative 6 ($\mathbf{A_6}$) has a maximum height of 589 mm, a cargo volume of 2.5 m^3, and a payload capacity of 484 kg, with 11 units in the fleet.

Alternative 7 ($\mathbf{A_7}$) features a maximum height of 1,662 mm, a cargo volume of 10 m^3, and a payload capacity of 1405 kg, with 12 vehicles available.

Alternative 8 ($\mathbf{A_8}$) offers a maximum height of 2,172 mm, a cargo volume of 15 m^3, and a payload capacity of 1,265 kg, with 10 units in the fleet.

Alternative 9 ($\mathbf{A_9}$) is a vehicle with a maximum height of 1,397 mm, a cargo volume of 5.3 m^3, and a payload capacity of 1,033 kg, with 30 units available.

Alternative 10 ($\mathbf{A_{10}}$) has a maximum height of 527 mm, a cargo volume of 2.2 m^3, and a payload capacity of 427 kg, with 30 such vehicles in the fleet.

From the information provided, it is evident that the specified vehicle characteristics serve as the evaluation criteria. Specifically, the criteria include the following: maximum height, cargo volume, payload capacity, and fleet size (number of vehicles). Moreover, additional data obtained from Provider 1 introduce complexities to the e-commerce delivery process. As a result, these factors have been incorporated into the problem-solving process, further expanding the list of evaluation criteria.

Alternative 1 ($\mathbf{A_1}$) completes 314 deliveries, with an average of 153 packages per delivery. Additionally, it handles 41 complaints. Furthermore, 9 lost and 29 damaged e-commerce shipments have been recorded.

Alternative 2 ($\mathbf{A_2}$) completes 345 deliveries, with an average of 155 packages per delivery. It processes 30 complaints, with 4 lost and 24 damaged shipments.

Alternative 3 ($\mathbf{A_3}$) completes 123 deliveries, with an average of 377 packages per delivery. It processes 94 complaints, with 52 lost and 62 damaged shipments.

Alternative 4 ($\mathbf{A_4}$)) completes 122 deliveries, with an average of 387 packages per delivery. It handles 106 complaints, with 34 lost and 62 damaged shipments.

Alternative 5 ($\mathbf{A_5}$) completes 327 deliveries, with an average of 157 packages per delivery. It processes 27 complaints, with 5 lost and 18 damaged shipments.

Alternative 6 ($\mathbf{A_6}$) completes 342 deliveries, with an average of 159 packages per delivery. It handles 24 complaints, with 8 lost and 28 damaged shipments.

Alternative 7 ($\mathbf{A_7}$) completes 114 deliveries, with an average of 369 packages per delivery. It processes 93 complaints, with 36 lost and 66 damaged shipments.

Alternative 8 ($\mathbf{A_8}$) completes 115 deliveries, with an average of 384 packages per delivery. It handles 101 complaints, with 23 lost and 61 damaged shipments.

Alternative 9 ($\mathbf{A_9}$) completes 77 deliveries, with an average of 17 packages per delivery. It processes 6 complaints, with 2 lost and 2 damaged shipments.

Alternative 10 ($\mathbf{A_{10}}$) completes 55 deliveries, with an average of 20 packages per delivery. It handles 3 complaints, with 3 lost and 1 damaged shipment.

Based on the provided data, the list of criteria has been expanded. The evaluation criteria now include: maximum height, cargo volume, payload capacity, number of vehicles, number of deliveries, average number of packages per delivery, number of complaints, number of lost shipments, and number of damaged shipments.

5.2 Results

As previously mentioned, the proposed model was tested using data provided by Provider 1. First, the SWARA method was applied to determine the criteria weights. By following the previously described steps of the SWARA method, the obtained criteria weights serve as the "input" for the WASPAS method (Table 9).

After determining the criteria weights, the initial decision matrix can be formed (Table 10). The values in the decision matrix include the following: the values of alternatives for each criterion (as provided at the beginning of this section), the criteria weights (Table 9), and the type of criteria. The criteria can be classified as either max or min types. The nature of each criterion determines whether it is classified as max or min. For example, criterion C_1, which represents the number of deliveries, aims to maximize the number of shipments; thus, it is classified as a max criterion. On the other hand, criterion C_5, which represents the number of complaints, should ideally be minimized; couriers benefit from having fewer complaints (ideally none), making it a minor criterion. In the same manner, all other criteria have been analyzed and classified accordingly.

After forming the initial decision matrix, the next step involves applying the previously described steps of the WASPAS method, with the objective of determining the best-ranked couriers/postal operators. Specifically, the initial decision matrix must be transformed into a normalized decision matrix, where the values of alternatives for each criterion fall within the range of 0 to 1, inclusive. At this stage, the type of criterion (max or min) becomes crucial, as it determines which normalization equation should be applied, either Eq. (5) or Eq. (6). Depending on

whether a criterion needs to be maximized or minimized, the appropriate equation is used to normalize the values. Through this process, the normalized decision matrix is obtained (Table 11).

Table 9. Determining criteria weights using SWARA method

Criteria	S_j	$K_j = S_j + 1$	Q_j	W_j
Number of deliveries (C_1)	-	1.00	1.000	0.179
Average number of packages per delivery (C_2)	0.25	1.25	0.800	0.143
Number of vehicles (C_3)	0.17	1.17	0.684	0.122
Payload capacity (C_4)	0.05	1.05	0.651	0.116
Number of complaints (C_5)	0.12	1.12	0.581	0.104
Cargo volume (C_6)	0.14	1.14	0.510	0.091
Number of damaged shipments (C_7)	0.03	1.03	0.495	0.088
Number of lost shipments (C_8)	0.07	1.07	0.463	0.083
Maximum height (C_9)	0.12	1.12	0.413	0.074
			5.598	1.000

Table 10. Initial decision-making matrix

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$
Type	Max	Max	Max	Max	Min	Max	Min	Min	Max
Weight	0.179	0.143	0.122	0.116	0.104	0.091	0.088	0.083	0.074
A_1	314	153	22	802	41	3.9	29	9	1.880
A_2	345	155	16	495	30	2.8	24	4	1.205
A_3	123	377	14	1.445	94	8	62	52	1.662
A_4	122	387	8	1.290	106	13	62	34	1.932
A_5	327	151	27	768	27	3.3	18	5	1.196
A_6	342	159	11	484	24	2.5	28	8	589
A_7	114	369	12	1.405	93	10	66	36	1.662
A_8	115	384	10	1.265	101	15	61	23	2.172
A_9	77	17	30	1.033	6	5.3	2	2	1.397
A_{10}	55	20	30	427	5	2.2	1	3	527

Table 11. Normalized decision-making matrix

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$
Type	Max	Max	Max	Max	Min	Max	Min	Min	Max
A_1	0.910	0.395	0.733	0.555	0.122	0.260	0.034	0.222	0.866
A_2	1.000	0.401	0.533	0.343	0.167	0.187	0.042	0.500	0.555
A_3	0.357	0.974	0.467	1.000	0.053	0.533	0.016	0.038	0.765
A_4	0.354	1.000	0.267	0.893	0.047	0.867	0.016	0.059	0.890
A_5	0.948	0.390	0.900	0.531	0.185	0.220	0.056	0.400	0.551
A_6	0.991	0.411	0.367	0.335	0.208	0.167	0.036	0.250	0.271
A_7	0.330	0.953	0.400	0.972	0.054	0.667	0.015	0.056	0.765
A_8	0.333	0.992	0.333	0.875	0.050	1.000	0.016	0.087	1.000
A_9	0.223	0.044	1.000	0.715	0.833	0.353	0.500	1.000	0.643
A_{10}	0.159	0.052	1.000	0.296	1.000	0.147	1.000	0.667	0.243

The next step involves determining the value of the parameter $Q_i^{(1)}$ for each alternative (courier or postal operator). Eq. (7) is applied to calculate these values. The results of this step are presented in Table 12.

Similar to the previous step, it is necessary to determine the values of the parameter $Q_i^{(2)}$ for each alternative (courier or postal operator). However, this time, Eq. (8) is applied. The results of this step are presented in Table 13.

The next step of the WASPAS method involves determining the total relative importance of the alternatives (Q_i). Eq. (9) is applied to calculate this. First, the case where λ=0.5 will be considered, and based on that, the alternatives will be ranked. The results obtained in this step are presented in Table 14.

In the following Table 15, a sensitivity analysis is conducted, where the parameter λ takes different values. Based on the sensitivity analysis, the change in the ranking of couriers/postal operators can be determined.

Table 12. The values of $Q_i^{(1)}$

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$	$\mathbf{Q_i^{(1)}}$
A_1	0.163	0.057	0.090	0.065	0.013	0.024	0.003	0.018	0.064	0.495
A_2	0.179	0.057	0.065	0.040	0.017	0.017	0.004	0.041	0.041	0.461
A_3	0.064	0.139	0.057	0.116	0.006	0.049	0.001	0.003	0.056	0.491
A_4	0.063	0.143	0.033	0.104	0.005	0.079	0.001	0.005	0.066	0.498
A_5	0.169	0.056	0.110	0.062	0.019	0.020	0.005	0.033	0.041	0.515
A_6	0.177	0.059	0.045	0.039	0.022	0.015	0.003	0.021	0.020	0.400
A_7	0.059	0.136	0.049	0.113	0.006	0.061	0.001	0.005	0.056	0.486
A_8	0.060	0.142	0.041	0.102	0.005	0.091	0.001	0.007	0.074	0.523
A_9	0.040	0.006	0.122	0.083	0.087	0.032	0.044	0.083	0.047	0.545
A_{10}	0.028	0.007	0.122	0.034	0.104	0.013	0.088	0.055	0.018	0.471

Table 13. The values of $Q_i^{(2)}$

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$	$\mathbf{C_6}$	$\mathbf{C_7}$	$\mathbf{C_8}$	$\mathbf{C_9}$	$\mathbf{Q_i^{(2)}}$
A_1	0.983	0.876	0.963	0.934	0.804	0.884	0.742	0.883	0.989	0.357
A_2	1.000	0.877	0.926	0.883	0.830	0.858	0.755	0.944	0.957	0.349
A_3	0.832	0.996	0.911	1.000	0.737	0.944	0.694	0.764	0.980	0.273
A_4	0.831	1.000	0.851	0.987	0.728	0.987	0.694	0.791	0.991	0.273
A_5	0.990	0.874	0.987	0.929	0.839	0.871	0.774	0.927	0.957	0.399
A_6	0.998	0.881	0.885	0.881	0.850	0.849	0.745	0.892	0.908	0.298
A_7	0.821	0.993	0.894	0.997	0.738	0.964	0.690	0.787	0.980	0.275
A_8	0.822	0.999	0.874	0.985	0.732	1.000	0.695	0.817	1.000	0.294
A_9	0.765	0.640	1.000	0.962	0.981	0.910	0.941	1.000	0.968	0.382
A_{10}	0.720	0.655	1.000	0.868	1.000	0.840	1.000	0.967	0.901	0.299

Table 14. The alternatives' values of Q_i ($\lambda = 0.5$) and ranking

	$\mathbf{Q_i = 0.5Q_i^{(1)} + 0.5Q_i^{(2)}}$	**Rank**
A_1	0.426	3
A_2	0.405	5
A_3	0.382	8
A_4	0.386	6
A_5	0.457	2
A_6	0.349	10
A_7	0.381	9
A_8	0.408	4
A_9	0.464	1
A_{10}	0.385	7

Table 15. Sensitivity analysis

	$\boldsymbol{\lambda = 0}$	$\boldsymbol{\lambda = 0.1}$	$\boldsymbol{\lambda = 0.2}$	$\boldsymbol{\lambda = 0.3}$	$\boldsymbol{\lambda = 0.4}$	$\boldsymbol{\lambda = 0.5}$	$\boldsymbol{\lambda = 0.6}$	$\boldsymbol{\lambda = 0.7}$	$\boldsymbol{\lambda = 0.8}$	$\boldsymbol{\lambda = 0.9}$	$\boldsymbol{\lambda = 1}$
A_1	0.357	0.371	0.385	0.398	0.412	0.426	0.440	0.454	0.467	0.481	0.495
A_2	0.349	0.360	0.371	0.383	0.394	0.405	0.416	0.427	0.439	0.450	0.461
A_3	0.273	0.295	0.317	0.339	0.361	0.382	0.404	0.426	0.448	0.470	0.491
A_4	0.273	0.295	0.318	0.341	0.363	0.386	0.408	0.431	0.453	0.476	0.498
A_5	0.399	0.410	0.422	0.434	0.445	0.457	0.468	0.480	0.492	0.503	0.515
A_6	0.298	0.308	0.319	0.329	0.339	0.349	0.359	0.370	0.380	0.390	0.400
A_7	0.275	0.296	0.317	0.339	0.360	0.381	0.402	0.423	0.444	0.465	0.486
A_8	0.294	0.317	0.340	0.362	0.385	0.408	0.431	0.454	0.477	0.500	0.523
A_9	0.382	0.399	0.415	0.431	0.447	0.464	0.480	0.496	0.512	0.528	0.545
A_{10}	0.299	0.316	0.334	0.351	0.368	0.385	0.402	0.420	0.437	0.454	0.471

Finally, the last step of the WASPAS method involves ranking the couriers/postal operators. The alternatives

are ranked based on the values of Q_i. The best alternative has the highest Q_i value. The ranking of alternatives is shown in Table 16. It can be observed that A_5 and A_9 emerge as the two best alternatives, with A_9 being the highest-ranked alternative overall. In 7 cases, where λ = [0.4; 0.5; 0.6; 0.7; 0.8; 0.9; 1], A_9 was the best-ranked, while in the remaining 4 cases λ = [0; 0.1; 0.2; 0.3], A9 was ranked as the second-best. On the other hand, A_5 was the best-ranked alternative in 4 cases: λ = [0; 0.1; 0.2; 0.3]. In other cases, it was ranked as the second-best (λ = [0.4; 0.5; 0.6; 0.7; 0.8; 0.9]), or the third-best (λ = 1).

Table 16. Alternative ranking

	$\lambda = 0$	$\lambda = 0.1$	$\lambda = 0.2$	$\lambda = 0.3$	$\lambda = 0.4$	$\lambda = 0.5$	$\lambda = 0.6$	$\lambda = 0.7$	$\lambda = 0.8$	$\lambda = 0.9$	$\lambda = 1$
A_1	3	3	3	3	3	3	3	3	4	4	5
A_2	4	4	4	4	4	5	5	6	8	9	9
A_3	9	9	9	8	9	8	7	7	6	6	6
A_4	9	9	8	7	8	6	6	5	5	5	4
A_5	1	1	1	1	2	2	2	2	2	2	3
A_6	6	7	7	10	10	10	10	10	10	10	10
A_7	8	8	9	8	7	9	8	8	7	7	7
A_8	7	5	5	5	5	4	4	3	3	3	2
A_9	2	2	2	2	1	1	1	1	1	1	1
A_{10}	5	6	6	6	6	7	8	9	9	8	8

When it comes to the remaining alternatives, the following observations can be made:

Alternative A_1 was ranked as the third-best alternative in 8 cases λ = [0; 0.1; 0.2; 0.3; 0.4; 0.5; 0.6; 0.7], as the fourth-best in 2 cases (λ = [0.8; 0.9]), and as the fifth-best in one case (λ = 1).

Alternative A_2 was ranked as the fourth-best alternative in 5 cases λ = [0; 0.1; 0.2; 0.3; 0.4], as the fifth-best in 2 cases (λ = [0.5; 0.6]), as the ninth-best in 2 cases (λ = [0.9; 1]), as the sixth-best in one case (λ = 0.7), and as the eighth-best in one case (λ = 0.8).

Alternative A_3 was ranked as the ninth-best alternative in 4 cases (λ = [0; 0.1; 0.2; 0.4]), as the eighth-best in 2 cases (λ = [0.3; 0.5]), as the seventh-best in 2 cases (λ = [0.6; 0.7]), and as the sixth-best in 3 cases (λ = [0.8; 0.9; 1]).

Alternative A_4 was ranked as the fifth-best in 3 cases (λ = [0.7; 0.8; 0.9]), as the sixth-best in 2 cases (λ = [0.5; 0.6]), as the eighth-best in 2 cases (λ = [0.2; 0.4]), as the ninth-best in 2 cases (λ = [0; 0.1]), as the fourth-best in 1 case (λ = 1), and as the seventh-best in 1 case (λ = 0.3).

Alternative A_6 was ranked as the worst alternative in 8 cases (λ = [0.3; 0.4; 0.5; 0.6; 0.7; 0.8; 0.9; 1]), as the seventh-best in 2 cases (λ = [0.1; 0.2]), and as the sixth-best in 1 case (λ = 0).

Alternative A_7 was ranked as the eighth-best in 5 cases (λ = [0; 0.1; 0.3; 0.6; 0.7]), as the seventh-best in 4 cases (λ = [0.4; 0.8; 0.9; 1]), and as the ninth-best in 2 cases (λ = [0.2; 0.5]).

Alternative A_8 was ranked as the fifth-best in 4 cases (λ = [0.1; 0.2; 0.3; 0.4]), as the third-best in 3 cases (λ = [0.7; 0.8; 0.9]), as the fourth-best in 2 cases (λ = [0.5; 0.6]), and as the second-best in 1 case (λ = 1), and as the seventh-best in 1 case (λ = 0).

Alternative A_{10} was ranked as the sixth-best in 4 cases (λ = [0.1; 0.2; 0.3; 0.4]), as the eighth-best in 3 cases (λ = [0.6; 0.9; 1]), as the ninth-best in 2 cases (λ = [0.7; 0.8]), and as the fifth-best in 1 case (λ = 0), and as the seventh-best in 1 case (λ = 0.5). This detailed ranking indicates that each alternative performs differently depending on the value of λ, highlighting the sensitivity of the results to changes in the parameter.

6 Conclusion

Based on all the aforementioned, it can be concluded that meeting increasingly stringent customer demands regarding home delivery can be achieved through adequate planning for e-commerce parcel distribution. Additionally, it is crucial to recognize how the involvement of a large number of entities can complicate this process further. Furthermore, it is essential to stay updated with current market trends to offer customers a suitable range of logistics services. The aim of this paper was to highlight how the complexity of various activities, circumstances, and situations can make e-commerce parcel distribution a challenging task. At the beginning of the paper, the problem was described along with a literature review. Understanding the activities and obligations involved in parcel distribution is particularly important to avoid misunderstandings with customers when providing logistics services, all with the goal of strengthening LML. The paper then discusses the implementation of LML by e-commerce operators. This was followed by an analysis of commodity flows in the municipalities of Belgrade, demonstrating how market segmentation could enhance the logistics of e-commerce parcel distribution. This part of the paper includes a discussion on the behavior of customers in Belgrade's municipalities when purchasing from online platforms, where

the types of goods and average parcel weights were highlighted. The goal was to plan for more efficient distribution, including vehicle capacity planning, and the potential need for additional services like parcel insurance. A key takeaway from this segment is the identification of future research directions, such as the constant need to "listen" to customers—monitoring demand, quantities, etc.

The central theme of this work is the creation of a model for evaluating and selecting the type of vehicle for e-commerce parcel distribution. The structure of the model is presented, incorporating the application of the WASPAS and SWARA methods. A practical example was used to demonstrate that distribution problems in practice are quite complex due to the large number of criteria that can complicate problem-solving. The model presented shows how logistics service providers can facilitate the distribution of e-commerce parcels, particularly in terms of vehicle selection and fleet management. The development of models that aim to improve the efficiency of courier and postal services is identified as a promising direction for future research. In practice, it is certain that there is an even broader list of criteria and constraints that could further complicate e-commerce parcel distribution. This makes the creation of models a necessity. Future research will focus on using the model for similar problems, creating new mixed models to solve this issue, and developing models that help with parcel delivery after the vehicle is chosen.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflict of Interests

The authors declare no conflicts of interest.

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