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Contact to corresponding author: Maja Kiba-Janiak, maja.kiba-janiak@ue.wroc.pl

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Maja Kiba-Janiak
Wroclaw University of Economics and Business, Poland
orcid.org/0000-0002-0491-7401

Katarzyna Cheba
West Pomeranian University of Technology in Szczecin, Poland
orcid.org/0000-0001-8753-7764

Magdalena Mucowska
Wroclaw University of Economics and Business, Poland
orcid.org/0000-0002-1541-5941

Leise Kelli de Oliveira
Universidade Federal de Minas Gerais (UFMG), Brasil
orcid.org/0000-0002-4756-4183

Segmentation of e-customers in terms of sustainable last-mile delivery

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Abstract

Research background: A rapidly developing e-commerce market and growing customer expectations regarding the speed and frequency of deliveries have made the last mile of the supply chain more challenging. The expectations of e-customers increase every year. They choose those companies that deliver goods faster and cheaper than others. A significant group of customers in Poland still selects home delivery. Many of them frequently return products to the retailer. These expectations and behaviour pose a challenge for the transport companies to deliver parcels to individual customers soon after the purchase, sometimes even on the same day. In addition, in-

creasingly frequent deliveries contribute to environmental pollution, congestion, and accidents, as well as more expensive deliveries.
Purpose of the article: The paper aims to identify e-customers' preferences and assess their impact on sustainable last-mile delivery (LMD) in the e-commerce market. The authors have also identified factors influencing e-customers' behaviour to make last-mile delivery more sustainable.
Methods: The conjoint analysis was applied to evaluate a set of profiles defined by selected attributes in order to investigate the overall preferences for the profiles created by the respondents to the survey.
Findings & value added: The segmentation of e-customers according to their preferences connected with last-mile delivery was presented. The added value of the paper is the presentation of the methodology to assess the impact of customer preferences on sustainable last-mile delivery. The obtained results may contribute to the formulation of recommendations for e-commerce and logistics companies regarding the preferences of e-customers to improve the sustainability of last-mile delivery.

Introduction

The development of the e-commerce market accelerated due to the coronavirus pandemic (Frajtova Michalikova *et al*., 2022; Zvarikova *et al*., 2022; Mucowska, 2021). As many as 77% of Polish shoppers shop online, according to data from a 2021 survey conducted by the Gemius agency. It is estimated that the value of Polish e-commerce will continue to grow rapidly and will reach 162 billion zlotys in 2026 (Orzoł & Szopik-Depczyńska, 2022). Similar trends are visible in most of the middle and developed economies. The intensely developing e-commerce market has created additional pressures on last-mile delivery, affecting road congestion, noise and air pollution (Mangiaracina *et al*., 2016; Puram *et al.*, 2021; Srinivas & Marathe, 2021). The negative externalities adversely impact road safety, the quality of life, and business entities' economic prosperity (Savelsbergh & Van Woensel, 2016; van Loon *et al*., 2015). There are more and more discussions on the solutions and methods which can make last-mile delivery more sustainable (Janßen & Langen, 2017; Taniguchi *et al*., 2016). These trends are in line with the goals of the European Green Deal (European Commission, 2019). The most important challenges of sustainable last-mile delivery are an increase in customer expectations and value creation in e-commerce last-mile delivery (Vakulenko *et al*., 2018).

According to previous research (Rai *et al*., 2019; Lemke *et al.*, 2016), customers purchasing on the e-commerce market when choosing the delivery method within the last-mile delivery are mainly guided by the price. At the same time, they would like to obtain the parcel quickly (Iwan *et al*., 2016; Lemke *et al*., 2016) straight to their homes/workplaces or places where it is easy to park (Deutsch & Golany, 2018). There is also an in-

crease in the interest in environmentally friendly delivery, albeit much smaller.

Customer preferences influence the acceleration of changes in last-mile deliveries (Vakulenko *et al*., 2018). In addition, courier companies are required to fulfil the European Union's expectations toward logistics emission-free cities by 2030 (European Commission, 2011). Therefore, courier companies implement environmentally friendly solutions, such as alternative delivery locations and pick-up points (Gatta *et al*., 2019, 2018; Morganti *et al*., 2014), cargo bikes (Rajesh & Rajan, 2020), or city micro-hubs (Browne *et al*., 2014; Lenz & Riehle, 2013). However, the main catalysts for changes in this area are, above all, the expectations and preferences of customers buying products on the e-commerce market and their consent, for example, to incur higher costs in the case of deliveries carried out by environmentally friendly means of transport.

Although the processes within the e-commerce market, also in terms of the impact of observed changes on the reduction of emissions resulting from last-mile deliveries, are currently among the important topics of research papers (Gatta *et al*., 2018; Ignat & Chankov, 2020), there is a research gap in a comprehensive approach to the identification and assessing the impact of customer preferences on sustainable last-mile delivery. Importantly, it is increasingly indicated that changes in this area require the active involvement of the customers of this market in the decision-making process regarding the mode of delivery (e.g., Caspersen & Navrud, 2021; Tolentino-Zondervan *et al.,* 2021; Gonzalez-Calderon *et al*., 2022).

It is worth noting that the Web of Science database identified only 38 papers that referred to the term sustainable last-mile delivery in the title, keywords or abstract. These are mostly papers published in 2021–2022 (24 publications). In addition, they describe the results of research conducted on research samples selected in a purposive rather than random manner. These publications mainly focus on a selected sector or area. For example, Caspersen and Navrud (2021) studied "whether consumers' environmental attitudes and behaviour are reflected in their stated preferences for last-mile delivery options for clothing rentals." In contrast, Tolentino-Zondervan *et al.* (2021) describe in their paper the results of 16 in-depth interviews conducted among salaried employees at the Heijendaal campus in the Netherlands regarding the last mile delivery tasks they perform and how they can be integrated into the process of sustainable last-mile delivery. Some papers also describe the technical aspects of organising last-mile delivery (see Krstić *et al*., 2021; Novotná *et al*., 2022). However, what is missing is a broader view of sustainable delivery in the e-commerce market, particularly the segmentation of customers according to their preferences for last-

mile delivery and the possibility of changing these preferences toward choosing more sustainable delivery.

The main purpose of the paper is to identify e-customers' preferences and assess their impact on sustainable last-mile delivery in the e-commerce market. In order to obtain the results, the authors surveyed 1100 inhabitants in all voivodship cities in Poland.

The authors posed the following research questions in the paper:

- Which factors affecting last-mile delivery are the most important to Polish e-customers?
- What are the preferences of e-customers in terms of last-mile delivery?
- What factors characterise the identified e-customer segments in terms of sustainable last-mile delivery?

The authors have also identified the factors influencing the e-customers' behaviour to make last-mile delivery more sustainable. For this purpose, conjoint analysis has been applied to evaluate a set of profiles, namely real or hypothetical products and services, defined by selected attributes to investigate the overall preferences for the profiles made by the respondents to the survey.

The literature review related to the preferences of e-customers in the area of last-mile deliveries in the e-commerce market was used by the authors of this work to design their research tool. Various studies have used different methods, ranging from qualitative to more advanced statistical and mathematical methods. Among them, it is worth paying attention to the methods of multidimensional statistical analysis, which allow for the simultaneous assessment of many different criteria customers consider when making decisions regarding, for example, the method of delivery or the choice of products. An interesting research direction in this area is the conjoint method to assess buyers' preferences. This method is frequently used in marketing research. At the same time, its applications are much less widespread in researching buyers' preferences regarding those elements of the services offered that reduce the negative impact of, for example, deliveries on the environment. In this paper, the authors will present this type of approach.

The obtained results contribute to the formulation of recommendations for e-commerce and logistics companies, local authorities, and e-commerce shops regarding the preferences of e-customers to improve the sustainability of last-mile delivery. From the scientific point of view, the results presented in the paper constitute a valuable source of information about the relatively new research on e-customers' preferences for sustainable last-mile delivery. The paper consists of six sections. Following the introduction describing the research aim of the study, Section 2 presents a review of

publications on sustainable last-mile delivery in the e-commerce market. Section 3 describes the research methods. In Section 4, statistical data was presented. Section 5 discusses the obtained results, while Section 6 compares the results with those obtained by other studies; Section 7 presents the conclusions.

Literature review on sustainable last-mile delivery in the e-commerce market

The literature review revealed that even though the e-customer is considered one of the key stakeholders of urban last-mile delivery, academics have mainly adopted the perspective of institutional or business entities (Rai *et al*., 2021b; Kiba-Janiak *et al*., 2021; Nogueira *et al*., 2021). Nevertheless, the role of e-customer in sustainable last-mile delivery is gaining significance (Caspersen *et al*., 2022; Collins, 2015; Joerss *et al*., 2016; Zhou *et al*., 2018). A new term has been coined, "logsumer" (Norell & Gammelgaard, 2020), i.e. the end-consumer of logistic service, who has gained the power to impose their ideas on how their last-mile needs need to be organised, also in terms of greenness (Ignat & Chankov, 2020; Wang *et al*., 2018). The researchers apply two main approaches – reflecting the customer opinion on solutions for the organisation of sustainable last-mile delivery and examining the attributes influencing customer preferences and behaviour in terms of sustainable last-mile delivery. The first one adopts the supply chain perspective and takes growing customers' expectations regarding green last-mile delivery for granted, thus introducing green vehicles or alternative places of delivery. The second one investigates customers' psychology and behaviour. The authors of this paper focused on the selected attributes that were examined under both approaches.

Considering the studies on customers' opinions on solutions for the organisation of sustainable last-mile delivery, most of them focused on measures such as parcel locker (Iwan *et al*., 2016; Vakulenko *et al*., 2018; Stefko *et al.*, 2022), cargo bikes and micro-hubs (Hagen & Scheel-Kopeinig, 2021), crowd shipping (Marcucci *et al*., 2017), drones (Yoo *et al*., 2018), and ecological means of transport (Lemardelé & Estrada, 2021). In the conducted research, the so-called customer experience (Vakulenko *et al*., 2018) was examined, and the inclination of customers to use solutions that are considered sustainable, namely generating lesser pressure on the environment, in comparison with traditional and home delivery. Based on that, the authors of the paper created a set of solutions/methods of organisa-

tion of sustainable last-mile delivery, which includes infrastructure and transportation means:

- Parcel Lockers/collection points – it seems that the customer response to parcel lockers has gained a vast amount of scientific interest, as they have been studied in various geographical locations such as Poland (Lemke *et al*., 2016), Italy (Iannaccone *et al*., 2021), Singapore (Zhou *et al*., 2018). Overall, the parcel locker option seems to be widely accepted and preferred by many e-customers.
- Micro-hubs – (Hagen & Scheel-Kopeinig, 2021) studied the acceptance for willingness to pay for an alternative last-mile delivery (micro-hub with cargo bikes) of German e-customers. The findings suggest that only 36% of the respondents are willing to pay for the use of micro-hubs even though most of the population (60%) would be interested in being customers. Delivery time and communication between customers and parcel companies are the most important factor for all respondents. However, those who declare WTP for micro-hub delivery care much more for ecological transport.
- Ecological means of transport, including, e.g., cargo bikes (Hagen & Scheel-Kopeinig, 2021), electric cars (Jaller *et al*., 2021; Wicki *et al*., 2022), and autonomous delivery vehicles (ADVs) – only one study investigates the level of users' acceptance related to autonomous delivery vehicles in last-mile delivery (Kapser & Abdelrahman, 2020), which are believed to have the potential to revolutionise LMD since it is more sustainable and focused on customer's needs. The findings suggest that price is the most decisive factor influencing behavioural intention.

In the analysed works, other less common solutions were also considered, including:

- Smart locks – the customer reception of smart locks was discussed by (Rai *et al*., 2021c, 2019). Those keyless electronic door locks allow the unlocking private delivery locations door to third parties, such as couriers, through the mobile app on consumer smartphones. It is a solution to a failed delivery problem, reducing the cost for delivery companies and the environmental burden. Nevertheless, potential customers are reluctant to use this solution due to the risk of hacking or theft (Yuen *et al*., 2019). Additionally, this solution does not seem to be environmentally friendly. Admittedly, it eliminates situations in which the courier cannot deliver the parcel due to the absence of the e-customer. Nevertheless, couriers are obliged to deliver parcels to individual recipients, contributing to more significant air pollution and congestion.
- Drones – drones have only been tested for last-mile deliveries, and they have a strong potential for delivering parcels up to 5kg at the time the

customers want (Lee *et al*., 2016). They are fast, cost-effective and environmentally friendly (Goodchild & Toy, 2018; Yoo *et al*., 2018). Therefore, people who share such beliefs are more likely to adopt them, even though customers are afraid of drone malfunction or privacy violations. Rural customers value the environmental advantages of drones more than urban customers (Berenguer *et al*., 2005; Yoo *et al*., 2018). However, there are still problems with safety regarding the implementation of drones in the urban area. Therefore, this solution is not yet so popular in urban areas (particularly with high population density).

The second stream of research focuses on attributes that influence customer preferences and behaviour regarding sustainable last-mile delivery (Caspersen *et al*., 2022; Guo *et al*., 2022; Kapser & Abdelrahman, 2020; Yuen *et al*., 2019). Collins (2015) points out that preferences might easily be mistaken with constraints, both by researchers and decision-makers. He acknowledges that a particular preference for a pick-up mode or a parcel locker location might result from a customer's lifestyle constraint. For example, some recreational activities or working hours may be perceived as constraints in terms of last-mile delivery. Therefore, he suggests that the customer choices need to be analysed resulting from preference and constraint. Also, not all solutions are used in a given city; therefore, the e-customer has a limited choice regarding sustainable deliveries.

However, some attributes significantly influence the e-customers' preferences and behaviour regarding last-mile delivery. Research shows that price is the most decisive attribute when e-customers select the last-mile delivery method (Rai *et al*., 2019; Lemke *et al*., 2016). However, numerous studies demonstrate that some e-customers are ready to pay more for the delivery provided they are sustainable. It has been found that women are more inclined to pay for sustainable delivery (Polinori *et al*., 2018). This study also proved that respondents with higher awareness of sustainability issues are more prone to pay more for sustainable last-mile delivery. The importance of information and education in increasing customers' awareness of sustainability issues also has been confirmed in other studies (Agatz *et al*., 2020; Rai *et al*., 2021a). Still, Caspersen *et al*. (2022) found that the intensity of online shopping negatively influences the willingness to pay for sustainable delivery alternatives.

Nevertheless, Rai *et al*. (2019) discovered that consumers are willing to pay if it means fewer home deliveries in favour of pick-up points and longer delivery times. Although the WTP (willingness-to-pay) considerably decreases when it concerns the usage of sustainable alternatives to combustion delivery vans, such as electric vehicles or cargo bikes. A relatively high percentage of neutral responses to the statements evaluating consum-

ers' attitudes to sustainability suggests that the interest and knowledge about sustainability in last-mile deliveries is insufficient. The idea that consumers, when provided with appropriate information and knowledge, tend to be willing to choose sustainable last-mile delivery was also confirmed by Agatz *et al*. (2020). He showed that consumers could switch to more sustainable last-mile delivery solutions if the right incentives are provided (like free delivery or green labels). Information about last-mile delivery solutions' environmental and social impacts also seems to be a promising approach to influence consumers to choose more sustainable last-mile deliveries (Rai *et al*., 2021a).

An interesting analysis was performed by Ignat and Chankov (2020), who analysed customers' preferences for sustainable last-mile delivery. The findings reveal that emphasising the environmental and social impacts of last-mile deliveries generally makes customers change their preferred delivery option for a sustainable one. The study includes all three dimensions of sustainability and offers choices based on economic, environmental, and social factors. Customers provided with relevant information are willing to make a financial sacrifice for the benefit of the planet (Rai *et al*., 2021a; Nogueira *et al*., 2021). Nevertheless, in most cases, the research is oriented towards changing customer preferences into more sustainable ones through various policies, such as price incentives — free delivery in sustainable price slots and green labels (Agatz *et al*., 2020). Based on the review of the existing literature, the compilation of previously studied preference attributes was created and presented in Table 1.

Studies considering the customer role in the organisation of sustainable last-mile delivery are based mainly on semi-structured or focus interviews (Rai *et al.*, 2021a) or surveys, sometimes including several scenarios (Rai *et al.*, 2019; da Silva *et al.*, 2019; Iannaccone *et al.*, 2021). A considerable number of studies were conducted as experiments (Agatz *et al.*, 2020; Rai *et al.*, 2021a; Caspersen *et al.*, 2022). Statistical methods range from calculating median to more advanced econometric analyses based on conjoint analysis (Nguyen *et al.*, 2019), cluster analysis (Oliveira *et al.*, 2019) or employing logit models (Collins, 2015; Iannaccone *et al.*, 2021; Yoo *et al.*, 2018).

The theoretical basis for those studies is provided by innovation diffusion theory (IDT) (Zhou *et al.*, 2018), the technology acceptance model (Kapser & Abdelrahman, 2020; Yoo *et al.*, 2018), customer value theory (Vakulenko *et al.*, 2018), the theory of planned behaviour (Ignat & Chankov, 2020; Polinori *et al.*, 2018), attitude theory (Wang *et al.*, 2018), the theory of reasoned action (Polinori *et al.*, 2018) and mental accounting (Nguyen *et al.*, 2019) among others. These studies focus on the importance

of consumer attitudes and beliefs in establishing the willingness and probability of adopting technological innovations (Wang *et al.*, 2018) and the socio-demographic variable of consumers (Caspersen *et al.*, 2022; Hagen and Scheel-Kopeinig, 2021; Iannaccone *et al.*, 2021; Nogueira *et al.*, 2021; Punel *et al.*, 2018; Yamane & Kaneko, 2021; Yuen *et al.*, 2018). In this regard, urban e-customers with high environmental awareness are more inclined to contribute financially to sustainable delivery and wait longer for ordered goods. Even though the price was a decisive factor for most customers (Kapser & Abdelrahman, 2020; Lemke *et al.*, 2016; Nguyen *et al.*, 2019), the financial motivations are not always the most obvious ones for all customers interested in sustainable delivery (Punel *et al.*, 2018; Poliak *et al.,* 2021). Interestingly, the studies show differences in attitudes to sustainable delivery regarding gender. Women have been more likely to choose more environmentally sustainable delivery options over speed and cost than men (Nogueira *et al.*, 2021).

Research method

In this paper, the conjoint analysis was applied to examine customer preferences in the e-commerce market in last-mile deliveries. The conjoint analysis was applied to evaluate a set of profiles (real or hypothetical products and services) described with the selected attributes (explanatory variables) in order to obtain information about the overall preferences for the profiles (a set of values of the dependent variable) made by the respondents to the survey (Wind & Green, 1975). Conjoint analysis is often perceived as a multi-element test procedure enabling the selection of analysis paths or various model creations using a variety of data and multiple techniques applied for estimating parameters, called partial utility (Bąk & Bartłomowicz, 2012). Its complex research procedure consists of deciding at every step of the process on, for example, the form of a model resulting from model variables and preferences, the way of obtaining data such as solid profiles, pairwise comparisons or the presentation of pairs of attributes. Additionally, one needs to select the presentation profiles, whether to describe a physical product, the product model or opt for a verbal description of the figure, and the preferences scale, which can be non-metric or metric. Moreover, one of the metric estimation methods (MONANOVA, PREFMAP, LINMAP, CCM, KMNK, MSAE) or probabilistic estimation methods such as MNW or EM needs to be selected. In the next stage, the credibility of the model is assessed in terms of rating accuracy and reliability. Finally, the results of measurements are interpreted, and the sample size

is determined mainly based on previous research (a standard test involves 300 to 550 respondents) (Wind & Green, 1975).

According to the terminology used in the relevant literature, explanatory variables describing goods or services are called attributes or factors, while their implementations are called levels. Attributes and their levels generate various variants of goods or services, called profiles. The number of all possible profiles depends on the number of attributes and levels, i.e., the product of the number of levels of all attributes.

The conjoint analysis model can be estimated at the individual level (in the cross-section of the respondent) and the aggregate level (in the cross-section of the entire examined sample). On the other hand, the results of the conjoint model estimation are used for (Bąk & Bartłomowicz, 2012): a) the identification of preferences, b) the analysis of market shares, c) consumer segmentation. Respondents rate profiles of products or services, thus expressing their preferences. Profile assessments are called total utilities and form the basis for further analysis, which consists in decomposing the total utility of profiles into partial utility levels of attributes and estimating the share of individual attributes in shaping the total utility of each profile (see Wind & Green, 1975). The next step is to decompose total preferences and calculate the share of each explanatory variable in the estimated total utility value of the object. Thus, estimated partial utilities related to attribute levels are obtained as a matrix.

Estimating partial utilities of individual attribute levels is based on the decomposition of the total utility obtained from the respondents' ratings. As a result, a matrix of partial utilities is obtained, based on which the relative importance of each attribute is determined. The importance of each attribute level is captured by introducing artificial explanatory variables into the constructed model, the number of which must be one less than the number of levels of the attribute in question.

The advantages of the conjoint analysis methods include a) the possibility of selecting the scale of measurement of preferences, b) the relatively simple design of a factor experiment, c) the possibility of estimating utility at the individual level of the respondent, d) estimated utility at the individual level allowing for easier market segmentation. On the other hand, the main disadvantages of this method include (Hair *et al*., 1995): a) a limited number of attributes used in the study, b) the ways of assessing profiles, which can often be far from the actual market choices of the consumer (ordering objects in the order from the most to the least satisfactory or vice versa or assessing the relative attractiveness of the presented objects), c) the limited possibilities of using a partial factor experiment. The calculations

used the conjoint package developed at the Department of Econometrics and Computer Science of the University of Economics in Wroclaw.

Statistical data

The basis of the analyses presented in the paper, the aim of which is to identify the preferences in terms of last-mile deliveries on the e-commerce market, is the research carried out at the turn of July and August 2021 on a sample of over 1,100 adult inhabitants of voivodship cities in Poland making purchases using the Internet during the year preceding the survey. The study used quasi-representative sampling, with the sample structured according to the place of residence, gender, and age. The list of factors that may affect the choice of the delivery method in the case of purchases made via the Internet was identified based on the literature review (section 2). Table 2 presents a set of attributes (factors) and their levels, which the respondents assessed during the survey.

Based on the distinguished factors and the corresponding levels, a set of hypothetical options for choosing the last-mile deliveries on the e-commerce market was created. Their number is the product of the number of levels of all describing factors. The study identified 4 factors of 3, 3, 3 and 2 levels, respectively. Based on them, 54 hypothetical variants (profiles) were obtained. Since a respondent cannot evaluate so many options, their number was limited to 9 by generating an orthogonal plan using the SPSS package, to which respondents awarded points from 0 (least preferable) to 100 (most preferable) according to their attractiveness (Table 3).

There are three nominal variables (attributes) in the conducted study with three levels, and one with two levels. Thus, seven artificial variables were introduced into the multiple regression model. The model for a sample respondent s thus takes the following form:

$$\widehat{Y_s} = b_{0s} + b_{1s}X_{1s} + \cdots + b_{7s}X_{7s}, \tag{1}$$

where:

$b_{1s},\ldots, b_{ns}$	the parameters of the regression equation,
b_{0s}	constant,
$X_1, \ldots, X_7$	artificial variables.

Study results

The result of the applied conjoint analysis is assessing the importance of each factor in determining the choice of the last-mile delivery method in the e-commerce market and the segmentation of respondents with similar preferences. Table 4 presents selected descriptive characteristics determined based on the assessments granted by the study participants to individual assessed profiles.

The profiles were ordered according to the designated average rating. The highest average score, above 70 points, was obtained by profiles 6 (76.95), 4 (76.90) and 3 (72.57). These profiles differ due to most of the evaluated factors (criteria). The differences are not limited to the delivery price, defined in each of these profiles as free delivery. Two of these profiles also assume that the delivery will be carried out using an environmentally friendly means of transport (profiles: 6 and 3). It is worth noting that the designated average ratings were the lowest for all profiles, where it was assumed that the delivery price would be higher than the standard price (profiles: 1, 5 and 7). The lowest rating was determined for profile 1 (48.18), in which it was assumed that delivery would happen within the standard deadline but at a price higher than the standard and would be carried out to a collection point by any means of transport.

The conducted analyses show that the price is an essential factor when respondents assess particular delivery methods (described using different criteria). These observations also confirm the obtained results in the scope of the so-called partial utilities, which were calculated based on the respondents' ratings (so-called total utilities). Partial utilities determine the relative importance of individual levels of attributes in total utility and are estimated based on empirical decompositions of total utility. For this purpose, the parameters of the regression model (formula 1) are determined. The explained variable is the total utility assigned by the respondent to individual profiles in the study. In the study of preferences of inhabitants of voivodship cities in Poland in the scope of last-mile deliveries in the e-commerce market, the model of main effects of conjoint analysis was used. The function caPartUtilities from the conjoint package estimated partial usefulness. A fragment of the results for the four sample respondents is presented in Table 5.

The obtained results mean that according to respondent 1, the most important criteria (factor levels) determining the choice of a specific method of last-mile delivery on the e-commerce market are: delivery to a parcel locker or delivery to a collection point station, standard price, custom delivery date (time indicated by the customer) and delivery by any means of

transport. In turn, for respondent 2, the most important is delivery to a parcel machine or delivery to a collection point station, free delivery, or delivery at a standard price, on a standard date, carried out by any means of transport. However, analysing the results at the aggregate level, it can be indicated that the most preferred are free deliveries (11.467), delivered to parcel machines (2.582) using ecological means of transport (1.166) (Table 6). Based on the obtained partial assessments, it is also possible to calculate the validity of individual factors in the cross-section of all respondents (Figure 1).

The most important factor determining the choice of the last-mile delivery method in the e-commerce market is the price (36.71%), then the delivery method (25.46%), delivery time (22.22%), and finally, the mode of transport (15.61%). Thus, previous observations indicating that price is the most crucial factor when choosing the delivery method have been confirmed.

The last stage in the conjoint analysis is segmentation, which was performed in the R program using the classification method of k-medoids, which enables the division of the data set into classes (from 2 to 10 classes). The gap index programmed in the clusterSIM package was used (Bartłomowicz, & Bąk, 2019) to select the number of classes. When determining the number of classes, the value of diffu was considered. The minimum number of classes for which diffu≥0 was 3, which means that respondents need to be divided into three classes. The stability of the resulting division was also examined using the Rand index amounting to 0.59886, which means that the division of respondents into three classes is relatively stable. The resulting classes can be characterised as follows:

- Class one – 346 respondents; it is a relatively homogeneous class considering the standard deviation of all variables; it includes respondents who most prefer free home delivery on a standard date but carried out by an ecological means of transport.
- Class two – 485 respondents; this is by far the most homogeneous class (considering the standard deviations of all variables); respondents in this class prefer those delivery variants (profiles) in which delivery is free (profiles: 3, 4, 6).
- Class three – 279 respondents; the homogeneity of this class is by far the lowest; this class is relatively homogeneous if only the following profiles are considered: 2, 3, 4, 6, 8, 9. So, these are profiles where free delivery or delivery at the standard price is preferred. The preferred factor is also the possibility of choosing an ecological means of transport.

It is also worth emphasising that in each of the analysed clusters, the first profile was the least preferred, assuming delivery to the collection

point, at a price higher than the standard one, within the standard time limit and carried out by any means of transport. In the third class, the least preferred was also profile 7, assuming home deliveries, at a price higher than the standard one, within the standard time limit, also carried out by any means of transport.

Discussion

The recent research (Caspersen *et al.*, 2022; Kapser & Abdelrahman, 2020) emphasises that consumer preferences and decisions are important when creating and implementing solutions for sustainable last-mile delivery. Therefore, courier companies and other stakeholders participating in the organisation of last-mile deliveries should recognise the preferences of e-customers before implementing any solutions. Much research focuses on studying the preferences of e-customers purchasing in e-commerce in terms of a narrow group of services or products. An example is Caspersen and Navrud (2021), who investigated whether attitudes and behaviours of Norwegian women aged 18 to 70 regarding environmental protection are reflected in their declared preferences for last-mile delivery options for clothing rentals. In turn, Tolentino-Zondervan *et al.* (2021) focused only on a group of employees in one of the campuses in the Netherlands. No publications are researching this aspect in a broader sense in the literature. Therefore, this paper fulfilled this research gap through the holistic approach to investigating the preferences of various groups of e-customers on last-mile delivery and the factors which could change their preferences towards more sustainable ones. This study is particularly valuable for couriers and large e-platforms that process orders for various products, from groceries to clothing, medicine, and household appliances. It is hard to apply research here that deals with a narrow group of products or services. The segmentation conducted by the authors shows that certain similar preferences characterise the identified groups of customers in terms of the choice of delivery method for products purchased online. If courier companies and e-platforms know these preferences, they can facilitate and accelerate the implementation of sustainable last-mile delivery efforts.

For example, the research conducted by the authors shows that the most preferred factor determining the choice of delivery of goods purchased online is the price (36.71%). This result confirms earlier studies by Rai *et al.* (2019), and Lemke *et al.* (2016), where price has also been recognised as the most decisive factor in choosing the last-mile delivery method. In the research conducted by the authors, the respondents recognised the delivery

method (25.46%) and delivery time (22.22%) as other important criteria. In turn, Nogueira *et al.* (2021) indicate that consumers prioritise cost and speed of supply over sustainability, ignoring the greenhouse gas impacts associated with the final distribution of purchased products. Their research among 421 respondents purchasing on the e-commerce market shows that the essential criterion for choosing the delivery method was its speed, delivery costs, and finally, information about the environment.

In the study conducted by the authors, the respondents prefer ecological means of transportation to conventional (combustion) ones. However, the condition for choosing an environmentally friendly means of transport is free delivery. That shows that respondents living in Polish provincial cities do not want to pay extra for sustainable supplies, similarly to those in the research conducted by Caspersen *et al.* (2022). According to Polinori *et al.* (2018), it may result from low pro-ecological awareness because, according to research conducted by his team, e-customers who are more pro-ecological are more willing to pay more for sustainable deliveries. The solution to this problem may be to highlight the environmental and social impact of last-mile delivery in the services offered by courier companies and e-platforms. According to Ignat and Chankov (2020), customers informed about the environmental impact of a particular delivery are more likely to behave in an environmentally friendly manner and even pay an extra fee to protect the planet (Rai *et al*., 2021a; Nogueira *et al*., 2021).

It is also disturbing that the respondents from among the assessed delivery options give higher ratings to those that assume deliveries are made directly to their homes. It may also result from the lack of awareness of the possible impact of a particular delivery method on environmental pollution. Deliveries to parcel machines or collection points are probably not perceived by respondents as choices limiting the negative impact of transport on the environment. Thus, the research carried out by the authors shows that the preferences of e-customers have a significant impact on the organisation of last-mile deliveries. The lack of awareness of e-customers about the nature and scope of sustainable last-mile deliveries leads to the choice of a delivery that is not environmentally friendly and generates costs for the courier (or retail company). According to Agatz *et al.* (2020), the awareness of the essence of sustainable delivery can be raised among e-customers through information and education activities. Therefore, courier companies, e-shops, online platforms, and local governments should promote, inform, and make e-customers aware of sustainable last-mile deliveries.

Conclusions

The article aims to identify the preferences of e-customers and, on their basis, to indicate their impact on the organisation of sustainable last-mile deliveries. The authors reviewed the existing research on e-customers' preferences for last-mile delivery in the theoretical part. On this basis, they have identified the attributes that influence e-customers' preferences in choosing the delivery of a product purchased online. What is an added value of this article is a holistic approach to the topic of researching e-customers' preferences for last-mile delivery. Many studies on related topics are conducted for a small territorial area, such as a university campus, for example, or a particular type of product. In addition, many of the studies to date focus primarily on analysing e-customers' preferences for purchases rather than on the choice of delivery method for the product purchased online.

In order to achieve the research objective, the authors conducted a survey among Polish e-customers selected according to their place of residence, gender, and age. The study enabled the identification of the preferences of e-customers in terms of last-mile delivery. It turns out that most respondents declared that price is the deciding factor in choosing delivery. At the same time, if the delivery is free, respondents prefer delivery by environmentally friendly means of transportation to conventionally driven vehicles. Unfortunately, a vast majority of Polish e-customers participating in the survey are unwilling to pay extra for green delivery. It is evidenced by the results of the conjoint analysis conducted. During the survey, respondents were asked to rank nine last-mile delivery profiles from most to least preferred. Based on the analysis, the most preferred profiles were those with free delivery. Following were those profiles where deliveries are made at a standard price and, at the very end, those offered at a price higher than the standard price. The most preferred last-mile delivery profile by survey respondents is one where deliveries are delivered to one's home for free, on a standard delivery date and with ecological means of transportation. The second most preferred was free delivery to the parcel locker, with a customised delivery date and by any means of transportation. Thus, the research shows that surveyed e-customers in Poland are not guided by environmental issues when choosing a delivery method, but primarily by price. It is confirmed by the last-mile delivery profile least preferred by surveyed e-customers. It includes delivery to the collection points with a standard rate, customised delivery time, and ecological means of transport. It is one of the most sustainable ways of delivering goods to the recipient, which, however, requires e-customers to pay for delivery.

In their research, the authors also distinguished three classes of e-customers, considering their preferences for last-mile delivery. There are some differences among particular classes. Class one — respondents prefer free home deliveries; class two — respondents prefer any delivery method if it is made for free; class three — respondents, in addition to free deliveries, also prefer the delivery of purchased goods at a standard price. For over 56% of respondents qualified for the first and third class, the possibility of choosing an environmentally friendly means of transport during last-mile deliveries is also an important criterion.

The study results discussed in this publication could be a valuable source of information for courier companies, e-shops, online platforms, and local governments regarding e-customers preferences on last-mile delivery in the e-commerce market. The key message for courier companies, e-shops and online platforms is that among the e-customers surveyed, price is the most important factor in choosing a delivery method. Nevertheless, with free delivery, respondents prefer environmentally friendly transportation to conventionally driven ones. In addition, the segmentation of e-customers shows that price is the deciding factor in choosing a delivery method in virtually every class. Thus, it can be concluded that the e-customers in Poland who participated in the survey are not ready to contribute to the costs associated with organising sustainable last-mile deliveries, such as paying an additional fee for delivery by a green means of transportation. Therefore, courier companies, e-stores, online platforms and, above all, local governments should take measures to make residents aware of the consequences of choosing non-ecological delivery of parcels purchased online. Raising awareness of e-customers in this regard can significantly accelerate and increase the effectiveness of courier companies' adoption of sustainable last-mile deliveries.

The authors are aware of the limitations of the research concerned with the sample selection (e-clients from voivodship cities) and thus the inability to formulate conclusions concerning the entire population of e-customers in Poland. The choice of urban residents was dictated by the fact that among e-customers, urban residents account for more than 70%. It should be added here that more than 20% of the Polish population lives in provincial cities. In addition, the authors deliberately divided the sample by age and gender, reflecting the population of the regions studied. Another limitation of the study is the choice of factors for the individual profiles based on which preferences were studied. Although they were selected in a very thoughtful manner on the basis of the relevant literature and last-mile delivery solutions available in Poland, they, unfortunately, do not take into account

those solutions that do not yet exist in Poland, but are being implemented in other countries (or are currently being tested).

In further research, the authors plan to extend the research to investigate what kinds of different factors and solutions can be applied in the area of last-mile delivery. Additionally, based on the in-depth interviews and focus groups with various representatives of e-commerce stakeholders, we would like to investigate what tools and methods should be applied to increase e-customers awareness of the impact of last-mile deliveries on the environment and society. It could also be interesting to discover how sustainable last-mile delivery can be co-created by various e-commerce stakeholders.

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Annex

Table 1. The list of attributes that influence customer preferences and behaviour in terms of sustainable last-mile delivery – literature review

Dimension	Attribute	Reference	Context
Cost	Price	Lemke *et al.* (2016); Iwan *et al.*(2016); Rai *et al.* (2019),	Top criterion among parcel locker users in selecting a service provider
	Free delivery/return	Rai *et al.*, (2019)	Consumers are willing to wait longer or collect orders on their own in exchange for free delivery or return.
	Willingness to Pay more than the standard price	1. Caspersen *et al.* (2021) 2. Hagen & Scheel-Kopeinig (2021)	1. Consumers' willingness to pay (WTP) for climate-friendly last-mile deliveries through reduced or no CO2 emissions from the delivery 2. Only 36% are willing to pay to use the micro-hub
Delivery date	Customised delivery date and location	Lemke *et al.* (2016), Vakulenko *et al.* (2018), Oliveira *et al.* (2019), Iannaccone *et al.* (2021)	The third criterion of selecting a delivery provider The possibility of deciding on the delivery date and its schedule most significantly influences consumers' utility depending on the customer segment
	Fast delivery and date/ time indicated by the customer	Lemke *et al.* (2016), Vakulenko *et al.* (2018), Rai *et al.* (2019)	The second most important criterion among parcel locker users in selecting a service provider
Convenience	Location - distance	Lemke *et al.* (2016), Deutsch & Golany (2018)	Preferable in the vicinity of their homes, workplaces, or places where it is easy to park
	Possibility of collection by bike or on foot	Lemke *et al.* (2016), Oliveira *et al.* (2019), Iannaccone *et al.* (2021)	The second preferred collection method on foot
Environment	Social pressure to act in a sustainable manner	Buerke *et al.* (2016)	Consumer awareness and sustainability-focused (especially environmentally friendly) value orientation have a direct positive influence on responsible consumer behaviour
	Personal environmental awareness	Punel *et al.* (2018), Yoo *et al.* (2018)	Environmentally aware younger and employed urban inhabitants who have already tried alternative delivery are most willing to use micro-hub
	Environmentally friendly delivery available	Ignat & Chankov (2020), Nogueira *et al.* (2021)	Consumers are willing to make economic sacrifices if this leads to environmental or social improvements

Table 2. Factors and their levels were used in the design of the research tool

Factor (criteria)	Levels
Delivery method (3 levels)	1. Home delivery (DM1) 2. Delivery to the collection point (DM2) 3. Delivery to a parcel locker (DM3)
Price (3 levels)	1. Free delivery(P1) 2. Standard rate (P2) 3. Price higher than the standard rate (P3)
Delivery date (3 levels)	1. Standard delivery date (DD1) 2. Customised delivery date, Mon-Fri (Sat, weekend, accelerated, delayed, but within the standard offer) (DD2) 3. Custom delivery: date and time indicated by the customer (DD3)
Means of transport (2 levels)	1. Any means of transport (T1) 2. Ecological means of transport (e.g., electric cars, cargo bicycles) (T2)

Table 3. Profiles

Profile	Description
1	DM2, P3, DD1, T1
2	DM1, P2, DD3, T1
3	DM2, P1, DD3, T2
4	DM3, P1, DD2, T1
5	DM3, P3, DD3, T2
6	DM1, P1, DD1, T2
7	DM1, P3, DD2, T2
8	DM3, P2, DD1, T2
9	DM2, P2, DD2, T2

Table 4. Descriptive statistics

Profile	Descriptive statistics			
	Mean	Median	Standard deviation	Coefficient of variation (%)
6	76.95	84	23.71	30.82
4	76.90	82	23.16	30.11
3	72.57	76	26.27	36.20
8	69.23	72	23.83	34.43
9	62.78	65	26.31	41.91
2	62.28	68	29.46	47.31
5	53.64	57	29.91	55.77
7	53.53	57	29.54	55.19
1	48.18	51	31.50	65.39

Table 5. Partial usefulness for selected respondents

Factor	Levels	Respondent number			
		1	**2**	**3**	**4**
Delivery method	1. Home delivery	-21.667	-6.111	20.556	-2.444
	2. Delivery to the collection point	10.333	13.222	-7.778	6.222
	3. Delivery to a parcel locker	11.333	-7.111	-12.778	-3.778
Price	1. Free delivery	-4.667	20.889	44.222	-4.111
	2. Standard rate	11.333	17.889	-3.111	4.556
	3. Price higher than the standard rate	-6.667	-38.778	-41.111	-0.444
Delivery date	1. Standard delivery date	-6.667	12.556	-0.111	5.222
	2. Customised delivery date, Mon-Fri (Sat, weekend, accelerated, delayed, but within the standard offer),	-4.667	-6.778	-21.444	-10.111
	3. Custom delivery date and time indicated by the customer	11.333	-5.778	21.556	4.889
Means of transport	1. Any means of transport	7.500	10.417	7.917	1.417
	2. Ecological means of transport	-7.500	-10.417	-7.917	-1.417

Table 6. The results at the aggregate level

Coefficients:	Estimate	Std. error	t-value	Significance level
Intercept	63.6158	0.2892	219.993	<2e-16***
DM1	0.2472	0.3856	0.641	0.5214
DM2	-2.8296	0.3856	-7.339	2.32e-13***
P1	11.4674	0.3856	29.742	,2e-16***
P2	0.7569	0.3856	1.963	0.0497*
DD1	0.7806	0.3856	2.025	0e0429*
DD1	0.3968	0.3856	1.029	0.3034
T1	-1.1659	0.2892	-4.032	5.57e-05***

Significance codes: *** 0.001, ** 0.01, * 0.05; Multiple R-squared:0.1195, Adjusted R-squared 0.1189

Figure 1. Average importance of factors