

Investigating the Choice of Receiving On-Line Purchases Through Discrete Choice Modelling Approach

Antonio Comi(✉), Ippolita Idone, Marco Cortese, and Olesia Hriekova

DII - Department of Enterprise Engineering "Mario Lucertini", University of Rome Tor Vergata, via del Politecnico 1, 00133 Rome, Italy
{comi,idone,hriekova}@ing.uniroma2.it

Abstract. The paper aims to analyse modern and innovative last-mile delivery solutions, investigating the attributes and levels that influence the preferred alternative for receiving online purchases. Based on this, a forecasting model is developed to simulate the choice behaviour of end consumers (using a discrete choice model), and its use for implementing more effective and efficient last mile delivery strategies is discussed. Thus, the paper, after a review of the main attributes and levels that guide the end consumers in choosing the way of receiving the purchases done online, identifies the main available alternatives (i.e., parcel lockers, drones, crowdshipping and delivery to trunk) and presents the results of a stated preference survey. Two blocks of nine different scenarios were designed, and *310* respondents were part of a stated preference survey, and whose results allowed a discrete choice model with significant results to be developed.

Keywords: city logistics · home delivery · pick up · parcel lockers · drones · crowdshipping · trunk delivery · discrete choice model · stated preferences · urban transport · last mile delivery

1 Introduction

To date, urban logistics has shown significant relevance around the world due to the numerous issues caused by the increase of freight flows in cities [1–4], driven by the changes occurring such as the growth of e-commerce and smaller and more frequent deliveries [5, 6]. In fact, last mile delivery (LMD) is an important part of the supply chain as it accounts for an average of *53%* of total delivery costs and accounts for about *25%* of urban congestion. In addition, empirical studies have shown that vehicles used in the LMD process have an average load factor of *30–40%*, with more than *20%* of vehicles running empty. Moreover, failed delivery attempts are still a real problem today, generating unnecessary costs for logistics operators, inconvenience for end consumers, and an increase in the number of vehicles in circulation (causing externalities such as pollution emissions, accidents, congestion and so on).

On the other hand, e-commerce is gaining momentum, creating new challenges and pressuring to explore modern approaches to address sustainable and liveable changes

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[7]. Nowadays, end consumers choose the way to receive purchases [8, 9]. New last mile delivery alternatives are emerging year by year [10].

Then the paper aims to investigate the choice of receiving e-purchases because it can have a strong impact on city sustainability. After a review of the main attributes that guide the end consumers in choosing the way of receiving the purchases done online, the main available alternatives were identified (i.e., parcel lockers, drones, crowdshipping and delivery to trunk) and presents the results of a stated preference survey (SP) where results were used for calibrating discrete choice models.

The rest of the paper is organized as follows. Section 2 discusses the state of the art and reviews of the relevant literature. After Sect. 3 discusses the method used, then Sect. 4 presents the results, divided into three subsections (sample, model calibration and validation and discussion). Finally, Sect. 5 draws conclusions and the road ahead.

2 Literature Review

The e-commerce sector has experienced significant growth in the last decade, focusing on convenience and accessibility, and generating a substantial increase in online purchases. However, this rapid growth is accompanied by several challenges that require in-depth analysis and targeted solutions. A recent study by Gupta et al. [11] adopted the Delphi approach involving industry experts and using 'Analytic hierarchy process' and 'Criteria importance through intercriteria correlation' methods to identify, classify and prioritize key advantages, challenges, and pathways within the e-commerce industry context.

Surveys reveal that affordable advertising and marketing, product availability and variety, along with global reach, emerge as key advantages. On the other hand, significant challenges include technological updates, return or refund management, and the presence of counterfeit products. To address these challenges, government compliance control, better relationships with delivery partners, and robust policies on data privacy and online security emerge as crucial pathways for the industry.

This study provides valuable insights for private companies, authorities, and researchers in e-commerce, outlining strategies to maximize benefits, mitigate challenges, and develop sustainable solutions. The accelerated growth of implementing technologies not only has improved consumer access to goods and services more conveniently but has also contributed to job creation and opened new global business opportunities. Additionally, e-commerce can be proven to be more environmentally sustainable than traditional retail due to its ability to reduce the need for physical spaces and optimize delivery systems [12]. However, it can cause a negative impact due to failure delivery [13–15].

One of the fundamental advantages of e-commerce is its ability to offer greater convenience to end consumers, allowing them to make purchases anytime without the constraints of parking or typical checkout lines in physical stores. This flexibility is particularly appreciated by working professionals, eliminating the need to visit physical stores during work hours. Furthermore, e-commerce offers a wider selection of products from around the world, greatly enhancing consumers' accessibility to a wide array of goods.

The convenience of online price comparison, coupled with a potential reduction in operational costs for e-commerce businesses, contributes to more competitive prices

for end consumers. Additionally, the use of big data and artificial intelligence enables effective customization of marketing strategies, enhancing customer satisfaction and loyalty.

The recent paper by Zang et al. [16] addresses the complex issue of urban LMD characterized by conflicting time windows. In 2020, the global volume of online retail transactions exceeded $4 trillion, with online retail sales in China reaching $2 trillion. In China, the e-purchase of over *80* billion parcels annually highlights the enormous flow of goods from e-commerce to end consumers, with over *200* million parcels shipped daily. The effectiveness of logistics services in e-commerce has a direct impact on online end consumer satisfaction and loyalty, an aspect that has attracted increasing attention from e-commerce platforms and logistics service providers.

Responding to diverse end consumer delivery needs, ensuring timely parcel delivery within their specified time windows emerges as an effective way to improve end consumer satisfaction in e-commerce. However, some significant challenges need to be addressed. First, the prevalence of small parcels that do not require personal signatures imposes new logistical considerations. Second, the hectic lifestyles of e-commerce customers make it difficult to wait at home for delivery, while expanding time windows result in delays, proving suboptimal. Furthermore, the vast scope of e-commerce customers can lead to conflicts between delivery time windows, complicating the search for feasible solutions. Finally, the concentration of urban customers results in frequent return trips and higher delivery costs, especially when they in the same community require different time windows.

The relative cost of global LMD, excluding pick up, transport, and sorting, was approximately EUR *70* billion in 2016, with the growth of online retail sales identified as the main driver of development [17, 18]. The expansion of digital technologies in the retail sector and the growth of business-to-customer (B2C) e-commerce have intensified the demand for LMD [19–21]. Additionally, end consumers' growing expectations for convenient and economical delivery services are pushing towards the development of more efficient and environmentally friendly LMD solutions. Due to the diversity of demand and the logistical peculiarities of urban distribution, crowdshipping (i.e., crowd logistics) emerges as an intriguing solution to meet the increasing expectations of end consumers for fast, reliable, and sustainable delivery services [22–37]. Leveraging the possibilities of geolocated real-time communication via mobile devices and the social trend toward sharing and collaboration, crowdshipping could bring significant benefits to the sustainable development of future cities. In particular, advanced telecommunications and crowdfunding-based networking technologies could significantly reduce infrastructure and operational costs, as well as traffic generated by couriers. Additionally, crowdshipping models that involve people traveling during their daily activities are particularly environmentally friendly due to the use of existing resources and fewer dedicated trips, contributing to more economical, real-time and accurate location services, crucial elements for efficient crowd analysis and task allocation. Due to the need for fewer vehicles and exchange points, delivery systems become more environmentally sustainable.

In recent years, parcel lockers, secure containers enabling automatic parcel pick-up and delivery for customers and carriers are gaining popularity as a flexible solution

for transferring goods between different modes and actors. In addition, to being seen as a practical solution for delivery and pickup in the B2C, parcel points (and lockers) could facilitate the exchange of goods between various actors in the supply chain for collaborative delivery [16, 35, 38–47]. They are located mainly in public spaces, ensuring easy access for both couriers and carriers. Ghaderi et al. [17] introduced the concept of collaborative crowdshipping, indicating that LMD could be managed by more than one crowdshipper, using parcel lockers as exchange points.

The cutting-edge alternatives for last mile delivery are by drones on the side of mode [48–54] and to car trunk on the side of location [47, 55–57]. In this study, in addition to the traditional (TR; that is, the conventional mode used by traditional carriers and couriers such as Bartolini, DHL, Poste Italiane, SDA, etc.), four innovative alternatives are presented that are revolutionizing the logistics and distribution landscape:

- pick-up pint and locker delivery (PL); it is a self-service approach to parcel pick up. These points and lockers are strategically placed in easily accessible locations such as shopping centres, gas stations, and railway stations (e.g., Amazon locker), ensuring extended hours; the pick-up lockers often up to *24* h a day and *7* days a week; once notified of the e-purchase deposit at the chosen pickup point (or locker) at the time of online purchase, the package can be collected freely within a predetermined time (e.g., *3* days);
- crowdshipping delivery (CR); crowdshipping represents a novel alternative that utilizes digital platforms to connect shipment demand with the supply of ordinary someone willing to deviate from their route to deliver packages to end consumers, receiving modest compensation in return [58, 59];
- delivery by drone (DR); this delivery alternative uses unmanned aerial vehicles to transport goods; the end consumer receives via App all notifications related to their e-purchase, i.e., from the moment it is assigned to the drone to when it arrives at their address; pick-up can be made by unlocking the compartment of the drone where the e-purchase is stored with a secret code; in 2024, Italy will be the first European country where Amazon will use drones for deliveries, entrusting the service to the new Mk30 model [60]; the use of drones promises extremely fast delivery times, with a perspective of only *30* min;
- delivery to trunk (BA); it is made by a courier or transporter directly to the end consumer's car during a parking; the courier or transporter, reaching the car, opens the trunk compartment with a secret code and leaves the e-purchase; the recipient receives a notification of successful delivery; this innovative delivery alternative, already in use in numerous cities across the United States, introduces a new delivery point [61]: the end consumer's car trunk; aimed primarily at those who cannot receive orders at home or at work, or who do not have convenient pick up points (and lockers), this service offers unique flexibility in parcel reception.

3 Methodology of Analysis

SP surveys are a set of techniques that use statements provided by respondents to estimate their behaviour in hypothetical contexts. The purpose of the SP survey is to acquire qualitative and quantitative data on the stated preferences of the respondents. This allows

a comprehensive understanding of the inclinations and preferences of the population involved and allows for any future decisions regarding services or policies based on such data. The responses provided in this section are considered important for the analysis and will be used to inform potential future developments.

This approach offers several advantages over the SP methodologies:

- introduction of new alternatives; SP surveys allow the introduction of choice alternatives that may not yet be available in the real world; for example, the alternative of new means of transportation could be evaluated in a context of mode choice;
- control of variability; SP surveys enable the variation of relevant attributes outside observed limits, thereby contributing to obtaining more accurate estimates of the related coefficients; this is particularly useful when assessing attributes that are difficult to quantify, such as urban transport costs;
- introduction of new attributes; traditional choice models may lack some important attributes; through SP surveys, it is possible to introduce such attributes in choice contexts, such as product delivery via drones or delivery to the end consumer's car trunk;
- wide range of information; SP surveys offer the opportunity to obtain a wide range of data from a limited sample, as each respondent can be exposed to various choice scenario; this leads to an efficient use of resources and a more complete set of information without increasing number of questions; during the survey, respondents are presented with various choice scenarios or contexts, each characterized by specific attributes and levels that define its characteristics.

For actual data collection, an online questionnaire was used to survey *310* respondents with *41* questions, which included closed-ended questions, open-ended questions, and asked respondents to rank the proposed attributes in order of importance. The questions are divided into three main sections: information about the respondent, information about the household, durable goods purchasing behaviour, SP survey.

In this type of survey, alternatives are defined by various attributes that can vary in a predefined number of levels. These can be specific, such as delivery times and costs, or relative, indicating variations from average attribute levels in the scenarios. In general, respondents may be asked to express their preferences in different forms: choice; ranking; voting. This paper implements a SP survey with three choice types. In the first choice type, the respondents indicate which levels of attributes they would choose from the proposed attributes and their levels. In the second choice type, the respondent is asked to rank the attributes proposed according to their preferences. In the last choice type, the respondent assigns a vote to each attribute based on his/her preference. In the choice set under study, the attributes and levels chosen are listed in the following list, where:

- delivery cost represents the amount to be paid for order delivery (*2* EUR, *5* EUR, *9* EUR, *10* EUR, *18* EUR, *20* EUR);
- delivery time required to receive the order (*2* days, *3* days, *4* days, *5* days);
- distance from usual home/workplace indicates how close the delivery location is to the home/work (*0* m, within *200* m, within *200 to 500* m); for example, the closest locker may be *500* m away;
- delivery customization is the possibility to customize the delivery according to one's needs; the two levels are:

1. inability to choose; the delivery date and time window are determined autonomously by the carrier, without the possibility of customization;
2. possibility to choose; there is the possibility of choosing the delivery date and time window, adapting the delivery to personal preferences (e.g., on Friday in the morning between *9:00* a.m. and *11:00* a.m.);

- delivery traceability is the ability to monitor the purchase during delivery process and can be of two levels:

  1. tracking for main stages; updates on the e-purchase status are received during the main stages of the delivery process (e.g., the service offered by traditional couriers that inform when the package is sorted in a distribution centre or when it is delivered to the destination location);
  2. real-time tracking: there is access to real-time information about the e-purchase; this type of tracking offers complete and instantaneous visibility on the e-purchase location;

- environmental sustainability of the delivery reflects how environmentally sustainable a delivery alternative is:

  1. low means a high negative impact on the environment (i.e., externalities); this applies to alternatives such as traditional delivery;
  2. medium represents a medium negative impact; it applies to pick up point/locker and delivery to trunk;
  3. high level means low negative impact on the environment; this applies to alternatives such as delivery by drones and crowdshipping.

Ngene software was used to create scenarios based on the alternatives, attributes and attributes levels discussed above. Based on the results from software, nine scenarios were included in the SP survey. Respondents are asked to evaluate and select delivery alternatives based on their preferences, needs and individual priorities. The next section discusses the sample of the survey and modelling based on the data.

4 Results

The methodology presented in the Sect. 3 has been implemented and the results obtained are summarized in the subsections below.

4.1 The Sample

The first part of the survey consists of *10* closed-ended questions and *3* open-ended questions and aims to obtain demographic and personal information from the respondents, necessary to provide an overview of the socio-economic status of the respondents and their individual and family characteristics. The objective of this study is to analyse the choice of alternative for receiving e-purchases; therefore, a section of the questionnaire classified them into subcategories through appropriate filter such as: gender; age; components of the household; level of education.

From the analyses conducted on the sample, it can be observed that the sample has a balanced gender distribution (*43%* female and *55%* male). Regarding age, the majority of the respondents (*68%*) are between *18* and *34* years old. A similar percentage of the sample (*75%*) consists of students and full-time employees. *35%* reside in southern Italy, mainly in cities located in Calabria and Puglia; *50%* reside in central Italy, predominantly in Rome, and the remaining portion (*15%*) resides in northern Italian regions. Digging deeper into the sampled families, it is observed that *50%* of Italian households consist of four members, while approximately *75%* of respondents declare belonging to families with at least two adult members.

Regarding the level of education of the end consumers involved in the survey, only *4%* currently hold a degree higher than a master degree, a degree possessed by *38%* of the respondents. The remaining part sees *33%* holding a bachelor's degree and *26%* having completed high school. Now, focusing on the commuting habits of Italians, it is observed that approximately *80%* of people hold only a B category driver's license, which allows driving all cars and certain types of motorcycles.

The second part of the questionnaire, through *25* questions, explores the purchasing behaviour of durable goods both in physical and online stores. It helps to investigate how often respondents make purchases in both types of stores, the chosen delivery alternative, and the preferred time to receive the goods. Responses to questions about motivation for online purchases, delivery preferences, and the most important aspects in choosing the delivery alternative help to outline a more detailed view of end consumer preferences. The first result obtained was to evaluate the frequency of purchasing durable goods in both physical and online stores. Durable goods are considered to be electronics, stationery, clothing and footwear, household products such as tableware or vases. *67%* of people go to a physical store to make purchases less than once a week but at least once a month. On the other hand, very low percentages of individuals go to physical stores every day (*2%*) or more than once a week (*12%*) to purchase durable goods. Regarding online purchases, there is a more uniform distribution of respondents who shop on average multiple times a week (*31%*), once a week (*23%*), and less than once a week but at least once a month (*35%*). The main categories of products purchased online by the respondent sample are clothing and footwear products, followed by electronic products and household products. *44%* of respondents make e-purchases because of the greater convenience of timing. This is justified by the fact that it is possible to shop online every day and at all hours of the day, in contrast to physical stores. Other identified reasons are greater economic convenience (stated by *24%* of the sample), a wider selection of products (*18%*), and time savings (*13%*). Respondents to the questionnaire are asked to identify the most important attributes that impact the choice of delivery alternatives. Almost all of the samples identified these attributes as delivery times and costs. Other considered very important by about *40%* of individuals are delivery flexibility, that is, the possibility of choosing a specific day or time window for delivery or picking up the purchase at a designated pick-up point (and locker), and shipment security (traceability, confirmation signatures or insurance). The survey also shows how the motivation for online purchases compared to purchasing in the physical store is related to the current employment situation. *62%* of students claim to shop primarily online for greater convenience of time and time savings by avoiding the consumer journey, while most employed workers (*77%*) cite greater

convenience of time and greater economic savings as the main motivation. Retirees who shop online do so to save money and avoiding additional journey (*73%*).

4.2 Model Calibration and Validation

Estimating a choice model involves three fundamental phases: model specification, model calibration, and model validation. Model specification is the initial crucial step in this process, where the complete definition of the model's mathematical structure occurs, including the choice of functional form, such as adopting a Multinomial Logit model or a Hierarchical Logit model, and the selection of variables to include.

Subsequently, attention is devoted to model calibration, which involves estimating the coefficients $\boldsymbol{\beta}$ based on the choices made by a sample of respondents. Random Utility Models can be interpreted as mathematical relationships that provide the probability $P^i[j]$ ($\boldsymbol{X}^i$, $\boldsymbol{\beta}$) that individual i chooses alternative j as a function of the vector $\boldsymbol{X}^i$ of attributes of all available alternatives and the parameter vectors related to systematic utility ($\boldsymbol{\beta}$). This dependence of choice probabilities on $\boldsymbol{X}$ and $\boldsymbol{\beta}$ occurs through the systematic utility functions, commonly modeled as linear combinations of attributes X with coefficients given by parameters $\boldsymbol{\beta}$. The estimation of these parameters is conducted using the Maximum Likelihood estimation method. Once the model is specified and calibrated, it is necessary to proceed with the validation phase. During this phase, the coherence and importance of the estimated parameters are verified, the model's ability to replicate the choices made by the sample of respondents is assessed, and the assumptions underlying the adopted functional form of the model are examined.

The process just described is an iterative process known as 'Trial-and-Error', in which the steps of specification, parameter estimation, and validation are performed iteratively until the model proves to be valid.

Regarding the choice of the functional form of the model, in this paper, it is considered more appropriate to adopt the Multinomial Logit model. This approach allows evaluating the utility (U) of each of the five proposed choice alternatives for each respondent. The selection of variables/attributes to consider also depends on the type of model intended to be developed. In this study, among the various aspects evaluated, attention is paid to ensuring that the variables are not collinear and, therefore, linearly dependent on each other.

The alternatives considered are respectively: traditional (*TR*), pick up point/locker (*PL*), crowdshipping (*CR*), delivery by drone (*DR*), while the considered attributes are:

- the delivery costs to be paid for the delivery for the *j*-th alternatives, i.e., *C_TR, C_PL, C_CR, C_DR, C_BA*;
- the delivery time for the *j*-th alternative, i.e., *T_TR, T_PL, T_CR, T_DR*;
- the distance from usual home/workplace for the *j*-th alternatives, i.e., *D_PL, D_CR*;
- the end-consumer characteristic representing respondents' age and are assumed alternative specific, i.e., *AGE_PL, AGE_CR, AGE_DR, AGE_BA*;
- the distance from usual home/workplace for the *j*-th alternatives, i.e., *D_PL, D_CR*;
- the delivery customization for crowdshipping (*CR*) alternative, i.e., *PERS_CR*;
- the delivery traceability for delivery to trunk (*BA*) alternative, i.e., *TRAC_BA*;

- the end consumers characteristic representing the residence of end consumer and are and are assumed alternative specific, i.e., *ZONEITA_PL, ZONEITA_CR, ZONEITA_DR, ZONEITA_BA*;
- the end consumers characteristic representing their level of education and are assumed alternative specific, i.e., *EDU_PL, EDU_CR, EDU_BA*; in particular, it is equal to 0 if secondary school, *1* if bachelor degree, *2* if master degree, *3* if PhD and *4* if master of specialization;
- the frequency of purchasing durable goods on line and are assumed alternative specific, i.e., *F_PL, F_CR, F_DR, F_BA*; in particular, it is equal to *0* if very seldom or never, *1* if less than once in a week but at least one in a month; *2* if once in a week, *3* if many times in a week, *4* if every day;
- the alternative specific attributes of the *j*-th alternative, i.e., *PL, CR, DR, BA*;
- the specific attribute of the alternative delivery to trunk, i.e., *BA*.

Below, two models have been specified and calibrated according to the different combinations of the attributes (X). The systematic utility (U) has been expressed as linear combination through parameters $\beta_{i,j}$ of the attributes $X_{i,j}$ as follows:

$$U(j) = \sum_i \beta_{i,j} \cdot X_{i,j} \tag{1}$$

The values of the estimated parameters $\beta_{i,j}$ for the models are reported in Tables 1 and 2. For what concerns *model 1* (Table 1), the utility functions were obtained as a combination of only the characteristic attributes of hypothetical scenarios. In order to verify the correct reproduction of the behaviour of the sampled respondents, the Rho-square and the corrected rho-square were calculated (see Table 1 last rows).

Table 1. Model 1: parameters estimation

Attributes		TR	PL	CR	DR	BA
T_j	β_{T_j}	−0.823	−0.097	−0.730	−1.077	–
	t-st	*−9.44*	*−1.32*	*−6.58*	*−3.25*	–
C_j	β_{C_j}	−0.086	−0.486	−0.349	−0.218	−0.901
	t-st	*−2.10*	*−10.69*	*−7.26*	*−4.26*	*−10.82*
D_j	β_{D_j}	–	−0.486	−0.749	–	–
	t-st	–	*−3.88*	*−7.05*	–	–
PERS_j	β_{PERS_j}	–	–	0.188	–	–
	t-st	–	–	*1.23*	–	–
TRAC_j	β_{TRAC_j}	–	–	–	–	0.261
	t-st	–	–	–	–	*1.84*

Rho-square/Corrected rho-squared 0.374/0.372

Referring to *model 2* (Table 2), the utility functions for the various delivery alternatives were derived as a combination of the respondent's individual socio-economic

Table 2. Model 2: parameters estimation

Attributes		TR	PL	CR	DR	BA
T_j	β_{T_j}	−0.482	−0.772	−0.739	−0.043	–
	t-st	*−3.57*	*−7.06*	*−4.29*	*−0.17*	–
C_j	β_{C_j}	−0.259	−0.569	−0.403	–	−0.892
	t-st	*−5.31*	*−12.33*	*−8.00*	–	*−10.66*
D_j	β_{D_j}	–	−0.673	−0.628	–	–
	t-st	–	*−4.92*	*−5.61*	–	–
TRAC_j	β_{TR_j}	–	–	–	–	0.482
	t-st	–	–	–	–	*3.43*
AGE_j	β_{A_j}	–	−0.531	−0.443	−0.164	−0.430
	t-st	–	*−12.16*	*−6.47*	*−1.92*	*−6.82*
ZONEITA_j	β_{Z_j}	–	−0.304	−0.201	0.487	−0.352
	t-st	–	*−3.43*	*−1.46*	*2.19*	*−2.90*
EDU_j	β_{EDU_j}	–	0.358	0.294	–	0.249
	t-st	–	*5.00*	*2.65*	–	*2.47*
F_j	β_{FR_j}	–	0.415	−0.101	0.327	0.665
	t-st	–	*7.26*	*2.65*	*2.43*	*8.42*

Rho-square/Corrected rho-squared 0.440/0.430

characteristics and the attributes of hypothetical scenarios, while the utility function for traditional delivery was obtained as a combination of delivery time and delivery cost. Here, all parameters are statistically significant, except for β_{T_DR} and β_{A_DR}. Slightly more positive results are obtained for this model compared to model 1.

Some attributes developed from the SP survey were discarded during the calibration phase because they had non-significant *t*-student values. Thus, model 2 consists of attributes with significant *t*-student values with socio-economic characteristics about the respondents.

The informal test pays particular attention to the consistency of the signs associated with the calibrated coefficients. Any inconsistent signs could indicate the presence of errors in the initial specification of the model. With respect to models, the signs of the various coefficients are consistent with our expectations since:

- delivery time (β_{T_j}) represents a negative value for each delivery alternative, therefore, other things being equal, as the delivery time increases, respondents are more inclined to choose traditional delivery;
- delivery cost (β_{C_j}) presents a negative value for each delivery alternative, therefore, other attributes being equal, as the cost of delivery increases, respondents are more inclined to choose traditional delivery;
- distance from the usual home/workplace (β_{D_j}) was found to be significant only for delivery to pick up points (and lockers) and for delivery by crowdshipping; it has a

negative value for both alternatives, so, other attributes being equal, as the delivery distance increases, respondents are more inclined to choose traditional delivery;
- delivery traceability (β_{TR_j})was found to be significant only for delivery to the trunk of the car; it presents a positive value, therefore, all other attributes being equal, as the traceability increases, i.e. moving from traceability in the main phases to real-time, end consumers are more inclined to choose delivery to the trunk of their own car;
- age (β_{A_j}) represents a negative value for each delivery alternative, therefore, all other attributes being equal, as age decreases, end consumers are more inclined to choose an innovative delivery alternative compared to traditional delivery;
- zone of Italy (β_{Z_j})has a negative value for delivery to pick up point/locker, for delivery via crowdshipping and for delivery to the trunk of the car; therefore, for other alternatives being equal, respondents residing in northern and central Italy show a greater propensity to use the aforementioned delivery alternatives compared to they residing in southern Italy; delivery by drones shows the opposite behaviour, which sees a positive value of (β_{Z_j}), symptomatic of a greater propensity to choose, all other attributes being equal, by respondents located in Southern Italy;
- level of education (β_{EDU_j}) presents a positive value for all the delivery alternatives considered, thus, other attributes being equal, as the level of education increases, respondents are more inclined to choose an innovative delivery alternative;
- online purchase frequency (β_{FR_j})has a positive value for delivery to a pick up point/locker, for delivery by drone, and for delivery to the trunk; a positive value of this coefficient indicates a greater propensity on the part of end consumers to choose the above delivery alternatives as the frequency of online purchases increases, keeping the value of the other attributes constant; on the other hand, for delivery by crowdshipping, (β_{FR_j}) takes on a negative sign, so that, other attributes being equal, as the frequency of e-purchases increases, respondents are more inclined to choose traditional delivery than delivery by crowdshipping.

4.3 Discussions

A sensitivity analysis is conducted to investigate how variations in model parameters can impact end consumer choice outputs. Our focus primarily lies on *model 2*, given its greater operability due to the inclusion of end consumer socio-economic characteristics.

Within this analysis, two scenarios from the questionnaire are selected, introducing distinct variations on two key parameters: first, the distance between pick up point (and locker) and the respondent's home/work, second, the age of the end consumer. This methodology allows us to examine the influence of these variations on the probability of choosing to deliver to pick up points (and lockers).

To precisely quantify this impact, the elasticity of the probability of choosing delivery to pick up point/locker relative to the varied parameter is calculated. In this formulation, elasticity is defined as the percentage change in the probability of choosing the considered alternative divided by the percentage change in a variable associated with that alternative:

$$E_{kj}^{p[j]} = \frac{\Delta p[j]}{p[j]} / \frac{\Delta X_{kj}}{X_{kj}} \tag{2}$$

where

- *p[j]* represents the probability of choosing alternative *j* associated with the initial scenario,
- $X_{k,j}$ is the initial value of the *k*-th variable/attribute of alternative *j* subject to change.

It should be noted that the analysis is not carried out using the data of a specific respondent present within the sample, but a hypothetical individual is taken as a reference, whose socio-economic characteristics are generally based on the average values of the entire sample. For questions where the responses do not translate into numerical values, such as gender or level of education, the most frequent response within the questionnaire is chosen. This methodology allows for the creation of a concentrated scenario representative of the average characteristics of the average end consumer within the sample. Net of the assumptions just presented, this average respondent is characterized by male gender, an age between *25* and *34* years, holding a master degree, and with an online purchasing frequency of once a week.

To conduct a sensitivity analysis, a certain reference context was taken, and the delivery distance was varied from '*within 200 to 500 m*' to '*within 200 m*'. The probabilities of choosing the various delivery modes varied as shown in Table 3. It is interesting to note that the probability of choosing the trunk of a car for delivery is *1%* in the original context and *0%* in the modified context. Since most families own a car, it can be assumed that such a low value is based on judgments about the low level of safety/security or the respondents' low awareness of this alternative. Using the equation described earlier, a value of the elasticity of the probability of choosing a delivery to pick up points (and lockers) is obtained relative to the delivery distance from the usual home/workplace, which is equal to -1.12. An elasticity value greater than 1 in absolute value indicates that the probability of choice is elastic with respect to the distance of the pickup point/locker from home/workplace. This means that a reduction in this distance has a significant effect on the probability of choice. The sign of the elasticity reflects the effect that the probability of choice increases as the distance to the nearest pick up point/locker decreases.

Table 3. Model 2: sensitivity analysis

Delivery alternative	Probability of choice in original context	Probability of choice in changed context
Traditional	12%	9%
Pick up point/locker	**27%**	**42%**
Crowdshipping	57%	45%
Delivery by drone	4%	3%
Delivery to the trunk	1%	0%

5 Conclusions and the Road Ahead

In this in-depth analysis focused on e-commerce and last mile delivery dynamics, the primary objective is to examine emerging solutions in detail to gain a deeper understanding of the multiple attributes and the level of attributes that influence decisions regarding delivery alternatives in the context of online purchases. Using an approach that encompasses both quantitative and qualitative data analysis, this paper aims to provide a comprehensive framework on the subject and incorporate a multinomial discrete choice model to simulate and interpret end-consumer behaviour in relation to various delivery alternatives.

Interesting findings emerge for the potential stakeholders, i.e., public administration that aim to reduce the impacts of e-deliveries and transport and logistics operators for implementing new delivery alternatives that can be successful meet the end consumers' needs. For example, the innovative delivery alternatives emerge as effective responses to various issues related to online purchases. For instance, the implementation of drone delivery opens the prospect of a significant reduction in delivery times, with the possibility of completing deliveries within *30* min. Simultaneously, options such as retrieval from autonomous pick-up lockers or car trunks not only resolve the issue of the timing of merchandise retrieval, but also provide a viable alternative to address the persistent problem of failed deliveries, currently responsible for over *14%* of total deliveries.

Furthermore, the analysis of variables highlighted that delivery times and costs are relevant factors in end consumer choices, with a clear preference for solutions characterized by short delivery times and reasonable costs. The distance from the delivery location and the traceability of the delivery process also appears as significantly influential elements in the delivery preferences.

Socio-economic characteristics play a prominent role in shaping end consumer choices. Young respondents and those with higher levels of education are more inclined to experiment with new delivery alternatives, emphasizing the importance of awareness and understanding of new technologies. The frequency of e-purchases, in turn, influences preferences, with an increasing propensity for innovative alternatives as the frequency of online purchase increases.

Finally, the complexity of the delivery preferences, influenced by an interrelated of interconnected attributes, is evident. It emphasizes the critical importance of flexible and personalized logistics strategies that can adapt to the changing needs and preferences of end consumers.

Looking toward the future, it is suggested to remain vigilant about the evolution of end consumer preferences and adapt delivery alternatives, accordingly, integrating emerging technologies such as autonomous delivery and own car trunk delivery. Besides, the model specification can be improved towards advanced logit models that take into due to consideration correlation among alternative, such as nested logit or the mixed one. In fact, it emerged that innovative alternatives can be considered not strongly independent by the end consumers. Besides, the estimation can be improved increasing the size of sample. However, the proposed comprehensive research not only contributes to outlining the intricate dynamics underlying last mile delivery choices, but also provides valuable guidance for an end consumer-centric, sustainable, and efficient future of e-commerce. The path to increasingly innovative delivery solutions is open, and the challenges and

opportunities that arise are intrinsic to the promise of an ever-evolving e-commerce, in harmony with the changing needs and expectations of end consumers.

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