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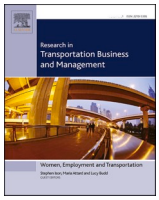

Environmental impact of business-to-consumer *e*-commerce: Does it matter to consumers?

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ABSTRACT

The rapid development of business-to-consumer e-commerce has sparked interest in the environmental impact of the last-mile logistics of goods purchased online. The distribution stage, with orders from many different manufacturers in far-flung locations and the need for the fastest possible parcel delivery, has become complicated, expensive and environmentally damaging. The aim of this paper is to investigate consumers' willingness to pay for reducing or offsetting the emissions generated by their online purchases and the acceptability of alternative collection methods in order to reduce the environmental impact caused. We surveyed 1204 Italians using a discrete choice experiment and analysed the data using multinomial logit (MNL) and mixed multinomial logit (MMNL) models. The results show that providing information on the amount of pollution reduction/offset and the type of project implemented significantly increased consumers' willingness to pay to reduce the environmental impact of last-mile logistics. Our sample was willing to pay up to €0.88 to fully offset the environmental impact caused by the delivery received and an additional amount of €0.17 if the funds raised would be used for reforestation projects. We also found that consumers' socio-demographic characteristics and online shopping habits influenced both the willingness to pay and the acceptability of choosing more sustainable logistic settings regarding delivery time and location. Eco-conscious customers were more likely to accept longer delivery times and non-home delivery points. The minimum discount required to accept these delivery options ranged from €0.20 to €0.80. Our findings are new to the literature and are relevant not only to businesses seeking to integrate sustainability and efficiency into delivery services but also to policy makers seeking to mitigate the environmental impacts of e-commerce and freight.

1. Introduction

European business-to-consumer online sales of goods and services reached €718 billion in 2021 (Lone & Weltevreden, 2022) and are expected to grow at a compounded average growth rate of around 9.91% through 2027 (Statista, 2021). The pandemic accelerated this demand expansion, with 42% of Italian consumers now shopping online. The European countries that have seen the largest percentage of people who e-shopped more during the pandemic are Spain (52%), Italy (44%), and Poland (43%) (PostNord, 2021). This has led to an increase in freight transport of goods purchased online (Büttgen, Turan, & Hemmelmayr, 2021) and express deliveries to meet customer demand (Cheah & Huang, 2022), creating new logistical and environmental challenges. The possibility for customers to purchase items from different platforms and the willingness of companies to deliver products in the shortest possible time make last-mile logistics the most polluting and challenging phase of the supply chain (Awwad, Shekhar, & Iyer, 2018; Gevaers, Van de Voorde, & Vanelslander, 2009). Failed deliveries and returns are increasingly common, forcing repeated deliveries and more kilometres travelled and worsening air and noise pollution and traffic congestion, especially in dense urban areas (Schöder, 2016; Visser & Lanzendorf, 2004). According to Zhang et al. (2022) a third of all goods ordered online are returned, and the value of returns exceeds €910 billion per year. Moreover, the larger size of trucks and vans compared to cars, and the lack of parking spaces in urban areas, increase the number of accidents, travel time and public transport delays (Bosona, 2020; Büttgen et al., 2021; Ranieri et al., 2018). Furthermore, packaging is largely made of non-renewable materials, and returns are often discarded rather than recycled and resold, contributing significantly to environmental damage of business-to consumer e-commerce (Escursell et al., 2021; Van

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Loon et al., 2015; Xie et al., 2021). Estimated emissions range from 0.880 to 3.400 $kgCO_2e$ per product, of which packaging accounts for 45%, returns for 25% and transport and logistics activities for 30% (Briseño, Chegut, Glennon, Scott, & Yang, 2021).

There are several stages of e-commerce logistics that can be improved to meet sustainability and circular goals (Collini et al., 2022): packaging (Gee, Davidson, Speetles, & Webber, 2019; Hischier, 2018; Lin, Chang, Li, Li, & Zhao, 2022; Pålsson, Pettersson, & Hiselius, 2017; Zhao, Wu, Gong, Yang, & Ni, 2019); vehicle type, load factor and routing (Cheah & Huang, 2022; Hardi & Wagner, 2019; Hischier, 2018; Pålsson et al., 2017; Rosqvist & Hiselius, 2016); collection point location (Hischier, 2018; Rai, Mommens, Verlinde, & Macharis, 2019; Rai, Verlinde, & Macharis, 2021; Zhao et al., 2019); and returns' management (Bertram & Chi, 2018; Fernández Briseño, Chegut, Glennon, Scott, & Yang, 2020; Hischier, 2018). Indeed, the literature provides several examples of strategies that companies could adopt. These include recyclable packaging to avoid excess waste (Bertram & Chi, 2018; Lu, Yang, Liu, & Jia, 2020), electric vehicles for transport and deliveries (Büttgen et al., 2021), logistics crowdsourcing or crowd shipping (Gatta, Marcucci, Nigro, Patella, & Serafini, 2018; Mangiaracina, Perego, Seghezzi, & Tumino, 2019) and lockers or pickup points instead of home deliveries (de Oliveira, Morganti, Dablanc, & de Oliveira, 2017; Edwards, McKinnon, Cherrett, McLeod, & Song, 2010; González-Varona, Villafáñez, Acebes, Redondo, & Poza, 2020; Iannaccone, Marcucci, & Gatta, 2021; Iwan, Kijewska, & Lemke, 2016; Mangiaracina et al., 2019; Schaefer & Figliozzi, 2021; Vakulenko, Hellström, & Hjort, 2018; Yuen, Wang, Ng, & Wong, 2018). However, these solutions are expensive and require significant financial resources that may not be available to small and medium-sized enterprises.

Majoral, Gasparín, and Saurí (2021) proposed an environmental tax to internalise the negative externalities of business-to consumer e-commerce deliveries. However, little is known about consumers' willingness to pay or to accept longer delivery times or deliveries at lockers or pickup points in order to reduce environmental damage from e-commerce. Indeed, to the best of our knowledge, there are no papers addressing both issues together and testing whether the willingness to pay is affected by how the funds raised would be used. This paper aims to fill the gap in the literature by using a discrete choice experiment to estimate: a) the willingness to pay to reduce/compensate for the pollution caused by the delivery of online purchases, b) the willingness to collect parcels from a delivery point instead of receiving them at home, c) the willingness to accept longer delivery times, d) the preferred way of reducing/compensating the environmental damage caused. We also tested whether socio-demographic characteristics, online shopping habits and environmental sensitivity have an impact on consumer preferences. To this end, we conducted a stated preference survey among a sample of 1204 Italian consumers who were online shoppers.

Our article will help companies understand whether consumers care about the environmental impact of e-logistics and whether they are willing to pay an additional delivery charge for more sustainable supply chains. Our results can also help companies understand whether less favourable delivery conditions would be acceptable to reduce environmental impact and which characteristics between time and place of delivery would be less likely to affect consumer satisfaction if downgraded for environmental purposes.

The paper is structured as follows. Section 2 reviews the literature on the willingness of consumers to accept less convenient delivery conditions to reduce the environmental impact of e-commerce. Section 3 describes the methodology used to select the sample and to collect the data. Section 4 illustrates the models we used to analyse the data and discusses the results obtained. Section 5 concludes by highlighting the management and policy implications of our research and describing the limits of our study and suggestions for future research lines.

2. Literature review

The literature on consumer preferences regarding the environmental impact of online shopping is still very limited. In total, we found only 12 papers. These were very recent studies, with the first published in 2017 on data collected in 2015 (de Oliveira et al., 2017), but most of the papers were published in the last three years. There is also a notable lack of homogeneity among the studies in terms of geographical scope. As many as three-quarters of the studies referred to the European context, with three papers on Italy, while there are only two papers on the Americas and one on Asia. The reason for this recent interest, particularly in the European context, is that the phenomenon of business-to consumer e-commerce has emerged as a preferred sales channel as a result of the Covid-19 pandemic.

There are three main topics addressed in the literature we reviewed. The first (Table 1) concerns the effect of information regarding the environmental impact of different types of delivery and on the acceptability of longer delivery times. Agatz et al. (2021) focused on the effectiveness of green labels on the choice of a specific delivery time slot. Caspersen et al., 2022 studied whether consumers would accept increased delivery time to reduce CO_2 emissions. Cheah and Huang (2022) analysed cross-border e-commerce from China to Singapore to assess the impact of carbon labelling on consumers' shipping preferences. Ignat and Chankov (2020) tested whether providing information on the environmental and social impacts of alternative last-mile delivery options induced consumers to change their preferred last-mile delivery. Rai et al. (2021) investigated which type of consumer was interested in a crowdsourced last mile and whether the sustainability improvements of crowdsourced options influenced consumer choice.

The second topic (Table 2) deals with the willingness to accept alternative delivery methods such as drones or deliveries at pick-up points or lockers instead of at home. Borghetti et al. (2022) and Merkert et al. (2022) analysed the acceptability of drones for last-mile delivery in the city of Milan and in urban Australia. de Oliveira et al. (2017) and Iannaccone et al. (2021) estimated the potential demand for lockers in the city of Belo Horizonte, Brazil, and the city of Rome, Italy, respectively. Hagen and Scheel-Kopeinig (2021) focused on the willingness to use a customer-driven central last mile micro depot in Germany.

The third topic (Table 3) addresses the willingness to pay higher rates for deliveries that have less environmental impact (Caspersen et al., 2022; Zerbini & Vergura, 2022).

None of the studies we reviewed analysed both the acceptability of longer delivery times/non-home delivery, the willingness to pay to reduce/compensate for the environmental impact of e-commerce deliveries and how the willingness to pay is affected by how the funds raised are used. The papers by Caspersen and Navrud (2021); Caspersen et al. (2022) is a notable exception, but the authors focus only on delivery time/delay and willingness to pay to reduce CO_2 emissions and do not consider the willingness to accept non-home deliveries, nor the role played by how the funds raised could be used.

The average sample size was about 600 people, with a minimum of 100 individuals (Borghetti et al., 2022) and a maximum of 2017 (Hagen & Scheel-Kopeinig, 2021). The age range for the majority of studies was 18–70, with a few notable exceptions, namely Rai et al. (2021) and Iannaccone et al. (2021), who surveyed people aged 18–45 and 18–30, respectively. Caspersen and Navrud (2021); Caspersen et al. (2022) surveyed only women, while Iannaccone et al. (2021) surveyed only students. All surveys were conducted online via e-commerce platforms (Amazon Mechanical Turk or FJONG), online survey platforms (Qualtrics, Google Forms or SurveyEngine), social media or email contacts with snowball sampling. Most studies did not focus on a specific product type, with the exceptions of Agatz et al. (2021), who focused on food, and Caspersen and Navrud (2021); Caspersen et al. (2022), who focused on clothing.

All studies used discrete choice experiments to analyse consumer

Table 1
Empirical studies focused on green labelling and delivery time.

Source	Sample and data collection	Econometric model	Product type	Findings
Agatz, Fan, and Stam (2021)	• 1032 individuals, average age 37, age range not provided • Online survey via Amazon Mechanical Turk • Discrete choice experiment • United States, 2020	MNL	Groceries	Green labels identifying the most sustainable delivery time window increased the acceptability of longer delivery times.
Caspersen, Navrud, and Bengtsson (2022)	• 513 females, ages 18–70 • Online survey via FJONG • Discrete choice experiment • Norway, 2020	MNL and latent class	Clothing	Information on the level of emission reduction determined the willingness to accept longer delivery times.
Cheah and Huang (2022)	• 188 individuals, ages 18–≥40 • Online survey involving only users of delivery points • Discrete choice experiment • Singapore, 2020	Univariate descriptive statistics	Purchases made via Taobao	Carbon labelling encouraged consumer choice towards sustainable cross-border deliveries (sea vs air).
Ignat and Chankov (2020)	• 248 individuals, ages 17–78 • Online survey shared via social media and university student network • Discrete choice experiment • Germany, 2018	McNemar test	–	Providing information on the reduction of CO_2 emissions increased consumers' acceptability of longer delivery times.
Rai et al. (2021)	• 403 individuals, ages 18–45 • Online survey via Qualtrics shared via social media, e-mail and snowballing technique • Discrete choice experiment • Belgium, 2020	Descriptive statistics	Shoes	Providing information on the reduced number of lorries and kilometres travelled encouraged consumers to accept longer delivery times.

Note: multinomial logit (MNL).

preferences, with the exception of Hagen and Scheel-Kopeinig (2021), who used a contingent valuation experiment, and Zerbini and Vergura (2022), who tested attitudes and perceptions using six indicators measured on a 7-point Likert scale. Most studies estimated logit or probit models with fixed parameters, the only exceptions being Caspersen et al. (2022) and Merkert et al. (2022), who estimated logit models with random parameters. Only a few studies performed only descriptive statistics (Rai et al., 2021) or univariate tests (Ignat & Chankov, 2020), while Zerbini and Vergura (2022) estimated a structural equation model.

3. Methodology and data collection

3.1. The questionnaire

To design the discrete choice experiment we carried out a focus group with colleagues from the University of Trieste and experts in the field of sustainable mobility. We then conducted a pre-test survey with a group of 40 people to validate the questionnaire, check the clarity of the proposed choice tasks and collect feedback on the research topic. On the basis of the feedback received, we modified the wording of some questions to clarify some doubts raised during the pre-test, and we extended the range of values proposed as delivery surcharges for the discrete choice tasks.

We structured the questionnaire into five sections. The first section explored consumers' shopping habits, including how often they shop online, the types of products they buy most often, how often they return products and whether they buy refurbished or recycled products. It also asked participants to state the main reasons why they shop online rather than in a physical store.

In the second section, respondents were asked if they would be prepared to change their current online shopping habits in order to reduce the environmental impact of parcel delivery. The alternatives to online shopping included buying in a physical store, collecting the parcel in a store, collecting the parcel in an unattended locker, extending the delivery time by two or four days and receiving the parcel on the weekend. Respondents were also asked if they would pay an extra delivery fee to reduce/offset the environmental impact of the delivery.

The third part of the questionnaire consisted of 12 hypothetical choice scenarios similar to the one illustrated in Table 4. The full set of 12 choice tasks was administered to each respondent. In each choice task, the respondents were asked to choose among three options: two hypothetical delivery alternatives (indicated as Hypothetical Delivery A and Hypothetical Delivery B in Table 4) and a standard delivery (indicated as Standard Delivery in Table 4) with characteristics similar to those offered to Amazon Prime members. The choice tasks were introduced with the following statement: 'If, in order to reduce or compensate for the environmental impact caused by the delivery of your purchase, you were offered to pay an additional delivery charge on top of the standard delivery charge and to accept the following delivery methods, which delivery type would you choose?' We used the Ngene Software (https://www.choice-metrics.com/) to develop an efficient design for the choice tasks (Bliemer & Rose, 2011) using the results obtained via the pre-test to build our a priori estimates.

We selected the attributes for the discrete choice experiment on the basis of the focus group interviews and the attributes and the attributes' levels most frequently used in previous studies (Table A1 in the Appendix). All studies included an attribute describing the delivery charge, with the exception of Caspersen and Navrud (2021), who did not mention this attribute in the choice task, and Rai et al. (2021), who set the deliveries as free. The delivery time and/or time window and the delivery location were described in almost all the reviewed studies. Only the experiments carried out by Agatz et al. (2021), Borghetti et al. (2022) and Caspersen and Navrud (2021); Caspersen et al. (2022) did not mention the delivery location. With the exception of the study by Iannaccone et al. (2021), none of the studies examined the role played by the distance to the locker. Half of the studies we reviewed provided some information on the environmental impact of e-commerce deliveries. Regarding this last attribute, some studies provided very general descriptions such as green/not green delivery (Agatz et al., 2021) or with/without environmental certification (Iannaccone et al., 2021). Other studies provided much more detailed descriptions of the amount of air pollutants and CO_2 produced (Caspersen et al., 2022; Caspersen & Navrud, 2021; Ignat & Chankov, 2020) or saved (Cheah & Huang, 2022) per delivery. Besides the attributes described in Table A1 in the Appendix, some studies also included the delivery traceability (Caspersen

Table 2
Empirical studies focused on innovative delivery methods and non-home deliveries.

Source	Sample and data collection	Econometric model	Product type	Findings
Borghetti et al. (2022)	• 100 individuals, age range not provided • Online survey via Google Forms shared through WhatsApp and Instagram • Discrete choice experiment • Italy, year not provided	MNL	–	Drones were an acceptable delivery option for prices under €5 and very short delivery times.
de Oliveira et al. (2017)	• 534 individuals, ages 20–70 • Online survey shared through email • Discrete choice experiment • Brazil, 2015	MNL	–	Secure and easily accessible locations and lower delivery charges increased the acceptability of lockers as delivery/collection points.
Hagen and Scheel-Kopeinig (2021)	• 2017 individuals, ages 18–≥65 • Online survey administered by a German market research company • Contingent valuation • 80 major German cities, 2019	Probit	–	While 60% of the respondents were willing to use a delivery/collection point, only 26% were willing to contribute with a premium of €1 or more.
Iannaccone et al. (2021)	• 282 students, ages 18–30 • Survey administered at Roma Tre University • Discrete choice experiment • Italy, 2019	MNL	–	Secure and easily accessible locations increased the acceptability of lockers as delivery/collection points.
Merkert, Bliemer, and Fayyaz (2022)	• 709 individuals, ages 18–- ≥ 70 • Online survey implemented via SurveyEngine • Discrete choice experiment • Australia, 2020	Error component logit	–	Lead-time and price affected the uptake of innovative and more environmentally sustainable solutions such as lockers and drones.

Note: multinomial logit (MNL).

Table 3
Empirical studies focused on willingness to compensate for environmental impact.

Source	Sample and data collection	Econometric model	Product type	Findings
Caspersen et al. (2022)	• 460 females, ages 18–70 • Online survey via FJONG • Discrete choice experiment • Norway, 2020	MMNL	Clothing	The willingness to pay to compensate for delivery emissions ranged between €0.26 (3 NOK) and €0.70 (8 NOK) depending on the amount of PM_{10} and CO_2 reduction, delivery time and delays. It rose to €2.62 (30 NOK) for wealthy respondents.
Zerbini and Vergura (2022)	• 391 individuals, age range not provided • Online survey via Facebook • 6 items assessed via 7-point Likert scale • Italy, 2020	Structural equation model	–	Personal norms and environmental awareness positively influenced the willingness to compensate for the CO_2 emissions caused by the delivery and packaging of online purchases.

Note: mixed multinomial logit (MMNL).

Table 4
Example of discrete choice tasks.

Attributes	Hypothetical delivery A	Hypothetical delivery B	Standard delivery
Additional delivery charge	€2.50	€1.00	€0.00
Environmental impact reduction/offset percentage	50% (half)	100% (total)	0% (none)
Use of funds raised	Reforestation projects	Product recycling/regeneration	–
Delivery time	5 days	3 days	1 day
Delivery location	Store near home/work	Unattended locker	At home/work

& Navrud, 2021; de Oliveira et al., 2017), product value (Borghetti et al., 2022), distance between the locker and the respondent's home/office (Iannaccone et al., 2021), carrier's social benefit (Ignat & Chankov, 2020) and locker's security (Merkert et al., 2022).

In our choice experiment, we included the monetary value of the additional delivery charge to be paid on top of the standard charge, the delivery time, the delivery location and the percentage of the environmental impact reduction/offset achieved by the projects funded with the amount of money raised. We chose these attributes because we wanted to compare our results with those found in previous studies and test whether consumers are more willing to pay an additional delivery charge than to change their habits to reduce the environmental impact of their online shopping. The values we used for the additional delivery charge were in line with those used by Hagen and Scheel-Kopeinig (2021) and Iannaccone et al. (2021) and were consistent with the results reported by PostNord (2021), according to which 35% of Italian consumers are willing to pay up to €3 to increase the environmental sustainability of e-deliveries. For the delivery time attribute, we selected the levels based on the PostNord (2021) findings according to which 68% of Italian online shoppers expect their orders to arrive within three to five days. As for the delivery location attribute, we selected the three most frequent levels that are addressed in the literature. Although, as pointed out by an anonymous reviewer, it would have been informative to include the distance to the locker, we decided not to include this additional attribute in order to limit the complexity of the choice task. Unlike Caspersen and Navrud (2021); Caspersen et al. (2022), Cheah and Huang (2022) and Ignat and Chankov (2020), we described the

Table 5
Attributes and levels of the discrete choice tasks.

Additional delivery charge	Environmental impact reduction/ Offset percentage	Use of funds raised	Delivery time	Delivery location
€0.00	Total (100%)	Electric vans for delivering	1 day	Store near home/ workplace
€0.50	Half (50%)	Recycling/ regeneration of returns	3 days	Unattended locker
€1.00	Small (10%)	Reforestation projects	5 days	Home/work
€1.50	None (0%)	Not specified		
€2.00				
€2.50				
€3.00				

environmental impact attribute as simply as possible. Instead of describing the kilograms or grams of pollutant emissions produced or saved per delivery, we quantified the reduction/offset in environmental impact as total (100%), half (50%), small (10%) or none (0%), as suggested by Cerri, Testa, and Rizzi (2018) and Nogueira, de Assis Rangel, and Shimoda (2021).

Unlike previous studies, we also included an attribute describing how the funds raised would be used. We wanted to check whether the

Table 6
Socio-demographic characteristics of the sample.

Socio-demographic characteristics	Sample (N = 1204)	Italian population
Gender		
Female	60%	51%
Male	40%	49%
Age		
18–21	28%	4%
22–29	40%	8%
30–75	32%	61%
Education		
Middle and high school	61%	69%
Bachelor, master's or PhD	39%	15%
Occupational status		
Student	49%	16%
Unemployed, retired or homemaker	6%	43%
Employed	45%	37%
Disposable family income		
≤€20,000	13%	43%
€20,001–40,000	32%	50%
€40,001–100,000	21%	6%
> €100,000	4%	1%
Preferred not to answer	30%	
Geographical macro-area		
Northeast	83%	21%
Northwest	9%	26%
Middle	2%	20%
South	4%	22%
Islands	1%	11%
Preferred not to answer	1%	
Municipality inhabitants		
≤10,000	24%	31%
10,001–50,000	25%	35%
50,001–250,000	40%	19%
> 250,000	11%	15%

Source: data for the Italian population published by the Italian National Institute of Statistics (https://www.istat.it/).

Table 7
Description of measurement unit and coding of the explanatory variables.

Explanatory variables	Measurement unit and coding
Attributes of the alternatives	
CHARGE	
Additional delivery charge of €0.00, €0.50, €1.00, €1.50, €2.00, €2.50 or €3.00	Euro cardinal: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5 or 3.0
ENV_OFF	
Environmental offset percentage: none (0%), small (10%), half (50%) or total (100%)	Cardinal: 0.0, 0.1, 0.5 or 1.0
FUND_USE_REF	
Funds raised invested in reforestation projects	Dummy: 1 if funds invested in reforestation, 0 otherwise
THREE_DAYS	
Delivery time within three days	Dummy: 1 if delivery within three days, 0 otherwise Reference: one day
FIVE_DAYS	
Delivery time within five days	Dummy: 1 if delivery in five days, 0 otherwise Reference: one day
STORE	
Delivery location: store near home/work	Dummy: 1 if delivery to a store, 0 otherwise Reference: home/work
LOCKER	
Delivery place: unattended locker	Dummy: 1 if delivery to an unattended locker, 0 otherwise Reference: home/work
Socio-demographic characteristics	
WOMAN	
Gender of respondents	Dummy: 1 if female, 0 if male
YOUNG	
Age of respondents: 18–21	Dummy: 1 if respondent age is 18–21, 0 otherwise
EMP	
Occupational status of respondents: employed	Dummy: 1 if employed, 0 otherwise Reference: student
NOT_WORK	
Occupational status of respondents: unemployed, retired or homemaker	Dummy: 1 if unemployed, retired or homemaker; 0 if student Reference: student
Online shopping habits and preferences	
ONLINE_FREQ	
Frequency of online shopping: never, once a year, twice a year, once every three months, once a month or every week	Ordinal: 0, 1, 2, 3, 4 or 5
RETURN_FREQ	
Frequency of returns of goods purchased online: never, almost never (one time in 10), often (one out of three times), quite often (one out of two times), almost every time	Ordinal: 0, 1, 2, 3 or 4
FAST	
Respondents buy online because it is faster than shopping in a store	Dummy: 1 if reason for online shopping is that it is faster than in-store shopping, 0 otherwise
Environmental sensitivity	
CHANGE_CONS	
Degree of agreement/disagreement on a 5-point Likert scale with the following statement: 'To reduce the environmental impact we produce, we have to change our consumption habits'	Ordinal: 1, 2, 3, 4 or 5
GREEN_CONS	
Degree of agreement/disagreement on a 5-point Likert scale with the following statement: 'I like to think of myself as a green consumer'	Ordinal: 1, 2, 3, 4 or 5

willingness to pay an additional delivery charge was influenced not only by the effectiveness of the environmental offset, but also by the type of project that could be implemented. To this aim, we listed two projects aimed at fostering the sustainability of the e-commerce supply chain (the purchase of electric vans for deliveries and investments in recycling/regeneration of returned products) and one project aimed at reforestation.

We checked the clarity and appropriateness of the levels of all attributes used in the pre-test. The attribute levels used in the choice task are reported in Table 5.

The fourth section of the questionnaire contained 12 statements designed to measure the respondents' environmental sensitivity, their commitment to environmentally responsible purchasing decisions, their self-perception of their environmental sensitivity and their willingness to discuss environmental sustainability issues with family and friends. In this part of the questionnaire, respondents were asked to use a 5-point Likert scale to express their perceptions, attitudes and preferences. In the fifth and final section of the questionnaire, we collected information on the socio-demographic characteristics of the respondents.

3.2. The sample

We implemented the questionnaire in Google Forms and administered it online in April 2021 via various social media sites: Whatsapp, Instagram, Linkedin, Facebook and Twitter. We used these survey channels because according to Statista (2023a), 97% of e-consumers share information on social media.

A total of 3925 people responded to the survey: 413 said they never or rarely shopped online, 2308 said they would not be willing to pay an additional delivery charge to reduce the environmental impact of their purchases and 1204 said they shopped online at least twice per year and would accept an additional delivery charge for environmental reasons. We administered the discrete choice tasks only to this last group of respondents in order to minimise the hypothetical bias of the choice experiment and to enhance the quality and reliability of the data collected. Therefore, the sample we used for our analysis consisted of 1204 people.

Table 6 reports the socio-demographic characteristics of the respondents. Since there are no socio-demographic statistics on Italian e-consumers, we cannot assess whether our sample is representative of the reference population. However, we compared it with the Italian population. The sample was fairly balanced in terms of gender, although 60% of the respondents were women, which is proportionally higher than in the Italian population (51%). The largest age group was 22–29, comprising 40% of the sample, followed by respondents ages 30–75 (32%) and 18–21 (28%). Our sample was much younger than the Italian population, but according to Statista (2023b), e-commerce penetration in Italy is highest among the 0–34 age group (56%), and according to Eurostat (2023), the 25–34 age group has the highest share of online buyers, followed by the 16–24 age group.

The younger age of our sample had a clear impact on the occupational status and educational level of the respondents, with our sample including a much higher proportion of students than the Italian population (49% vs. 16%) and of people with a bachelor, master's, or PhD than the Italian population (35% vs. 15%). However, according to Eurostat (2023), level of education is positively correlated with e-commerce. In fact, while only 56% of people with a low level of formal education shop online, this rises to 74% and 88% for those with a medium or high level of education, respectively. Moreover, while 81% of both students and employees/entrepreneurs shop online only 56% of retired individuals and 63% of unemployed people use online shopping (Eurostat, 2023).

Almost one-third of our sample preferred not to report their annual household disposable income, while the rest had a higher-than-average income level compared to the Italian population. This was probably due to their higher-than-average level of education and the fact that most of them lived in the richest regions of the country. Indeed, four-fifths of the sample lived in the northeast of Italy, <10% in the northwest and a residual part in the rest of Italy. Our sample was therefore very different in terms of place of residence compared to the Italian population, which is much more evenly distributed across the five macro-regions, with a predominance of southern and island residents. There were also significant differences in terms of the size of the place of residence. While the largest percentage of respondents (40%) lived in medium-sized cities (50,000–250,000 inhabitants), the largest percentage of the Italian population lives in small cities (10,000–50,000) or rural areas (10,000).

4. Results and discussion

4.1. Model specification

We estimated several multinomial logit (MNL) and mixed multinomial logit (MMNL) models in order to get the best-fitting ones. We started with a MNL model that initially included only the attributes of the alternatives, then we added the socio-demographic characteristics of the sample, we introduced the variables describing the online shopping habits of the respondents and finally we added a few indicators that capture the environmental sensitivity of the respondents. We decided to use a step-by-step procedure to check the consistency of the estimates and the robustness of the model as we developed it. Once we had found the best-fitting MNL model, we switched to a MMNL to account for the potential heterogeneity of the preferences of the respondents. In the final best-fitting MMNL model, the parameters of all attributes characterising the alternatives are random except for the environmental reduction/offset percentage, a delivery time of three days and a delivery location corresponding to the respondent's home or workplace. We tested different distribution functions for the random parameters and chose the triangular distribution to ensure finite moments and avoid long tails. To avoid shifts in the sign from positive to negative, we also restricted the distribution of the random parameters to be either positive or negative (Daly, Hess, & Train, 2012; Hensher & Greene, 2003). Table 7 reports the measurement units and the coding of the explanatory variables we used to specify the models.

For the MMNL model, we specified the utility function of each alternative as reported in Eq. (1), although we added the alternative-specific constant (ASC) and the relative interaction terms only in the equation of the utility function of the standard delivery:

$$U_{n,j,t} = ASC_{n,j,t}\left(\alpha_{asc,n} + \gamma_{woman*asc}\, WOMAN_n + \delta_{online\_freq*asc}\, ONLINE\_FREQ_n + \vartheta_{change\_cons*asc}\, CHANGE\_CONS_n\right)$$

$$+\mathrm{CHARGE}_{n,j,t}\left(\beta_{\mathrm{charge},n}+\vartheta_{\mathrm{change\_cons*charge}}\,\mathrm{CHANGE\_CONS}_n\right)$$

$$+\mathrm{ENV\_OFF}_{n,j,t}\left(\beta_{\mathrm{env\_off}}+\Upsilon_{\mathrm{emp^*\ env\_off}}\,\mathrm{EMP}_n+\Upsilon_{\mathrm{not\_work^*\ env\_off}}\,\mathrm{NOT\_WORK}_n+\delta_{\mathrm{online\_freq^*\ env\_off}}\,\mathrm{ONLINE\_FREQ}_n\right.$$
$$\left.+\delta_{\mathrm{return\_freq^*\ env\_off}}\,\mathrm{RETURN\_FREQ}_n+\vartheta_{\mathrm{change\_cons*env\_off}}\,\mathrm{CHANE\_CONS}_n\right)$$

$$+\beta_{\mathrm{fund\_use\_ref},n}\,\mathrm{FUND\_USE\_REF}_{n,j,t}$$

$$+\mathrm{THREE\_DAYS}_{n,j,t}\left(\beta_{\mathrm{three\_days}}+\vartheta_{\mathrm{green\_cons*three\_days}}\,\mathrm{GREEN\_CONS}_n\right)$$

$$+\mathrm{FIVE\_DAYS}_{n,j,t}\left(\beta_{\mathrm{five\_days},n}+\vartheta_{\mathrm{change\_cons*five\_days}}\,\mathrm{CHANGE\_CONS}_n+\vartheta_{\mathrm{green\_cons*five\_days}}\,\mathrm{GREEN\_CONS}_n\right)$$

$$+\mathrm{STORE}_{n,j,t}\left(\beta_{\mathrm{store}}+\Upsilon_{\mathrm{young*store}}\,\mathrm{YOUNG}_n+\delta_{\mathrm{fast*store}}\,\mathrm{FAST}_n+\vartheta_{\mathrm{green\_cons*store}}\,\mathrm{GREEN\_CONS}_n\right)$$

$$+\mathrm{LOCKER}_{n,j,t}\left(\beta_{\mathrm{locker}}+\Upsilon_{\mathrm{woman*locker}}\,\mathrm{WOMAN}_n+\vartheta_{\mathrm{green.cons*locker}}\,\mathrm{GREEN.CONS}_n\right) \quad (1)$$

In our mathematical notation, the parameter β refers to the marginal utility of the attributes of the deliveries. The parameters Υ, δ and ϑ refer to the interaction terms between the characteristics of the deliveries and the socio-demographic characteristics, online shopping habits and environmental sensitivity of the respondents, respectively. We estimated the MNL and MMNL models using the Apollo package in R (Hess & Palma, 2019). For the MMNL model, we used the modified Latin hypercube sampling method with 500 inter-individual draws because it is more robust to collinearity problems than the Halton draw method (Bhat, 2003; Hess, Train, & Polak, 2006).

4.2. Results and discussion

The description of the parameters and the results we obtained estimating the best-fitting MNL and MMNL models are reported in Table 8, including the goodness of fit indices of each model. All the parameters we estimated were statistically significant and had the expected sign. There was remarkable consistency between the results of the MNL and MMNL model, especially with regard to the parameters of the interaction terms. As we do not have any information on the socio-demographic characteristics of the Italian e-consumer population and we could not adjust our results accordingly, we warn the reader that our results refer to the preferences of our sample and cannot be directly extended to the Italian population.

According to our results, the choice of one of the hypothetical and more sustainable delivery options proposed during the experiment was preferred, ceteris paribus, to the standard delivery option; indeed, the expected value of the alternative specific constant representing the standard delivery option was negative ($\alpha_{asc} = -6.086$). Our findings are in line with previous studies on the willingness to accept alternative delivery methods (Borghetti et al., 2022; de Oliveira et al., 2017; Hagen & Scheel-Kopeinig, 2021; Iannaccone et al., 2021; Merkert et al., 2022). However, respondents' preferences for this feature varied, as evidenced by the statistical significance of the spread of the triangular distribution of this parameter (spread of $\alpha_{asc} = 2.377$). Indeed, the interaction terms led us to conclude that women ($\Upsilon_{woman*asc} = -0.538$) and respondents who believed that they should change their consumption habits to protect the environment ($\vartheta_{change\_cons*asc} = -0.312$) were more likely to choose the hypothetical greener alternatives. In contrast, respondents who shopped online more frequently were less willing to give up the standard delivery option ($\delta_{online\_freq*asc} = 0.475$).

The negative sign of the expected value of the parameter of the additional delivery charge ($\beta_{charge} = -1.732$) confirmed our a priori as well as the respondents' rationality. As the value of the additional charge increases, the respondents' utility decreases. However, with reference to this attribute, the preferences were significantly heterogeneous, in fact the spread of the triangular distribution of this parameter was large and statistically significant (spread of $\beta_{charge} = 3.464$). We were able to identify one specific segment of our sample whose sensitivity with respect to the additional delivery charge was lower, that is, individuals who believed that they should change their consumption habits to protect the environment ($\vartheta_{change\_cons*charge} = 0.334$).

We also found that the higher the percentage of environmental impact reduced/compensated for by projects financed with the additional charge, the higher the utility of the respondents and their willingness to choose more environmentally friendly options ($\beta_{env\_off} = 1.528$). Also according to Caspersen and Navrud (2021); Caspersen et al. (2022) and Ignat and Chankov (2020) providing information on the amount of pollutant emissions produced or saved per parcel influences the choice of delivery mode. The preferences of our respondents were quite homogeneous with regard to this attribute; in fact we could not find a statistically significant spread when we specified this parameter as random instead of fixed. However, there were some segments of the sample whose preferences differed from the average. In particular, students were more sensitive to the level of environmental compensation than the employed ($\Upsilon_{emp*\ env\_off} = -0.378$) or unemployed respondents, pensioners and housemakers ($\Upsilon_{not\_work*\ env\_off} = -0.425$). Caspersen and Navrud (2021) and Iannaccone et al. (2021) found similar results. The same was true for respondents who thought they should change their consumption habits in order to protect the environment ($\vartheta_{change\_cons*env\_off} = 0.007$). In contrast, people who often shopped online ($\delta_{online\_freq*\ env\_off} = -0.098$) and returned goods bought online ($\delta_{return\_freq*\ env\_off} = -0.157$) were less influenced in their choice by the percentage of environmental damage offset, in line with the findings of Saphores and Xu (2021) and Wang and Zhou (2015).

One finding of our research, which is entirely new to the literature, is that providing respondents with information about how the funds raised would be used increases their willingness to choose more sustainable delivery options. In our experiment, we proposed three different uses:

Table 8
Estimates of the parameters of the best fitting MNL and MMNL models.

Parameters	MNL		MMNL	
	Mean	s.e.	Mean	s.e.
ASC standard delivery *(expected value)* α_{asc}	−1.483***	0.24	−6.086***	0.67
ASC standard delivery *(spread of the triangular distribution)*	–	–	2.377***	0.30
ASC standard delivery × woman $\Upsilon_{woman*asc}$	−0.293***	0.06	−0.538***	0.21
ASC standard delivery × online shopping frequency $\delta_{online\_freq*asc}$	0.244***	0.03	0.475***	0.11
ASC standard delivery × change consumption habits $\vartheta_{change\_cons*asc}$	−0.188***	0.04	−0.312***	0.11
Additional delivery charge *(expected value)* β_{charge}	−0.471***	0.07	−1.732***	0.06
Additional delivery charge *(spread of the triangular distribution)*	–	–	3.464***	0.06
Additional delivery charge × change consumption habits $\vartheta_{change\_cons*charge}$	0.072***	0.02	0.334***	0.02
Environmental offset percentage β_{env_off}	0.913***	0.22	1.528***	0.25
Environmental offset percentage × employed $\Upsilon_{emp*\ env\_off}$	−0.306***	0.05	−0.378***	0.07
Environmental offset percentage × not working $\Upsilon_{not\_work*\ env\_off}$	−0.214*	0.11	−0.425***	0.15
Environmental offset percentage × online shopping frequency $\delta_{online\_freq*\ env\_off}$	−0.071**	0.03	−0.098**	0.04
Environmental offset percentage × return frequency $\delta_{return\_freq*\ env\_off}$	−0.160***	0.03	−0.157***	0.05
Environmental offset percentage × change consumption habits $\vartheta_{change\_cons*env\_off}$	0.125***	0.04	0.077*	0.04
Funds used for reforestation *(expected value)* $\beta_{fund\_use\_ref}$	0.175***	0.04	0.298***	0.05
Funds used for reforestation *(spread of the triangular distribution)*	–	–	0.596***	0.05
Delivery time three days β_{three_days}	−0.471***	0.12	−0.554***	0.15
Delivery time three days × being a green consumer $\vartheta_{green\_cons*three\_days}$	0.145***	0.03	0.202***	0.05
Delivery time five days *(expected value)* β_{five_days}	−0.743***	0.14	−1.391***	0.10
Delivery time five days *(spread of the triangular distribution)*	–	–	2.782***	0.10
Delivery time five days × change consumption habits $\vartheta_{change\_cons*five\_days}$	0.081***	0.03	0.167***	0.09
Delivery time five days × being a green consumer $\vartheta_{green\_cons*five\_days}$	0.067***	0.02	0.123***	0.03
Delivery place store β_{store}	−0.185**	0.08	−0.356***	0.09
Delivery place store × aged 18–21 $\Upsilon_{young*store}$	−0.164***	0.05	−0.185***	0.06
Delivery place store × importance of fast delivery $\delta_{fast*store}$	−0.162***	0.04	−0.148***	0.05
Delivery place store × being a green consumer $\vartheta_{green\_cons*store}$	0.009***	0.02	0.102***	0.03
Delivery place locker *(expected value)* β_{locker}	−0.427***	0.09	−0.605***	0.09
Delivery place locker *(spread of the triangular distribution)*	–	–	1.21***	0.09
Delivery place locker × woman $\Upsilon_{woman*locker}$	−0.090**	0.04	−0.095*	0.05
Delivery place locker × being a green consumer $\vartheta_{green\_cons*locker}$	0.084***	0.03	0.116***	0.67
Likelihood	−12,818		−11,291	
Adj. Rho-squared	0.193		0.287	
Akaike information criterion	25,686		22,634	
Bayesian information criterion	25,875		22,830	

the purchase of electric vehicles to deliver products bought online, the recycling or regeneration of returned products and the financial support of reforestation projects. However, investment in reforestation projects was the only destination use that was statistically significant ($\beta_{\text{fund\_use\_ref}} = 0.298$). Our interpretation is that respondents believed that the responsibility for greening the supply chain lies with the logistics provider, the distributor or the manufacturer, who should bear the burden of purchasing less-polluting vehicles and reducing the amount of waste. As a result, consumers were willing to pay an additional delivery charge but only if they are said how the funds are used and if the projects directly improve the environment, such as replanting trees in areas where they have been depleted either by natural causes or human intervention. It should be noted that the preferences of our sample were heterogeneous with regard to the preferred use of the funds raised. In fact, the spread of the triangular distribution was statistically significant (spread of $\beta_{\text{fund\_use\_ref}} = 0.596$).

The delivery time was an important factor driving the respondents' choice between standard and more sustainable delivery settings. We specified the delivery time attribute via two dummy variables: three days versus one day and five days versus one day. Both parameters were statistically significant and negative. According to our results and in line with our expectations, waiting four additional days ($\beta_{\text{five\_days}} = -1.391$)

Table 9
Maximum additional delivery charge and minimum discount required by delivery attribute and respondent characteristics.

Delivery attribute	Euro	*s.e.*
Full compensation of environmental impacts caused by the delivery		
Willingness to pay of the reference segment (students seldom shopping online and returning goods bought online who do not believe they should change consumption habits to protect the environment)	0.88***	0.19
Willingness to pay of employed (compared to students)	0.66***	0.06
Willingness to pay of unemployed, retired or homemaker (compared to students)	0.63**	0.11
Willingness to pay of respondents who frequently shop online (once a month)	0.64*	0.03
Willingness to pay of respondents who frequently return goods bought online (one out of two times)	0.61**	0.04
Willingness to pay of respondents who believe they should change their consumption habits to protect the environment	1.00	0.03
Funding projects aimed at reforestation		
Willingness to pay of the sample	€0.17***	0.03
Delivery requiring to wait an extra two days		
Willingness to accept of the reference segment (respondents who do not define themselves as green consumers)	€0.32***	0.03
Willingness to accept of respondents who define themselves as green consumers	€0.0***	0.12
Delivery requiring to wait an extra four days		
Willingness to accept of the reference segment (respondents who do not believe they should change consumption habits to protect the environment and do not define themselves as green consumers)	€0.80***	0.07
Willingness to accept of respondents who believe they should change their consumption habits to protect the environment	€0.50***	0.02
Willingness to accept of respondents who define themselves as green consumers	€0.59***	0.02
Delivery in a store		
Willingness to accept of the reference segment (respondents aged 22 or older who do not shop online because it is faster and do not define themselves as green consumers)	€0.20***	0.06
Willingness to accept of young respondents (18–21)	€0.30***	0.03
Willingness to accept of respondents who shop online because it is faster than in store	€0.28***	0.03
Willingness to accept of respondents who defined themselves as green consumers (3 on a 5-point Likert scale)	€0.0***	0.03
Delivery in a locker		
Willingness to accept of the reference segment (men who do not define themselves as green consumers)	€0.35***	0.06
Willingness to accept of women	€0.40*	0.03
Willingness to accept of respondents who defined themselves as green consumers (3 on a 5-point Likert scale)	€0.14***	0.02

had a significantly greater effect on the respondents' utility than waiting two more days ($\beta_{three\_days} = -0.554$). Caspersen and Navrud (2021); Caspersen et al. (2022) and Merkert et al. (2022) found similar results. Regarding the heterogeneity of our sample's preferences for the delivery time attribute, we found that while they were essentially homogeneous for an extra two days, indeed when we specified the coefficient as random the spread of the distribution was not statistically significant, they were more diversified when it came to an extra four days. In fact, for this second parameter, we found that the spread of its triangular distribution (spread of $\beta_{five\_days} = 2.782$) was statistically significant. Moreover, respondents who defined themselves as green consumers ($\vartheta_{green\_cons*three\_days} = 0.202$ for an extra two days and $\vartheta_{green\_cons*five\_days} = 0.123$ for an extra four days) or that stated they should change their consumption habits to protect the environment ($\vartheta_{change\_cons*five\_days} = 0.167$ for an extra four days) were more willing to accept longer delivery times.

In terms of delivery location, we found that home/work delivery was preferred to receiving the parcel in a shop ($\beta_{store} = -0.356$) or a locker ($\beta_{locker} = -0.605$), similar to the results reported in previous studies (de Oliveira et al., 2017; Hagen & Scheel-Kopeinig, 2021; Iannaccone et al., 2021; Merkert et al., 2022). However, the reluctance to receive a parcel at a locker was higher and more heterogeneous when compared to home delivery. Women were significantly less willing to receive a parcel at a locker ($\Upsilon_{woman*locker} = -0.095$), probably for security reasons, while respondents who defined themselves as green consumers were more favourable to this delivery method ($\vartheta_{green\_cons*locker} = 0.116$), willing to bear the disadvantage of not receiving the parcel at home if it helped to reduce the environmental impact of delivery. As for in-store delivery, it was particularly disliked by younger respondents ($\Upsilon_{young*store} = -0.185$) and respondents who buy online because it is faster than purchasing in store ($\delta_{fast*store} = -0.148$), while respondents who defined themselves as green consumers were more favourable to this delivery method ($\vartheta_{green\_cons*store} = 0.102$).

4.3. Willingness to pay/accept in order to change the characteristic of the standard delivery

Based on the results obtained with the MMNL model, we estimated respondents' willingness to pay to increase the environmental sustainability of e-commerce deliveries and their willingness to accept a discount to wait for longer delivery times or to receive the package in a store or locker instead of at home/work. We applied the delta method using the Apollo package in R (Hess & Palma, 2019). Table 9 shows the estimates we obtained.

Our findings show that respondents would be willing to pay an additional delivery charge of between €0.61 and €0.88 to fully offset the environmental impact of e-delivery. This value depends on the socio-demographic characteristics of the respondents, their online shopping habits and their environmental sensitivity. Our results are in line – although not directly comparable– with those of Caspersen and Navrud (2021); Caspersen et al. (2022) for Norway and Ignat and Chankov (2020) for Germany, as they expressed the environmental impact in terms of the amount of emissions produced or saved per delivery. Specifying how the funds raised by the additional delivery charge would be used further increased the willingness to pay. In our case study, respondents' willingness to pay increased by an additional €0.17 if the funds were used for reforestation projects.

The willingness to accept a discount for longer delivery times ranged from €0.32 to €0.80. However, for respondents who were sensitive to environmental issues, the required discount could be as low as zero. The willingness to accept a discount for a delivery to a place other than the home/workplace ranged from €0.20 if the delivery was made to a shop to €0.40 if it was made to a locker. The values varied according to the respondents' environmental sensitivity, age, gender and online shopping habits.

The management implications of our findings are very important. On the one hand, they show that consumers are willing to make a financial contribution to reducing the environmental impact of deliveries, and that this contribution is all the greater the more the funds raised are used for environmental restoration projects. Online platforms should therefore offer their customers the opportunity to make a voluntary contribution to environmental protection. This would benefit the company in terms of improving its green reputation, the environment in terms of the funds used to protect it, and consumers in terms of feeling part of a community that cares about the common good. On the other hand, they show that consumers are willing to accept slower delivery times or delivery to locations other than their home in return for marginal discounts on shipping costs. Online platforms should therefore offer customers the option of accepting slower delivery times or delivery locations other than their home, with the benefits not only of reducing express delivery costs and optimising loads, but also of reducing environmental impact.

5. Conclusions

Our work investigates the willingness to accept longer or less convenient e-commerce deliveries and the willingness to pay extra charges to reduce the environmental impact of e-commerce deliveries among a sample of Italian consumers. According to our results, the discount required to accept less convenient but more sustainable deliveries was quite low, ranging from a maximum of €0.80 for an extra four days over the standard delivery time to a minimum of €0.20 for deliveries to a store instead of to home/work. The willingness to pay to reduce or compensate for the environmental impact was on average €0.88, rising up to €1.05 if the funds raised would be used for reforestation projects.

The occupational status of the respondents had a significant impact on these results, as the willingness to pay was higher for students compared to other segments of the sample. This result is in line with our expectations, as the environmental sensitivity of the younger generation is higher and stronger compared to the rest of the population. This phenomenon has emerged not only internationally but also in Italy, as highlighted by the Fridays for the Future events (https://fridaysforfutureitalia.it/). One of the latest surveys sponsored by the European Parliament through Eurobarometer showed that the environment remains a top priority for the younger generation; 51% of young Europeans aged 15 to 24 said they are very concerned about climate change, compared to 45% of all other age groups. In Italy, the generation gap is even wider, with almost two out of three young people very concerned about climate change, compared to an average of 53% for the population as a whole.

Gender also plays a role, particularly in terms of delivery location. Women were less likely to choose unattended lockers and would need larger discounts to choose this delivery setting. However, women were also more likely to choose greener deliveries, ceteris paribus. This finding is consistent with a recent stream of literature demonstrating women's greater sense of responsibility for climate change and environmental sustainability issues (Birindelli, Iannuzzi, & Savioli, 2019; Nadeem, Bahadar, Gull, & Iqbal, 2020; Tingbani, Chithambo, Tauringana, & Papanikolaou, 2020).

To build trust and encourage consumers to order online, e-commerce companies offer free or flat rate deliveries and returns (e.g., Amazon Prime service), but this policy results in more online returns than traditional brick and mortar retailers, with environmental and financial costs rising disproportionately with the return rate (Asdecker & Karl, 2022). Especially when buying clothes, consumers order two or three sizes of the same product, knowing that they can return the wrong size free of charge. The scientific director of the Hamburg Environmental Institute reported that it is not uncommon for these products to travel thousands of kilometres to Africa or Asia, where there are often no disposal facilities. If they are not purchased there either, they end up in landfills or simply left lying around (Maiwald & Materla, 2023). According to our results, respondents who frequently shopped online and

returned online purchases were less likely to choose more environmentally sustainable delivery methods but were still willing to help reduce or offset the environmental impact of their e-commerce deliveries.

Environmental sensitivity is a key factor influencing respondents' choice and willingness to accept more environmentally sustainable deliveries. This was the case for respondents who believed that they should change their consumption habits to protect the environment and considered themselves to be green consumers. This segment of the sample was not only willing to pay a higher delivery charge to reduce or offset the environmental impact of shopping online but was also willing to accept longer delivery times and delivery destinations other than their home/work.

In terms of managerial insights, e-commerce companies can use our findings to properly design and promote environmental offsetting campaigns and fundraising for environmental protection. Young consumers and women should be targeted in particular to collect voluntary contributions, which could range from a minimum of €0.61 to a maximum of €1.05 on top of the standard delivery charge. However, the collection of voluntary contributions should be accompanied by information campaigns describing how the funds collected would be used, and investments should prioritise environmental protection or restoration projects, such as reforestation, rather than greening logistics activities, which, according to our results, are perceived as the responsibility of manufacturers, distributors and logistics operators. To this aim, it is important that the details of the projects to be carried out are clearly explained and that the results are certified by external regulatory bodies. This commercial strategy, which aims to share the cost of environmental protection with consumers, has already been successfully implemented by several airlines and is beginning to produce the expected results, both in terms of funds raised and the quantity and quality of carbon offsetting and environmental restoration projects undertaken (Rotaris, Giansoldati, & Scorrano, 2020). However, for this management strategy to be successful, proper communication of the environmental goals achieved through the supported projects is crucial. This is not an easy task. Simply quantifying the amount of CO_2 reduced or offset is not enough. It is necessary to use innovative and more engaging communication techniques so that consumers feel responsible for the environmental damage caused by their consumption choices but also perceive that they can actively contribute to its reduction or compensation. This is an area of research that is still in its infancy and deserves to be further explored. From the social point of view, this management approach makes it possible to internalise the external environmental costs of e-commerce in line with the "polluter-pays principle", except that it is voluntary rather than mandatory and is introduced by the supply side of the market rather than by the regulator. This has the advantage of increasing the acceptability of such a measure in case a full internalization of the social costs is needed, still building a sense of responsibility from the demand side of the market that could be subsequently usefully exploited by the regulator.

Particular attention should also be paid to frequent buyers and consumers who often return goods purchased online. The sustainability of both the environmental and financial costs of free delivery and returns actually used by most e-commerce companies is at risk. Two main strategies can be pursued. *E*-commerce companies could either start sharing at least part of the costs of greening their logistic activities with their customers applying a charge within the willingness to pay range we have found. This would make consumers more aware of the economic burden of their choices. Alternatively, or in addition, e-commerce companies could inform their customers about the environmental impact of their online purchases, enabling consumers to make more informed choices. Trenitalia, Italy's main railway operator, has successfully used this strategy since 2012 (https://www.fsitaliane.it/). The backs of train tickets show the average CO_2 emissions for the customer's journey by train, car and plane, encouraging consumers to opt for the more environmentally sustainable transport mode. *E*-commerce companies could do the same, offering different delivery options in terms of time and place of delivery and their respective environmental costs.

A final critical issue for companies to consider is the location and design of collection points and lockers. The use of these logistical hubs by consumers as an alternative to home/work deliveries is crucial in order to reduce the number of missed deliveries, avoid deliveries during highly congested time windows and increase the optimisation of vehicle utilisation and routing. To this end, and particularly with regard to female consumers, collection points and lockers should be equipped with surveillance cameras and located in shopping centres or other easily accessible and monitored areas.

The increasing environmental awareness of new generations is pushing e-commerce companies to take responsibility and act to reduce the environmental impact of their businesses. The sooner they begin implementing effective green strategies, the greater the competitive advantage they will build and the longer they will profitably stay in the marketplace.

In this framework, the role of the regulator is crucial, especially with reference to the collection of voluntary additional delivery charges aimed at reducing/offsetting the e-logistics environmental impact. The regulator will have to monitor the information on environmental reduction and compensation published by e-commerce companies and check how the funds raised are actually used. It should also set guidelines and rules on how the funds raised can be used, appoint the external bodies that will certify that the projects funded comply with the guidelines and rules, and check that the certifying bodies do not collude with the regulated companies. If the regulator does not play its role timely and properly, consumers may continue to increase their online purchases in the belief that their environmental impact will be offset via their donations, while the funds collected by the companies will not be used for their intended purpose. This would be doubly damaging for the environment. In the long run, the market for voluntary contributions will collapse and the whole economic and social system will be damaged.

With reference to the limits of our research, we acknowledge that the results of our study might have been influenced by the value of the additional delivery charge we proposed in the discrete choice experiment. We based these values on the results of the existing literature on the willingness to pay to reduce the environmental impact of deliveries, but as pointed out by an anonymous reviewer, it may be preferable to base them on the actual costs of greening delivery logistics or on the monetary value of the external costs of deliveries. At the time we conducted the experiment, the literature on these costs was lacking. We therefore suggest that much more effort should be put into researching this topic, to the benefit of companies wishing to green their logistics, consumers wishing to know the environmental impact of their consumption choices, and researchers wishing to study the willingness to pay for more sustainable business-to-consumer e-commerce. A second limit of our research is that most of the people we surveyed are young individuals from northeast Italy and this is most probably due to the social media sites we used to collect the data. Although there are no socio-demographic statistics on Italian e-consumers except that younger people make the largest segment of e-consumers, in our feature research we need to increase the representativeness of our sample compared to the Italian population.

Future lines of research include collecting additional data from Italian consumers in order to have a sample that is more representative of the Italian population in terms of socio-demographic characteristics. We also plan to collect data from other European countries. This would allow us to investigate whether the willingness to change online shopping habits and pay additional delivery charges to reduce or compensate for the environmental damage caused is influenced by the culture, perceptions and lifestyles of different regions and geographical areas. Given the positive trend in the environmental sensitivity of the Italian population, it would also be interesting to repeat the discrete choice

experiment in a few years' time to see how the willingness to pay a voluntary contribution or accept less convenient delivery changes over time. It will also be interesting to test whether the willingness to pay estimated using the discrete choice approach would be in line with estimates obtained using the contingent valuation approach as a data collection method. Finally, we plan to use the data collected via all the psychological and attitudinal indicators to estimate the extent to which latent variables influence the choice process of e-consumers.

Author statement

Marta Biancolin: Data curation, Formal analysis, Writing-Reviewing and Editing.

Lucia Rotaris: Conceptualization, Methodology, Investigation, Project administration, Supervision, Formal analysis, Writing- Original draft preparation.

Declarations of Competing Interest

None.

Declaration of Competing Interest

Our paper and the related research have been conducted during and with the support of the Italian inter-university PhD course in Sustainable Development and Climate Change.

Appendix A. Appendix

Table A1
Levels of most frequently used attributes by paper.

Source	Delivery charge	Delivery time	Delivery location	Information on environmental impact
Agatz et al. (2021)	Discount of €1.82 ($2), €4.56 ($5) or €7.30 ($8) on the standard delivery fee (of €7.30)	Time windows of one or more hours from Monday to Friday between 10 a.m. and 8 p.m.	–	Depending on their environmental impact, delivery windows may or may not be labelled green.
Borghetti et al. (2022)	Van: €1 Bicycle: €1 or €2 Scooter: €2 or €4 Drone: €5 or €3	Van: 90 or 40 min Bicycle: 60 or 20 min Scooter: 40 or 15 min Drone: 30 or 10 min	–	
Caspersen and Navrud (2021)	–	1, 5, 10 or 20 days	–	CO_2 emissions per delivery: 0, 0.28 or 1.40 kg PM_{10} emissions per delivery: low, medium or high
Caspersen et al. (2022)	€0 (0 NOK), €4.29 (49 NOK) or €8.66 (99 NOK)	1, 5, 10 or 20 days	–	CO_2 emissions per delivery: 0, 0.28 or 1.40 kg
Cheah and Huang (2022)	Air: €6.75 ($7.40) or €7.11 ($7.80) Sea: €4.01 ($4.40)	Air: 7–11 days Sea: 10–17 days	Home vs. collection points	CO_2 emissions saved: Air: 3.60, 3.61 or 3.75 kg Sea: 0.67 kg
de Oliveira et al. (2017)	Current delivery fee vs. discounted fee	Opening hours (8 a.m.–6 p.m.) vs. flexible delivery time (at the most convenient time for the customer)	Home vs. parcel locker	–
Hagen and Scheel-Kopeinig (2021)	Additional shipping costs: €0, €0.50, €1.0, €1.5, €2.0, €2.5 or €3.0	Opening hours (8 a.m.–6 p.m.) vs. 24/7 at the parcel locker	Home vs. parcel locker	–
Iannaccone et al. (2021)	If choosing parcel locker, discount of: €0, €1 or €2	Opening hours (8 a.m.–6 p.m.) vs. 24/7 at the parcel locker	Automated vs. staffed parcel locker; pickup point in a station, shopping centre or service area	Environmental certification: yes vs. no
Ignat and Chankov (2020)	€3, €5, €6 or €10	Same day vs. 2–3 days	Home vs. pickup point	CO_2 emissions per delivery: 15, 100, 150, 200, 300 or 400 g
Merkert et al. (2022)	Postal delivery or locker: Small standard parcel: €6, €8, €10 or €12 Small express parcel or large standard parcel: €12, €14, €16 or €18 Large express parcel: €18, €20, €22 or €24 Drone: Small standard parcel: €2, €4, €6 or €8 Small express parcel or large standard parcel: €8, €10, €12 or €14 Large express parcel: €14, €16 or €18	Postal delivery or locker: 5, 3, 2 or 1 days Drone: 5, 3, 2 or 1 days, same day, 2 h Postal delivery: daytime, 2-h choice daytime, 3-h choice daytime, evening Locker: 24/7 Drone: daytime, 2-h choice daytime, 1-h choice daytime, 30-min choice daytime	Postal delivery or drone: at front door vs. in a safe place	–
Rai et al. (2021)	Free	Fast (1 day) vs. slow (3 days)	At home	Information on the number of vehicles used and kilometres travelled

Appendix B. Section 1_A Description of the econometric models used

Discrete choice models are widely used to explain individual preferences for non-market goods or products and services not yet commercialised (Adamowicz, Louviere, & Williams, 1994). Discrete choice models are based on random utility theory (Lancaster, 1966; Louviere, Hensher, & Swait, 2000; McFadden, 1974) which assumes that an individual n evaluates the set of J available alternatives in each choice situation $t \in T$ and chooses the alternative with the highest utility (Train, 2003). The utility ($U_{n,j,t}$) that individual n gets from choosing alternative $j \in J$ in choice task t is defined as

follows:

$$U_{n,j,t} = \text{asc}_j + \beta_j^{'} X_{n,j,t} + \gamma_j^{'} Z_n + \varepsilon_{n,j,t}$$
$$\varepsilon_{n,j,t} = \text{IID extreme value type 1} \quad \text{(A1)}$$

where asc_j is the alternative-specific constant, $X_{n,j,t}$ is the vector of attributes characterising the j alternative in choice task t, Z_n is the vector of socio-demographic characteristics of individual n and $\varepsilon_{n,j,t}$ is the stochastic disturbance term representing characteristics unobservable by the analyst and is assumed to be an independent and identically distributed extreme value type 1. The vectors of the unknown coefficients β and γ represent the marginal utility of the attributes and the impact that the socio-demographic characteristics have on the preferences for each alternative, respectively. If it is assumed that individuals' preferences are homogenous and there are no interpersonal differences, the β vector is made by fixed parameters to be estimated via a MNL model (McFadden, 1974). If the homogeneity assumption is relaxed, the β vector is made by random parameters accounting for individual specific preferences that are estimated via a MMNL model (Hensher & Greene, 2003; McFadden & Train, 2000). In this case, the utility function in Eq. (A1) is reformulated as follows:

$$U_{n,j,t} = \text{asc}_{n,j} + \beta^{'}_{n,j} X_{n,j,t} + \gamma^{'}_{j} Z_n + \varepsilon_{n,j,t} \quad \text{(A2)}$$

In the MMNL model, the vector $\beta_{n,j}$ is made by parameters that are distributed according to a density function $(\beta_j|\varphi)$, the shape (e.g., normal, lognormal, uniform or triangular), mean and variance of which are unknown and are estimated via the maximisation of a log likelihood function with the aim of getting the best data fitting model. The choice probability is a weighted average of the logit formula with weights drawn by the random parameters' density function:

$$P_{n,j} = \int \left(e^{V_{nj}(\beta)} \Big/ \sum_j e^{V_{nj}(\beta)} \right) f(\beta_j|\varphi) d\beta_j \quad \text{(A3)}$$

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