

Unlocking sustainable last mile deliveries through interventions in the pre-delivery stage

Alinda Kokkinou^{a,*}, Aistė Lastauskaitė^b, Hans Quak^{c,a}, Andreas Karaoulanis^b, Ondrej Mitas^a, Albert Mandemakers^a

^a Breda University of Applied Sciences, Mgr. Hopmansstraat 2, 4817 JS Breda, the Netherlands

^b Kauno Kolegija Higher Education Institution, Pramonės Av. 20, LT-50468 Kaunas, Lithuania

^c TNO, Sustainable Transport and Logistics, Anna Van Buerenplein 1, 2595 DA Den Haag, the Netherlands

ARTICLE INFO

Keywords:

Sustainability
Consumer behavior
Last mile logistics
Delivery preference
Parcel lockers

ABSTRACT

Technological innovations such as parcel lockers can only contribute to reducing the negative impact of last mile logistics on people, planet and profit outcomes if consumers adopt them. Using the Unified Theory of Acceptance and Use of Technology (UTAUT) as a theoretical lens, the purpose of this study was to design effective interventions in the pre-delivery stage that stimulated consumers to choose to use parcel lockers, focusing on incentives and actions that online retailers and logistic service providers can easily implement. A vignette-based experiment was used to examine the impact of providing consumers with information about sustainability, information about parcel lockers and information about distance to nearest parcel locker on their choice to use a parcel locker instead of receiving their package at home. The originality of the study is twofold. The role of geographical context which is oftentimes overlooked was examined explicitly in this study by conducting the study with participants from the Netherlands and Lithuania. The present study used causal mediation analysis to study the combined effects of interventions and previous experience with parcel lockers through the UTAUT constructs. The findings showed that providing information about sustainability and information about the distance to the nearest parcel locker were effective interventions, however the effect of distance was country specific. Causal mediation analysis showed that familiarity with parcel lockers was positively associated with the choice to use parcel lockers by increasing perceived ease of use, expected performance, and reducing perceived risk.

1. Introduction

The sustainability of last mile logistics is gaining attention both in academic literature (Alejandra Maldonado Bonilla et al., 2024; Heikkinen, 2024; Niemeijer & Buijs, 2023) and in the popular press (CNN, 2019; Financial Times, 2020; Scientific American, 2020; The New York Times, 2019). Last mile logistics consist of the activities to deliver a parcel from the last upstream consolidation point the intended recipient's location (Kin & Quak, 2025; Mangiaracina et al., 2019). Consumers are increasingly settling in cities and concurrently ordering more products online, expecting a cheap, yet fast delivery. This situation is putting pressure on urban infrastructures. The ongoing urbanization trend and the compounding effect of an increase in delivery frequency has exposed the negative impact of last mile logistics on the livability of

cities (Cauwelier et al., 2024). Compared to the total supply chain, last mile logistics have a disproportionately large negative impact on social, ecological, and financial outcomes. Pressure is put on delivery drivers through tight planning, causing them stress. Last mile logistics also contribute to congestion in cities and are generally perceived to be highly polluting (González-Romero et al., 2025). These negative outcomes are expected to worsen with the continued growth of e-commerce. Without changes, the World Economic Forum (2024) predicts that by 2030, delivery vehicles could increase by 61 %, carbon emissions by 60 %, and congestion by 14 %. Not only would this lead to 200 h of lost productivity per delivery vehicle, but it would also have a significant negative impact on resident and driver health outcomes. Logistic Service Providers (LSPs) are thereby caught between several competing interests.

* Corresponding author.

E-mail addresses: Kokkinou.A@buas.nl (A. Kokkinou), aiste.lastauskaite@go.kauko.lt (A. Lastauskaitė), hans.quak@tno.nl (H. Quak), andrekaraulpublish@gmail.com (A. Karaoulanis), Mitas.O@buas.nl (O. Mitas), Mandemakers.A@buas.nl (A. Mandemakers).

<https://doi.org/10.1016/j.clscn.2025.100250>

Received 22 January 2025; Received in revised form 7 July 2025; Accepted 8 July 2025

Available online 10 July 2025

2772-3909/© 2025 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Improving the triple bottom-line of last mile logistics has de facto become the task of LSPs. In any given market, multiple LSPs compete on cost and quality to serve online retailers, even charging rates below their costs (Allen et al., 2018), yet consumers expect high service levels combined with convenience and flexibility. Concurrently, governments are increasingly imposing regulations in emissions and restrictions on urban traffic to improve the livability of cities. Thus, LSPs need to find effective ways to meet the cost, quality, and sustainability requirements of a diversity of stakeholders. While LSPs develop and offer 'green' distribution services (Agatz et al., 2021; Sallnäs & Björklund, 2020; Zhou et al., 2020), online retailers determine how to promote distribution alternatives on their websites. Furthermore, consumers are an important driver for environmentally sustainable supply chains through their behavior (Sallnäs & Björklund, 2020). Thus, consumer behavior needs to be considered when designing interventions in the pre-delivery stage to stimulate consumers to select more sustainable delivery options (Kokkinou et al., 2024; Viet et al., 2023). Parcel lockers are such an option for sustainable delivery.

Parcel lockers, also known as smart lockers (Cai et al., 2021), automated parcel cabinets (Zhou et al., 2020), or locker banks are a form of self-collection (Zhou et al., 2020). They are a form of unattended delivery that relies on self-service technology to allow consumers to autonomously pick up their parcel (Alejandra Maldonado Bonilla et al., 2024; Vakulenko et al., 2019). Parcel lockers allow LSPs to consolidate deliveries and reduce unsuccessful delivery attempts, resulting in significant cost savings per delivery. Consolidation also reduces delivery times, traffic congestion, e.g. caused by vans double parking and hindering traffic when making a home-delivery as most consumers do not have delivery bays close by, and the associated emissions, noise and energy consumption (Iwan et al., 2016). In a recent study, Peppel and Spinler (2022) found that optimally designed parcel locker networks could generate cost savings of up to 11.0 % for LSPs. Furthermore, they could reduce CO₂ emissions of shipments and pick-ups by up to 2.5 %.

For LSPs to achieve the benefits of self-collection services, and parcel lockers in particular, consumers currently need to choose this delivery option when ordering at an online retailer. Previous studies examining consumers' intention to use parcel lockers have used the Innovation Diffusion Theory (IDT) (Tsai & Tiwasing, 2021; Yuen et al., 2018), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM) (Chen et al., 2020) and Unified Theory of Acceptance and Usage of Technology (UTAUT) (Cai et al., 2021; Zhou et al., 2020). These studies investigated the impact of consumers' beliefs about parcel lockers on their intention to use them. These studies have found that, in general, consumers can be motivated to use parcel lockers if they perceive them to be convenient, functional and safe (Tsai & Tiwasing, 2021; Wang et al., 2019; Zhou et al., 2020). In addition to these cognitive motivation aspects, customers can also be motivated affectively, through the perceived safety and enjoyment of using parcel lockers (Wang et al., 2019). Nevertheless, few studies applying models such as TAM and UTAUT go beyond providing global recommendations to practitioners to test the effect of specific interventions (Venkatesh, 2022). This leads to the research question:

RQ1: Which intervention designs motivate consumers to have their packages delivered to a parcel locker?

As LSPs and online retailers control the delivery options offered to consumers (Zhou et al., 2020), more research is needed to understand how consumers can be stimulated to choose parcel lockers. Furthermore, previous studies have typically either applied models such as UTAUT, or studied the impact of interventions, but not used UTAUT to explain the effect of interventions on consumer behavior. This leads to the second research question:

RQ2: What factors explain the success of interventions?

The purpose of this study was therefore to investigate how consumers can be stimulated to use parcel lockers, focusing on interventions

that online retailers and LSPs can easily implement. As online retailers are still reluctant to consider financial incentives due to the highly competitive market in which they operate (Barker & Brau, 2020), this study focused on the provision of information to online shoppers. Drawing on best practices for the use of experiments in supply chain management (Carter et al., 2024), the present study used a 2 (information about sustainability) x 2 (information about parcel lockers) x 3 (information about distance to nearest parcel locker) vignette-based experiment in combination with a binary choice dependent variable, and the UTAUT constructs as mediating variables. We also answered the call of Zhou et al. (2020) to examine prior experience by controlling for familiarity with parcel lockers. Furthermore, as previous studies have acknowledged that geographical differences may apply (An et al., 2022; Zhou et al., 2020) we replicated the study across two countries, the Netherlands and Lithuania. This study contributes to the literature on consumer adoption of parcel lockers by highlighting the role of geographical context in shaping consumer behavior in last-mile logistics.

The remainder of this paper is organized as follows: In the next section, we review the literature on UTAUT and connect it to previous research examining the impact of interventions on consumer choices regarding parcel lockers and other forms of self-service technology. We also review previous literature addressing familiarity with parcel lockers and geographical context. Subsequently, we formulate a comprehensive conceptual framework that links interventions to behavior through the mediating effects of UTAUT constructs and the moderating effects of familiarity with parcel lockers and geographical context. The methodology section details the procedures employed for the vignette-based experiment, including the design of the data collection instrument and sampling procedures. As the originality of the study also greatly hinges on the use of UTAUT variables as mediating constructs, the causal mediation analysis procedures are detailed separately. The results section details the use of logistic regression and causal mediation analysis. The discussion of the results is followed by implications for practitioners. The paper concludes with limitations and recommendations for further research.

2. Review of literature

An increasing body of research asks how consumers can be nudged to engage in more sustainable last mile behavior (Agatz et al., 2021; Buldeo Rai et al., 2021; Kokkinou et al., 2024; Viet et al., 2023). Nevertheless, this line of inquiry is characterized by the lack of a coherent theoretical framework. Research on sustainable last mile delivery is still emerging and as such characterized by its focus on practical relevance (Svanberg, 2020). We therefore follow the steps for engaged research as recommended by Sternberger et al. (2024). First, we address a real-life problem by improving last mile delivery from a triple bottom line perspective. Second, we view problem through a particular area of concern, namely using knowledge of consumer behavior in the last mile to design interventions that nudge consumers towards more sustainable delivery alternatives. Third, we apply a theoretical framework, which in this study is UTAUT.

2.1. UTAUT

UTAUT was proposed by Venkatesh et al. (2003, 2012) as a general framework explaining the adoption of technology. UTAUT integrates prior theoretical models examining information technology adoption, including IDT, TAM, and TPB. UTAUT has been applied in a large variety of contexts to explain individuals' intention to use a variety of technologies, both in professional contexts (Pieters et al., 2022) and in personal situations (Cai et al., 2021). According to UTAUT, individuals' intention to use technology is determined by their perceived characteristics of the technology and their attitudes towards the technology. These include expected ease of use, expected performance, social

influence, and facilitating conditions. In addition to the four UTAUT constructs (Venkatesh et al., 2003), we also examine the impact of perceived risk (Zhou et al., 2020). Ease of use, also denoted as effort expectancy, is defined as the degree of ease associated with using a particular technology (Venkatesh et al., 2003). Expected performance represents users' belief that the focal technology will help them accomplish a particular task with relatively little effort (Venkatesh et al., 2003; Zhou et al., 2020). In the context of parcel lockers and other self-service technologies, consumers expect parcel lockers to save them time and effort (Vakulenko et al., 2018). A concept frequently associated with last mile delivery technologies yet not included in the original UTAUT is perceived risk (Schmidt & Saraceni, 2024). Perceived risk represents the overall potential for loss associated with using parcel lockers and is likely to negatively influence consumers' behavioral intention to use parcel lockers. Facilitating conditions describe consumers' perception that there are resources available to guide and support them in using the technology (Cai et al., 2021; Zhou et al., 2020). This includes infrastructure, access to information, and other resources that facilitate the use of the technology (Venkatesh et al., 2012). Social influence describes the degree to which a consumer believes that third parties that are important to them (e.g. friends, family, co-workers) support the usage of the technology (Venkatesh et al., 2003). The prevailing notion is that consumers will be more likely to choose to use a technology if they receive active and positive social support (Cai et al., 2021).

Previous research examining consumers' behavioral intention to adopt and use technology has typically viewed expectations vis-à-vis the focal technology as context independent. Studies based on technology adoption models have frequently provided recommendations for interventions to improve expectations and thus behavioral intentions. Nevertheless, while these studies provide important insights into how consumers decide between (technological) parcel delivery alternatives, they remain too abstract to provide practitioners with actionable recommendations. The present study therefore follows the lead of Buldeo Rai et al. (2021), Viet et al. (2023) and Kokkinou et al. (2024) and examines the impact of specific interventions that LSPs and online retailers can enact. However, unlike previous studies, the present study uses the UTAUT constructs as mediators. This is consistent with more recent calls to study of the impact interventions in combination with the UTAUT constructs as new research contributions to the technology adoption literature (Venkatesh, 2022).

2.2. Information disclosure and interventions

Information disclosure has been shown to be an effective way to stimulate consumer behavior through non-financial incentives (Rose et al., 2025). Previous UTAUT research has similarly shown that consumers are more inclined to use parcel lockers if they perceive them to be convenient, reliable and low risk (Tsai & Tiwasing, 2021; Zhou et al., 2020). Additionally, information about the sustainability of parcel lockers acts as a motivator for consumers to choose this more sustainable alternative (Agatz et al., 2021; Buldeo Rai et al., 2019; Viet et al., 2023). Therefore, for the purpose of this study, three interventions were designed based on information disclosure (Rose et al., 2025). The three interventions were (1) providing information about sustainability, (2) providing information about the distance to the nearest parcel lockers, and (3) providing information about the convenience and safety of parcel lockers. We also investigated familiarity with parcel lockers and attitude towards the environment (Chen, 2020) as a covariates.

For consumers to make more sustainable last mile logistics choices, they need to be knowledgeable about the issue. Yet, there is information asymmetry between retailers and LSPs on the one hand, and consumers on the other hand, regarding the sustainability of different delivery options (Sallnäs & Björklund, 2020; Viet et al., 2023). As the sustainability of last mile delivery alternatives is still relatively unknown to consumers (Buldeo Rai et al., 2019), pro-actively informing consumers about the sustainability implications of their last mile delivery options is

still expected to be an effective non-financial intervention to stimulate them to select the parcel locker (Buldeo Rai et al., 2021; Viet et al., 2023). Similarly, previous research has shown that individuals with a more developed environmental consciousness also engage in more sustainable behavior (Agatz et al., 2021). However, more research is needed on the role that consumers' environmental consciousness plays in their delivery choices (Buldeo Rai et al., 2021).

Convenience plays an important role in consumers' willingness to participate in last mile logistics (Rose et al., 2025). In contrast with home delivery, a characteristic of parcel lockers is that consumers need to execute a part of the last mile logistics themselves, requiring them to invest time and effort in the process (Vakulenko et al., 2018). In their study, Agatz et al. (2021) showed that consumers became less sensitive to both financial incentives and other last mile interventions as choices became less convenient. Previous studies applying UTAUT also concluded that consumers were more likely to use self-service technologies if they believed that they have the necessary knowledge to use them, otherwise known as facilitating conditions (Zhou et al., 2020).

2.3. Familiarity with parcel lockers

Until recently, few consumers had experienced the use of parcel lockers (Iannaccone et al., 2021). As their popularity increases, however, so does the number of consumers that have prior experience using them. Cai et al. (2021) showed that habit formation was an important antecedent of behavioral intention. Similarly, Vakulenko et al. (2019) found that consumers' expectations are shaped by previous experiences. Wang et al. (2019) found that prior experience with parcel lockers had a negative effect on future intention to use them. They attributed this to the early stages of implementation of the infrastructure in Singapore where the data was collected, leading to negative initial experiences with parcel lockers. Conversely, Kokkinou et al. (2024) found that increased familiarity with parcel lockers led to an increase in likelihood to choose it as a delivery option in the Netherlands, where parcel locker infrastructure was more prevalent. This could be explained through the mediating effects of expected ease of use, expected performance and perceived risk.

2.4. Geographical differences

Despite evidence that parcel locker adoption varies per country, geographical differences have not been examined explicitly in academic literature. The adoption and usage of parcel lockers has been examined in the context of Singapore (Wang et al., 2018), Taiwan (Chen et al., 2020), United States of America (An et al., 2022), and the Netherlands (2024). Results have not been compared across countries with the exception of Viet et al. (2023), who replicated part of their study across the Netherlands and the United Kingdom. Yet, local conditions and consumer habits differ across geographical locations. Furthermore, previous research using experiments in the context of supply chain management has been criticized for using mostly WEIRD participants, where WEIRD stands for Western, Educated, Industrial, Rich, and Democratic (Carter et al., 2024). For this study, we compare a WEIRD country, the Netherlands, to a non-WEIRD country, Lithuania (Balundė et al., 2019).

3. Conceptual framework

This section presents the conceptual framework and hypotheses for this study.

3.1. UTAUT hypotheses

Based on UTAUT, several hypotheses can be formulated regarding why consumers choose to use parcel lockers. Previous studies have shown that when consumers expect a technology to be easy to use, they

are more likely to use it (Venkatesh et al., 2012), leading to the following hypothesis:

H1: Ease of use is positively associated with the choice to use a parcel locker

Amongst UTAUT constructs, expected performance is often the strongest predictor of consumers' behavioral intentions (Cai et al., 2021). Consumers expect parcel lockers to save them time and effort (Vakulenko et al., 2018). We therefore hypothesize that:

H2: Expected performance is positively associated with the choice to use a parcel locker.

Conversely, consumers may anticipate risks associated with using parcel lockers such as privacy issues and the potential loss of packages (Encarnación & Amaya, 2025). This would negatively influence their behavioral intention to use parcel lockers. We therefore hypothesize that:

H3: Perceived risk is negatively associated with the choice to use a parcel locker.

According to UTAUT, access to information, and other resources should facilitate the use of the technology (Venkatesh et al., 2012). In the context of parcel lockers, facilitating conditions also include accessibility and site features (Encarnación & Amaya, 2025). We therefore hypothesize that:

H4: Facilitating conditions are positively associated with the choice to use a parcel locker

Similarly, social influence has been shown to stimulate the use of technology (Venkatesh et al., 2012). In the context of self-service delivery, consumers are stimulated to use the technology through the positive experiences shared by friends or others (Zhou et al., 2020). We therefore hypothesize that:

H5: Social influence is positively associated with the choice to use a parcel locker.

3.2. Information disclosure hypotheses

Based on previous research, three interventions expected to stimulate choice to use delivery at parcel lockers were developed using the concepts of convenience, reliability, and risk (Rose et al., 2025; Tsai & Tiwasing, 2021; Zhou et al., 2020). Labeling more sustainable delivery options as 'green' has been shown to be more effective at stimulating consumers' choice of the more sustainable delivery (Buldeo Rai et al., 2021). In the context of delivery at home, Viet et al. (2023) and Kokkinou et al. (2024) showed that when given information about the environmental sustainability of delivery options, consumers were willing to wait longer for delivery at home. In the context of parcel lockers, we therefore hypothesize:

H6 providing information about sustainability of the delivery option is positively associated with the choice to use a parcel locker.

Consumers with a more positive attitude towards the environment are expected to be more receptive to a message about the sustainability of delivery options (Kokkinou et al., 2024). Thus, we hypothesize the following interaction:

H6' attitude towards the environment strengthens the impact of providing information about sustainability of the delivery option on the choice to use a parcel locker.

In the context of picking up from a parcel locker, an important driver of convenience is travel distance. Iannacone et al. (2021) showed that consumers were more willing to use parcel lockers if they were located close to their home and/or place of work. Furthermore, Yuen et al. (2018) showed that for consumers to use parcel lockers, their advantage

over other last mile delivery options needs to be actively marketed. Therefore, we hypothesize that:

H7 providing information about the distance to the nearest parcel locker will increase expected performance.

Concurrently, an important element of creating the conditions facilitating the usage of parcel lockers is providing information about their accessibility (Encarnación & Amaya, 2025; Zhou et al., 2020). Therefore, we test the effect of pro-actively informing consumers about the benefits of using parcel lockers, namely their availability (24/7), ease of use, and safety by testing the hypotheses:

H8 providing information about parcel lockers will increase consumers' perceptions of facilitating conditions

3.3. Familiarity with parcel lockers hypotheses

According to Venkatesh et al. (2003), effort-oriented constructs such as expected ease of use play a more important role in the early stages of a new behavior, when consumers have to overcome the hurdles associated with learning a new process. Conversely, as consumers develop new skills and habits, these constructs lose in importance. Zhou et al. (2020) also showed that perceived risk negatively impacted behavioral intention. We therefore hypothesize:

H9 familiarity with parcel lockers is positively associated with ease of use

H10 familiarity with parcel lockers is positively associated with expected performance

H11 familiarity with parcel lockers is negatively associated with perceived risk

3.4. Mediation hypotheses

Given the above information, we also formulate the following mediation hypotheses:

HA ease of use mediates the impact of familiarity with parcel lockers on the choice to use a parcel locker.

HB expected performance mediates the impact of providing information about distance to the nearest parcel locker on choice to use a parcel locker.

HC perceived risk mediates the relationship between familiarity with parcel lockers and the choice to use a parcel locker.

HD facilitating conditions mediate the impact of providing information about parcel lockers (availability and safety) on the choice to use a parcel locker.

3.5. Moderating Hypotheses: the Role of Geographical Context

The Netherlands and Lithuania differ in terms of parcel locker density and usage. In the Netherlands, 63 % of households are located within walking distance of a parcel locker or pickup location (ACM, 2020). Over 83 % of the parcels are delivered at the home address (ACM, 2024). The density of parcel lockers in the Netherlands is much lower than in Lithuania with parcel locker densities of respectively 0.34 and 3.51 parcel lockers per 10,000 residents in 2021 (Breinbauer et al., 2021). Based on the 2023 Communications Regulatory Authority (RRT) report, 58 % of postal parcels in Lithuania were collected from self-service terminals, suggesting a preference in consumer habits (Verslo žinios, 2023). In the Netherlands, fewer than 7 % of postal parcels were collected from self-service terminals during the same period (ACM, 2024). We thus examine the moderating effect of geographical location, operationalized here as country. Specifically, we hypothesize that:

H9' country moderates the relationship between familiarity with parcel lockers and expected ease of use.

H10' country moderates the relationship between familiarity with parcel lockers and expected performance/

H11' country moderates the relationship between familiarity with parcel lockers and perceived risk.

The conceptual model and hypotheses are shown in Fig. 1.

4. Methods

This section describes and justifies the design of the vignette-based experiment and data collection instrument. This is followed by a description of the sampling procedures and study sample. Given the novelty of causal mediation analysis, a brief review of this method is provided.

4.1. Vignette experiment

To test the study hypotheses, a vignette-based experiment was used, administered online using a Qualtrics survey. This type of research design has been used in previous research on consumer logistics in last mile delivery (Buldeo Rai et al., 2021; Carter et al., 2024; Viet et al., 2023) and, more generally, in research on consumer usage of self-service technology (Kokkinou & Cranage, 2015). Vignette-based experiments have a long history of being used as a form of laboratory study that enables researchers to have control over experimental conditions while reducing noise and not interfering with sensitive business processes (Carter et al., 2024; Kokkinou & Cranage, 2011; Viet et al., 2023). In this study, the vignette-based experiment consisted of a 2 (information about sustainability) x 2 (information about parcel lockers) x 3 (information about distance to nearest parcel locker) study design. Participants were randomly assigned to one of the twelve conditions. The interventions were based on the information disclosure hypotheses presented in section 3.2.

4.2. Data collection instrument

The Qualtrics survey used in this experiment consisted of five parts,

namely the (A) informed consent, (B) experimental manipulation, (C) questions about the dependent variables, (D) questions about the independent variables, and (E) demographics questions. The experimental manipulation was adapted from Buldeo Rai et al. (2019) and consisted of showing participants a mock shopping basket containing a pair of shoes. Shoes are an item that is frequently purchased online, of an average value, with limited associated risks (Buldeo Rai et al., 2021), and a relative limited weight, as weight of the parcel has been shown to affect consumers' choice of delivery alternative (Cauwelier et al., 2024).

Participants were given the choice between next-day delivery at home or next-day delivery to a parcel locker and picking up their package from there. Depending on the scenario to which they were randomly assigned, participants received additional information about sustainability, and/or information about parcel lockers, and/or information about the distance of the parcel locker from their home address. Table 1 shows the 12 experimental scenarios.

Behavior intention to use parcel lockers was collected using a binary

Table 1
Overview of Experimental Conditions.

Sce.	Information about sustainability	Information about parcel lockers	Information about distance	Choice to use a parcel locker (%)	Choice to use a parcel locker (%)
				NLD	LITH
1	No	No	No	21 %	94 %
2	No	No	Yes (400 m)	38 %	86 %
3	No	No	Yes (800 m)	46 %	93 %
4	No	Yes	No	34 %	93 %
5	No	Yes	Yes (400 m)	47 %	76 %
6	No	Yes	Yes (800 m)	42 %	89 %
7	Yes	No	No	53 %	88 %
8	Yes	No	Yes (400 m)	63 %	85 %
9	Yes	No	Yes (800 m)	61 %	90 %
10	Yes	Yes	No	43 %	88 %
11	Yes	Yes	Yes (400 m)	65 %	95 %
12	Yes	Yes	Yes (800 m)	66 %	89 %

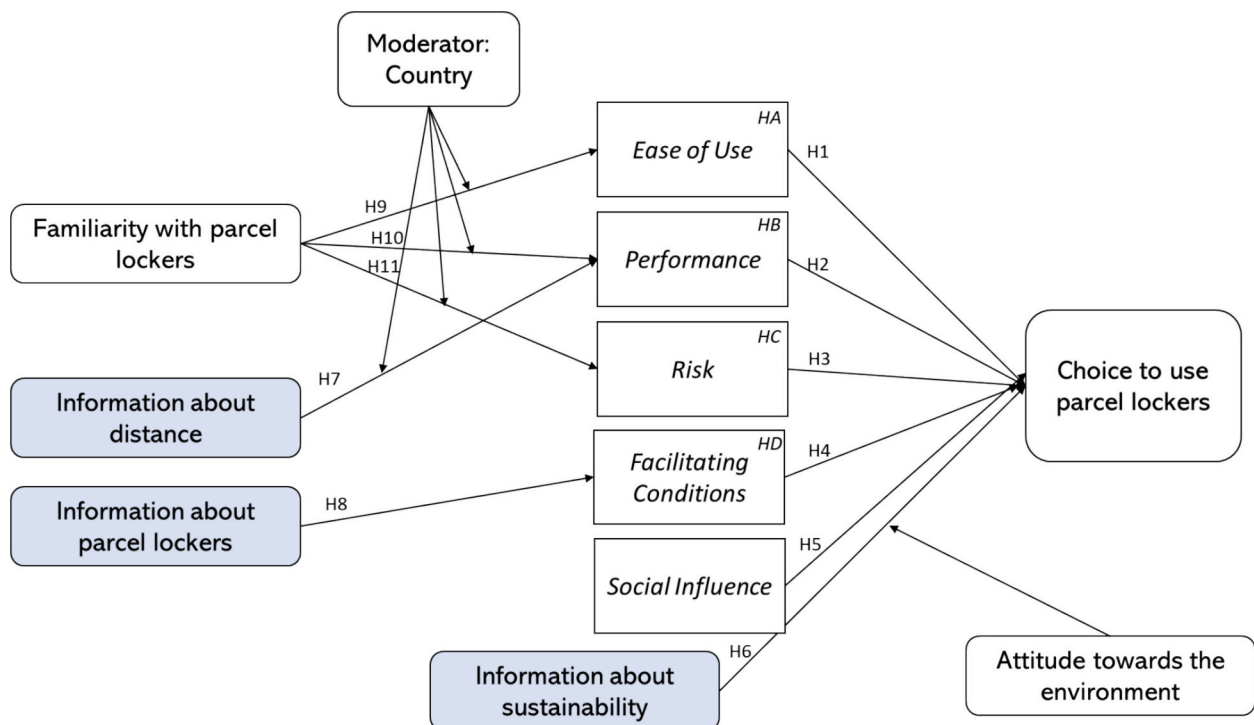


Fig. 1. Conceptual Framework and Study Hypotheses.

variable. While previous studies have used continuous scales to measure intention to use the focal technology, the use of a binary choice variable removes the ambiguity of which value on the scale corresponds to the choice to use the focal technology (Kokkinou & Cranage, 2011).

The third section of the survey was used to collect data on independent variables. Previously developed scales were used to measure the UTAUT constructs ease of use, expected performance, social influence, facilitating conditions and perceived risk of using parcel lockers (Zhou et al., 2020), attitude towards the environment (Chen, 2020) and familiarity with parcel lockers (Kokkinou et al., 2024). Demographic questions were included at the end of the survey.

4.3. Sampling

To ensure that the samples across countries were relatively demographically homogeneous, and to limit the influence of exogenous variables, the choice was made to focus on university students. Participants were thus recruited from two universities, one located in the Netherlands, and one located in Lithuania. We thereby compare a WEIRD country, the Netherlands, to a non-WEIRD country, Lithuania (Balundė et al., 2019; Carter et al., 2024). Students are included in the age group (18–45) with the highest frequency for online shopping (Buldeo Rai et al., 2021). Student samples (Agatz et al., 2021) and samples of young adults have been used previously in similar research (Chen et al., 2020; Iannaccone et al., 2021).

For the Dutch sample, 519 surveys were included in the analysis. Participants' average age was 21.805 (sd = 2.635) with 66 % being female. This overrepresentation of female students is consistent with the university's student population. On average, participants reported having ordered online 1.93 (sd = 1.689) times in the past month, not including food and groceries. Similarly, for the Lithuanian sample, 360 surveys were included in the analysis. The average participant age was 20.72 (sd = 3.01) and 71.8 % of participants identified as female, consistent with the university's population. The average online purchase frequency was 2.562 times in the past month (sd = 1.809). A comparison of the Dutch and Lithuanian sample characteristics to Cauwelier et al.'s (2024, p. 4) sample shows similar patterns of over-representation of females (55.5 %). Both study samples fit with Cauwelier et al.'s (2024, p. 4) typology of young (18–24 years old) frequent online shoppers.

4.4. Causal mediation analysis procedures

Prior to testing hypotheses, we reviewed the reliability and discriminant validity of our measurement model. We subsequently tested our hypotheses in three steps (Kim et al., 2023). First, we employed logistic regression to examine the impact of the experimental variables and of UTAUT variables on participants' choice to pick up from a parcel locker. Second, we employed linear regressions to test for the effect of the interventions on the hypothesized mediators. Third, we tested for causal mediation following the procedures of Imai et al. (2010) using the R package *Mediation* for causal mediation (Tingley et al., 2014). Causal mediation analysis is particularly appropriate for testing mediation effects that lie in causal pathways between treatments and outcomes (Imai, Keele, & Tingley, 2010).

5. Results

5.1. Reliability, convergent and discriminant validity

Reliability, convergent and discriminant validity were assessed first. For each construct, internal consistency was confirmed as all Cronbach Alphas exceeded 0.7. Exploratory Factor Analysis (EFA) was used to assess convergent and discriminant validity. The standardized factor loadings were examined to ensure that each measurement item variable loaded on its corresponding factor and that the factor loading exceeded 0.5. For all constructs, the Average Variance Extracted (AVE) exceeded

the recommended threshold of 0.5 and composite Reliability (CR) exceeded the recommended value of 0.7 (see Table 2). The requirements for convergent validity were thus deemed to be met. Discriminant validity was assessed by checking that the square root of AVE of each construct exceeded its correlation with the other constructs. As Table 3 shows, this was the case, leading to the conclusion that the requirements for discriminant validity were met. Summated scales were computed for each construct and each respondent.

5.2. Assumptions of logistic regression

Logistic regression analysis has previously been used in studies investigating behavioral intention in the context of parcel lockers (Zhou et al., 2020) and other self-service technologies (Iannaccone et al., 2021; Kokkinou & Cranage, 2015; Wang et al., 2024; Zhong et al., 2022). It is appropriate for this study as the outcome is a dichotomous variable. Three more assumptions of linear regression were tested, namely that there were no extreme values or outliers in the continuous predictors, that there was no multicollinearity between the predictor variables, and that there was a linear relationship between the logit of the outcome and each predictor variable (Stoltzfus, 2011; Zhong et al., 2022). The influence of outliers was explored by visualizing the Cook's distance values. Multicollinearity was tested through the Variance Inflation Factor (VIF). For all predictor variables, VIF did not exceed the recommended value of 5, with the highest VIF being 1.89 for the Facilitating Conditions scale. The Box-Tidwell test was used to test for the assumption of linearity between the independent variables and the logit of the outcome variable. The test showed a possible violation of the linearity assumption between Ease of Use and Choice. However, the Box-Tidwell test is sensitive to large sample sizes. Subsequent visual inspection of the relationship showed a straight line, with no curve or wave, leading us to conclude that the significant Box-Tidwell test was an artefact of the large sample size (>600).

5.3. Logistic regression – impact of interventions affecting choice to pick up from parcel lockers

Logistic regression was used to examine the choice to pick up from a parcel locker. The proportion of participants selecting to pick up their package from a parcel locker for each scenario by country is shown in Table 1. To assess model fit, a chi-square statistic comparing the hypothesized model to a baseline model was used. The UTAUT and information disclosure variables, and hypothesized interaction terms were subsequently introduced iteratively. Introducing the treatment variables, co-variables and their hypothesized interactions significantly reduced the $-2\log\text{likelihood}$ ($-2LL$) from 897.15 to 669.65 ($\chi^2 = 227.498p < 0.001$). To assess the practical relevance of the model, pseudo- R^2 measures reflecting the amount of variation explained by the

Table 2
Convergent validity, reliability, and descriptive statistics.

Scale	Cronbach Alpha	Average Variance Extracted (AVE)	Composite Reliability (CR)	Mean	St. Dev.
Expected Ease of Use	0.829	0.663	0.835	4.316	0.832
Expected Performance	0.842	0.760	0.844	3.670	0.950
Social Influence	0.936	0.886	0.936	2.854	1.083
Facilitating Conditions	0.766	0.589	0.769	3.915	0.769
Perceived Risk	0.704	0.532	0.713	2.712	1.134
Attitude towards environment	0.919	0.805	0.919	3.874	0.855

Table 3

Discriminant validity.

Scale	EoU	Perf	SI	FC	Risk	Att.
Expected Ease of Use (EoU)	0.815 ^a					
Expected Performance (Perf)	0.581	0.872 ^a				
Social Influence (SI)	0.392	0.616	0.941 ^a			
Facilitating Conditions (FC)	0.631	0.620	0.536	0.767 ^a		
Perceived Risk (Risk)	−0.323	−0.255	−0.255	−0.346	0.730 ^a	
Attitude towards the environment	0.145	0.258	0.258	0.240	−0.049	0.897 ^a

^a Square root of AVE.

model were used (Hosmer-Lemeshow pseudo $R^2 = 0.254$; Cox and Snell pseudo $R^2 = 0.282$; Nagelkerke pseudo $R^2 = 0.386$).

To avoid overfitting the model, non-significant interactions were trimmed. Furthermore, as the information about parcel lockers was not significant, this variable was also removed from the model, resulting in the model shown in Eq. (1). The results of the final trimmed model are shown in Table 4. This model performed as well, yet was simpler, reducing the $-2\log\text{likelihood}$ ($-2LL$) to 672.64 ($\chi^2 = 224.516$, $p < 0.001$) and maintaining similar pseudo- R^2 measure values (Hosmer-Lemeshow pseudo $R^2 = 0.250$; Cox and Snell pseudo $R^2 = 0.278$; Nagelkerke pseudo $R^2 = 0.382$).

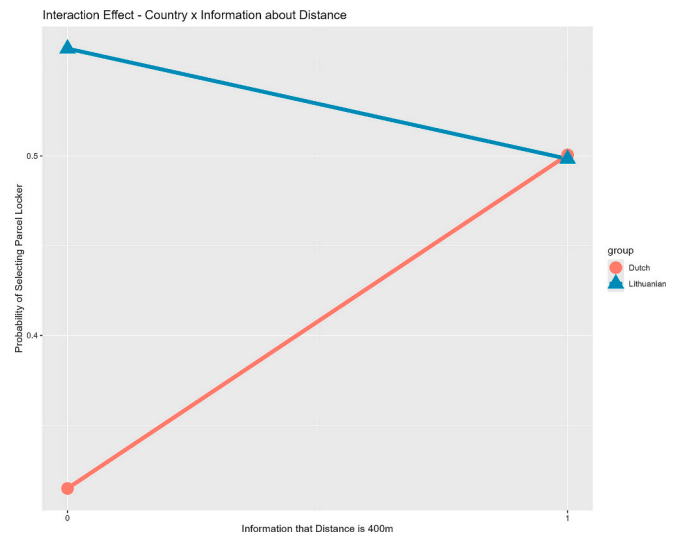
The logistic regression model results showed that when holding all other predictor variables constant, the odds of participants choosing to use the parcel locker increased by 155 % (95 % CI [1.747; 3.756]) when they received information about sustainability of parcel lockers. The odds that participants chose the parcel locker were 118.28 % higher (95 % CI [1.323; 3.618]) if they were informed that the nearest parcel locker was 400 m, and 100.17 % higher (95 % CI [1.265; 3.197]) if they were informed that the distance given was 800 m, compared to no distance given. The odds of participants choosing to use parcel lockers increased by 74.91 % for each additional unit on the familiarity with parcel lockers scale (95 % CI [1.382; 2.234]) and by 75.82 % for each additional unit on the attitude towards the environment scale (95 % CI [1.430; 2.176]).

While there was no direct effect of the moderator country (-6.195 , $p = 0.142$), there was a marginally significant interaction effect between country and distance ($b = -1.028$, $p = 0.053$), and country and familiarity with parcel lockers ($b = 2.166$, $p < 0.05$). Informing participants that the nearest parcel locker was located 400 m away had opposite effects on Dutch and Lithuania participants (see Fig. 2). When Dutch participants were informed that the nearest parcel locker was located less than 400 m away, their intention to select the parcel locker increased. Conversely, the same information decreased Lithuanian participants' likelihood to select the parcel locker. There was no such interaction effect when the distance given was 800 m.

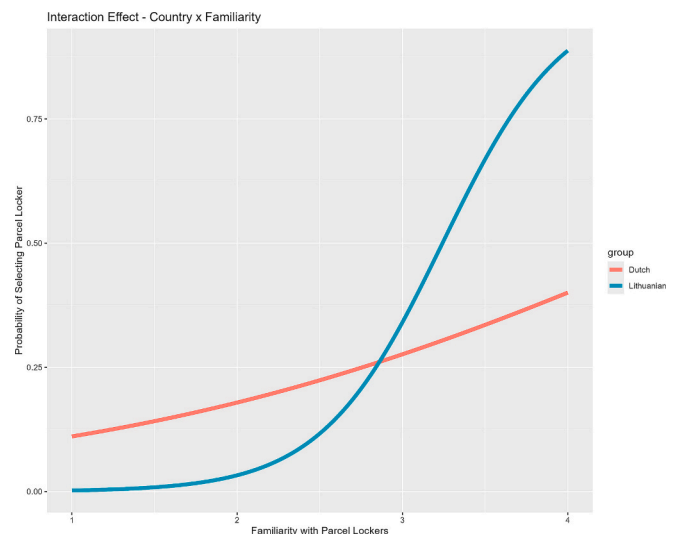
Table 4

Logistic Regression Results for Scenario Based Model – Choice.

	B(SE)	p	95 % CI		
			Lower	Odds Ratio	Upper
Constant	−4.826	$p < 0.001$	0.002	0.008	0.026
Country (x_1)	−6.195	$p = 0.142$	0.000	0.002	13.829
Information about sustainability (x_2)	0.936	$p < 0.001$	1.747	2.550	3.756
Information about distance – 400 m (x_3)	0.781	$p < 0.01$	1.329	2.183	3.618
Information about distance – 800 m (x_4)	0.694	$p < 0.01$	1.265	2.002	3.197
Familiarity with parcel lockers (x_5)	0.559	$p < 0.001$	1.382	1.749	2.234
Attitude towards the environment (x_6)	0.564	$p < 0.001$	1.430	1.758	2.176
Country x distance – 400	−1.028	$p = 0.053$	0.127	0.358	1.034
Country x familiarity	2.166	$p < 0.05$	0.928	8.724	82.746

**Fig. 2.** Interaction Between Country and Information that Parcel Locker is Located 400 m.

Familiarity with parcel lockers also affected Dutch and Lithuanian participants' intention to select parcel lockers differently (see Fig. 3). When unfamiliar with parcel lockers, Lithuanian participants exhibited much lower intention to select parcel lockers than Dutch participants. However, at higher levels of familiarity with parcel lockers, Lithuanian participants were more likely than Dutch participants to select the parcel locker. This increase of likelihood to select the parcel locker as a

**Fig. 3.** Interaction Between Country and Familiarity with Parcel Lockers.

function of familiarity with parcel lockers was much steeper for Lithuanian participants than Dutch participants.

To model the probability that a customer would select the parcel locker, Eq. (1) can be applied:

$$p(W) = 1 / (1 + e^{-(4.826 - 6.195x_1 + 0.936x_2 + 0.781x_3 + 0.694x_4 + 0.559x_5 + 0.564x_6 - 1.028x_1x_3 - 2.166x_1x_5)}) \quad (1)$$

where

- $p(W)$ is the probability that the customer will select to have their parcel delivered at a parcel locker,
- x_1 is a dummy variable representing the country (0=Netherlands, 1 = Lithuania)
- x_2 is a dummy variable representing whether the customer received information about sustainability (0 = no information, 1 = information)
- x_3 is a dummy variable representing whether the consumer was informed that the nearest parcel locker was 400 m away
- x_4 is a dummy variable representing whether the consumer was informed that the nearest parcel locker was 400 m away
- x_5 is a scale variable representing more familiarity with parcel lockers
- x_6 is a scale variable representing a more positive attitude towards the environment

5.4. Logistic regression – effect of UTAUT constructs

We repeated the logistic regression analysis with the UTAUT constructs and attitude towards the environment, thereby testing hypotheses H1–H6. To avoid overfitting, we trimmed the non-significant interaction between information about sustainability and attitude towards the environment, thereby also rejecting H6'. The results of the final trimmed model are shown in Table 5. The introduction of these variables significantly reduced the $-2\log\text{likelihood}$ ($-2LL$) from 899.21 to 738.81 ($\chi^2 = 243.51, p < 0.001$) compared to the baseline model. The Hosmer-Lemeshow R^2 measure for this model was 0.271, Cox and Snell R^2 was 0.298 and Nagelkerke R^2 was 0.408. The results showed that ease of use, expected performance, social influence and attitude towards the environment all have a positive impact on the choice to use a parcel locker, supporting hypotheses H1, H2, H5 and H6. Perceived risk and facilitating conditions did not have a significant effect, leading to the rejection of hypotheses H3 and H4.

To model the probability that a customer would select the parcel locker, accounting for variation in responses to UTAUT dimensions, Eq. (2) can be applied.

$$p(W) = 1 / (1 + e^{-(5.807 + 0.598x_1 + 0.800x_2 - 0.026x_3 - 0.156x_4 + 0.494x_5 + 0.901x_6)}) \quad (2)$$

Table 5
Logistic Regression Results for UTAUT Model – Choice.

	B(SE)		95 % CI		Hypothesis
		Lower	Odds Ratio	Upper	
Constant	−5.807	0.000	0.003	0.014	
Expected Ease of Use (x_1)	0.598***	1.349	1.818	2.467	H1 Supp.
Expected Performance (x_2)	0.800***	1.710	2.226	2.927	H2 Supp.
Perceived Risk (x_3)	−0.026 ns	0.821	0.975	1.159	H3 Not Supp.
Facilitating Conditions (x_4)	−0.156 ns	0.608	0.855	1.195	H4 Not Supp.
Social Influence (x_5)	0.494***	1.319	1.640	2.046	H5 Supp.
Sustainability Information (x_6)	0.901***	1.690	2.482	3.678	H6 Supp.

*** Significant at $p < 0.001$; ** Significant at $p < 0.01$; * Significant at $p < 0.05$.

where

- $p(W)$ is the probability that the customer will select to have their parcel delivered at a parcel locker,

- x_1 is a scale variable representing Expected Ease of Use
- x_2 is a scale variable representing Expected Performance
- x_3 is a scale variable representing Perceived Risk
- x_4 a scale variable representing Facilitating Conditions
- x_5 a scale variable representing Social Influence
- x_6 is a dummy variable representing whether participants received information about sustainability

5.5. Causal mediation analysis

Unlike approaches such as Structural Equation Modeling (SEM), it was not possible to test multiple mediators simultaneously using causal mediation analysis procedures (Keele, 2015). Instead, we examined each mediator and the corresponding mediation hypothesis (HA–HD) separately. For each of the four mediation hypotheses, we examined the impact of the treatment variable and co-variables on the outcome variable (choice to use a parcel locker) using logistic regression (Model 1). We subsequently tested the impact of the treatment variable and co-variables on the mediator variable using linear regression (Model 2). We then tested the impact of the treatment variable, co-variables and mediator on the outcome variable using logistic regression (Model 3). This is summarized in Fig. 4. We then applied Imai et al. (2010) general estimation algorithm to test whether the independent variable affected the outcome (Choice), through a mediator variable M. For this, we estimated bootstrap confidence intervals derived from 1,000 samples. The full results for each mediation hypothesis are shown in Online Appendix A.

This approach was used to examine the mediation hypotheses HA, HB, HC, and HD. The full results shown in the online Appendix demonstrate that ease of use fully mediated the effect of familiarity with parcel lockers on the choice to use a parcel locker, providing support for HA. Expected performance did not mediate the relationship between providing information about distance to the nearest parcel locker and choice to use a parcel locker, leading to the rejection of HB. We found that perceived risk partially mediated the effect of familiarity with parcel lockers on the choice to use a parcel locker, and thus support for HC. Furthermore, the signs of the estimates show that familiarity decreased perceived risk, while perceived risk decreased the likelihood that participants will choose the parcel locker. Finally, no mediation effect of facilitating conditions on the relationship between providing information about parcel lockers and choice to use the parcel locker was found, leading to the rejection of HD.

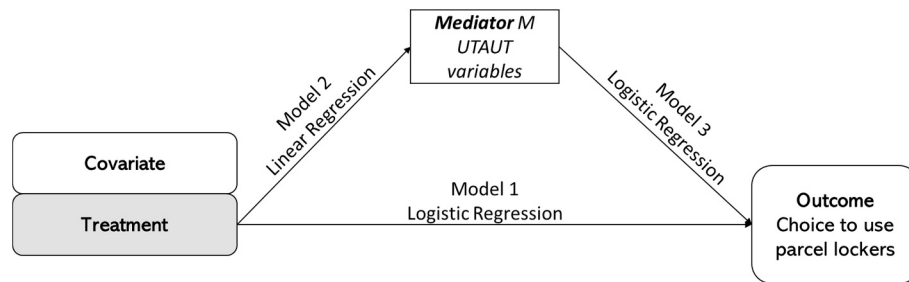


Fig. 4. Causal Mediation Analysis.

6. Discussion

The purpose of the study was to examine how consumers can be stimulated to choose for delivery of their parcels to a parcel locker and pick up their parcels themselves from there, focusing on interventions that retailers and LSPs can easily implement. Stimulating the use of parcel lockers enables LSPs to achieve the benefit of parcel consolidation, and the corresponding positive effects on the triple bottom line such as less congestion in cities, less stress on delivery drivers, fewer emissions, and improved profitability. The apprehensiveness of retailers to charge consumers for delivery (Allen et al., 2018; Buldeo Rai et al., 2019; Sallnäs & Björklund, 2020) strengthens the relevance of the study, which showed that consumers could be stimulated by non-financial interventions to select delivery to a parcel locker.

The study findings showed that several interventions could motivate consumers to choose to have their parcel delivered to a parcel locker. Consistent with previous research, our findings show that providing information about sustainability is an effective way to stimulate more sustainable consumer logistics behavior (Agatz et al., 2021; Buldeo Rai et al., 2019; Kokkinou et al., 2024; Viet et al., 2023). In our study, participants who were informed that parcel lockers were the more sustainable delivery alternative were more likely to select them. This could be explained by the fact that in the context of last mile delivery, consumers are still relatively unaware of the sustainability implications of their delivery choices (Buldeo Rai et al., 2019). Increasing consumer knowledge about sustainability is therefore an effective way to promote more sustainable behavior.

A second effective intervention was providing information about the distance to the nearest parcel locker. Our findings showed that providing information about distance to the nearest parcel lockers positively influenced consumers' choice to have a parcel delivered to the parcel locker and pick it up themselves. Nevertheless, our study findings showed that what is considered an acceptable distance to the nearest parcel locker is country-specific. While the information that the nearest parcel locker was located 400 m away increased the likelihood that Dutch participants would choose to pick up their parcel from a parcel locker, it decreased the likelihood that Lithuanian participants would choose to pick up their parcel from a parcel locker. This is consistent with the different parcel locker densities prevailing in each country (Breinbauer et al., 2021), namely that 400 m is considered nearby for Dutch parcel lockers, yet far away for Lithuanian parcel lockers, where parcel locker density is far greater. This finding supports Peppel and Spinler's (2022) recommendation to increase parcel locker density as a way to stimulate their use. It also addresses the call of Venkatesh et al., (2012) to test UTAUT across cultural settings by showing that the formation of expectations vis-à-vis technology can be context specific, including cultural context.

Various technology acceptance models stipulate that individuals' intention to use self-service technology is dependent on the effort required to use them, their perceived convenience, and thus expected performance (Tsai & Tiwasing, 2021; Wang et al., 2019; Yuen et al., 2018; Zhou et al., 2020). Providing information about the distance was a way to operationalize this perceived convenience and was expected to

lead to a higher expected performance and thus increased choice to use parcel lockers. However, our findings showed that while providing information about distance to the nearest parcel locker is positively associated with choosing the parcel locker for parcel delivery, this does not happen through the mediating effect of expected performance. This novel finding shows the added value of causal mediation analysis as a way to explain how treatments affect outcomes (Imai, Keele, & Tingley, 2010).

Familiarity with parcel lockers was another factor that increased the likelihood that consumers would choose to use parcel lockers, consistent with previous research (Kokkinou et al., 2024). However, there was again a difference between Dutch and Lithuanian participants in how this variable affected their likelihood to pick up from a parcel locker. The findings showed that Lithuanian participants were less likely to select parcel lockers as a delivery alternative when they were unfamiliar with them. Conversely, they were more likely to select the parcel locker option when they were familiar with them. The causal mediation analysis showed that familiarity acted on the choice of using a parcel locker through ease of use, expected effort and perceived risk. This is consistent with the finding that, in the context of last mile logistics, habit formation occurs (Cai et al., 2021) and that consumers are driven by past experience (Agatz et al., 2021). Constructs such as ease of use play an important role in the early development of new habits, when consumers encounter actual or perceived hurdles (Venkatesh et al., 2003). As consumers gain experience in using these novel technologies, they develop new habits, increasing the expected performance of using the technology. The causal mediation analysis also showed that as familiarity with parcel lockers increases, perceived risk decreases, also leading to increased likelihood of choosing the parcel lockers (Zhou et al., 2020).

7. Implications for practitioners

Our findings show that it is possible to stimulate consumers to select more sustainable last mile logistics delivery alternatives. LSPs can therefore work with retailers to ensure that consumers are given more options during the check-out process, thereby also giving them more control over last mile logistics. Simple interventions, including informing consumers about the sustainability implications of the various delivery options, are effective at nudging them towards more sustainable delivery alternatives and enabling them to make more conscious decisions. Not providing this information contributes to the information asymmetry between LSPs and consumers (Sallnäs & Björklund, 2020; Viet et al., 2023), thereby leading to less informed decision-making. Furthermore, providing consumers with information about the distance to the nearest parcel locker enables them to make better-informed decisions in the pre-purchase stage, thereby also giving them more control over post-purchase logistics. For online retailers and LSPs operating internationally, attention needs to be given to the local geographical context, as consumers will differ in terms of their familiarity with parcel lockers and other delivery options. These differences will also be related to each country's geographical characteristics and the last mile delivery infrastructure available (Wang et al., 2019).

8. Limitations and future research

Our study is an example of practically relevant research, characterized by its problem-driven approach, leading to novel insights that can easily be implemented by online retailers in a cost-effective way (Svanberg, 2020). Due to the hypercompetitive nature of the online retailing industry, our study focused on non-financial interventions. Nevertheless, financial incentives have been found to be even more effective at stimulating sustainable consumer logistics behavior (Barker & Brau, 2020). Future research should therefore examine how financial incentives can be combined with other interventions to maximize their impact while maintaining consumer satisfaction.

A limitation of our study design and analysis is that there are currently no generally accepted approaches to test multiple mediating effects concurrently. Approaches such as SEM, Partial Least Square – Structural Equation Modeling (PLS-SEM), and moderated mediation analysis using PROCESS (Hayes, 2018) cannot accommodate binary outcome variables and/or multiple mediating effects (Keele, 2015). We therefore chose to first use logistic regression to simultaneously test the effect of the treatments, and in a second logistic regression model test the UTAUT constructs. We subsequently tested the mediation hypotheses using subcomponents of our conceptual model. Some hypotheses that were not significant in the more complex model became significant when tested in isolation. This demonstrates that statistical modeling is not always well suited to the real-life complexity that is required when conducting practically relevant research (Svanberg, 2020).

9. Conclusion

In conclusion, the study supports the potential for non-financial interventions to motivate consumers to choose to have their parcels delivered to a parcel locker, thereby contributing to the sustainability of last mile logistics. By providing information about the sustainability benefits and the distance to the nearest parcel lockers, retailers and LSPs can effectively motivate consumers towards more sustainable delivery options. The findings support the importance of increasing consumer awareness about the environmental impact of their delivery choices, as well as the convenience of nearby parcel lockers.

The findings also highlight that the effectiveness of these interventions varies based on geographical contexts and consumer characteristics. For instance, the acceptable distance to a parcel locker differs between countries like the Netherlands and Lithuania, reflecting the varying densities of parcel lockers in these regions. This suggests that interventions should be tailored to local contexts. Furthermore, consumers' familiarity with parcel lockers plays a crucial role in their decision-making. This highlights the need for efforts to increase consumers' familiarity and reduce perceived risks associated with their use.

Overall, the study provides valuable insights for retailers and LSPs eager to promote sustainable last-mile logistics. By implementing simple yet effective interventions, retailers and LSPs can enhance consumer control over delivery choices, reduce environmental impact, and improve their operational efficiency. These findings thus contribute to the broader goal of achieving sustainable urban logistics and highlight the importance of context-specific strategies in consumer behavior interventions.

CRedit authorship contribution statement

Alinda Kokkinou: Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Aistė Lastauskaitė:** Writing – review & editing, Data curation, Conceptualization. **Hans Quak:** Writing – review & editing, Methodology, Data curation, Conceptualization. **Andreas Karaoulanis:** Writing – review & editing. **Ondrej Mitás:** Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization. **Albert Mandemakers:** Writing – review & editing, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.clscn.2025.100250>.

Data availability

Data will be made available on request.

References

- ACM. (2020). *Marktstudie last mile pakketbezorging* (No. Zaaknummer ACM/18/034097). <https://www.acm.nl/sites/default/files/documents/2020-05/marktstudie-last-mile-pakketbezorging.pdf>.
- ACM. (2024). *Post- En Pakkettenmonitor 2023*. <https://public.tableau.com/views/Post-enpakketmonitor>.
- Agatz, N., Fan, Y., Stam, D., 2021. The impact of green labels on time slot choice and operational Sustainability. *Prod. Oper. Manag.* 30 (7), 2285–2303. <https://doi.org/10.1111/poms.13368>.
- Alejandra Maldonado Bonilla, M., Bouzon, M., Cecilia Peña-Montoya, C., 2024. Taxonomy of key practices for a sustainable last-mile logistics network in E-retail: a comprehensive literature review. *Cleaner Logist. Supply Chain* 11, 100149. <https://doi.org/10.1016/j.clscn.2024.100149>.
- Allen, J., Piecyk, M., Piotrowska, M., McLeod, F., Cherrett, T., Ghali, K., Nguyen, T., Bektaş, T., Bates, O., Friday, A., Wise, S., Austwick, M., 2018. Understanding the impact of e-commerce on last-mile light goods vehicle activity in urban areas: the case of London. *Transp. Res. Part D: Transp. Environ.* 61, 325–338. <https://doi.org/10.1016/j.trd.2017.07.020>.
- Scientific American. (2020, January 11). *Delivery Vehicles Increasingly Choke Cities with Pollution*. <https://www.scientificamerican.com/article/delivery-vehicles-increasingly-choke-cities-with-pollution/>.
- An, H.S., Park, A., Song, J.M., Chung, C., 2022. Consumers' adoption of parcel locker service: protection and technology perspectives. *Cogent Business Manage.* 9 (1), 2144096. <https://doi.org/10.1080/23311975.2022.2144096>.
- Balundė, A., Perlaviciute, G., Steg, L., 2019. The relationship between people's environmental considerations and pro-environmental behavior in Lithuania. *Front. Psychol.* 10, 2319. <https://doi.org/10.3389/fpsyg.2019.02319>.
- Barker, J.M., Brau, R.I., 2020. Shipping surcharges and LSQ: pricing the last mile. *Int. J. Phys. Distrib. Logist. Manag.* 50 (6), 667–691. <https://doi.org/10.1108/IJPDLM-09-2019-0292>.
- Brinbauer, A., Strauss, D., Hadzic, B., 2021. State of the art: paket- und umschlagsboxen – verbreitung, erfolgskriterien und best practice beispiele. *Wirtschaft Und Management* 7–44.
- Buldeo Rai, H., Broekaert, C., Verlinde, S., Macharis, C., 2021. Sharing is caring: how non-financial incentives drive sustainable e-commerce delivery. *Transp. Res. Part D: Transp. Environ.* 93, 102794. <https://doi.org/10.1016/j.trd.2021.102794>.
- Buldeo Rai, H., Verlinde, S., Macharis, C., 2019. The “next day, free delivery” myth unravelled: possibilities for sustainable last mile transport in an omnichannel environment. *Int. J. Retail Distrib. Manag.* 47 (1), 39–54. <https://doi.org/10.1108/IJRDLM-06-2018-0104>.
- Cai, L., Yuen, K.F., Xie, D., Fang, M., Wang, X., 2021. Consumer's usage of logistics technologies: integration of habit into the unified theory of acceptance and use of technology. *Technol. Soc.* 67, 101789. <https://doi.org/10.1016/j.techsoc.2021.101789>.
- Carter, C.R., Rockwood, R.F., Patel, P.C., Bachrach, D., Bendoly, E., DuHadway, S., Kaufmann, L., 2024. Experiments in supply chain management research: a systematic review and future directions. *J. Bus. Logist.* 45 (3), e12382. <https://doi.org/10.1111/jbl.12382>.
- Cauwelier, K., Buldeo Rai, H., Puttemans, K., Macharis, C., Mommens, K., 2024. From cart to door: unravelling consumer behaviour through attitudinal sustainability profiles. *Transp. Res. Part D: Transp. Environ.* 130, 104168. <https://doi.org/10.1016/j.trd.2024.104168>.
- Chen, M., 2020. The impacts of perceived moral obligation and sustainability self-identity on sustainability development: a theory of planned behavior purchase intention model of sustainability-labeled coffee and the moderating effect of climate change skepticism. *Bus. Strateg. Environ.* 29 (6), 2404–2417. <https://doi.org/10.1002/bse.2510>.
- Chen, C.-F., White, C., Hsieh, Y.-E., 2020. The role of consumer participation readiness in automated parcel station usage intentions. *J. Retail. Consum. Serv.* 54, 102063. <https://doi.org/10.1016/j.jretconser.2020.102063>.

- CNN. (2019, July 15). *America's addiction to absurdly fast shipping has a hidden cost*. <https://edition.cnn.com/2019/07/15/business/fast-shipping-environmental-impact/index.html>.
- Encarnación, T., Amaya, J., 2025. Determinants of parcel locker adoption for last-mile deliveries in urban and suburban areas. *Transp. J.* 64 (1), e12031. <https://doi.org/10.1002/tjo.3.12031>.
- González-Romero, I., Ortiz-Bas, Á., Prado-Prado, J.C., 2025. Decarbonizing the last mile. innovations from an online retailers' perspective. *Transp. Res. Part D: Transp. Environ.* 143, 104752. <https://doi.org/10.1016/j.trd.2025.104752>.
- Hayes, A.F., 2018. *Introduction to mediation, moderation, and conditional process analysis: a regression-based approach* (second edition). Guilford Press.
- Heikkinen, H., 2024. Exploring how retail and logistics service provider managers make sense of sustainability in last mile delivery. *Int. J. Phys. Distrib. Logist. Manag.* 54 (2), 139–162. <https://doi.org/10.1108/IJPDLM-02-2023-0073>.
- Iannaccone, G., Marcucci, E., Gatta, V., 2021. What young E-Consumers want? forecasting Parcel lockers choice in Rome. *Logistics* 5 (3), 57. <https://doi.org/10.3390/logistics5030057>.
- Imai, K., Keele, L., Tingley, D., 2010a. A general approach to causal mediation analysis. *Psychol. Methods* 15 (4), 309–334. <https://doi.org/10.1037/a0020761>.
- Imai, K., Keele, L., Yamamoto, T., 2010b. Identification, inference and sensitivity analysis for causal mediation effects. *Stat. Sci.* 25 (1). <https://doi.org/10.1214/10-STS321>.
- Iwan, S., Kijewska, K., Lemke, J., 2016. Analysis of Parcel lockers' efficiency as the last mile delivery solution – the results of the Research in Poland. *Transp. Res. Procedia* 12, 644–655. <https://doi.org/10.1016/j.trpro.2016.02.018>.
- Keele, L., 2015. Causal mediation analysis: Warning! Assumptions Ahead. *Am. J. Evaluat.* 36 (4), 500–513. <https://doi.org/10.1177/1098214015594689>.
- Kim, Y., Myeong, S., Ahn, M.J., 2023. Living labs for AI-enabled public Services: functional determinants, user Satisfaction, and continued use. *Sustainability* 15 (11), 8672. <https://doi.org/10.3390/su15118672>.
- Kin, B., Quak, H., 2025. The impacts of alternative last mile delivery networks: exploring the options besides zero emission technology. *Res. Transp. Bus. Manag.* 59, 101303. <https://doi.org/10.1016/j.rtbm.2025.101303>.
- Kokkinou, A., Cranage, D.A., 2011. Modeling human behavior in customer-based processes: the use of scenario-based surveys. In: *Proceedings of the 2011 Winter Simulation Conference (WSC)*, pp. 683–689. <https://doi.org/10.1109/WSC.2011.6147796>.
- Kokkinou, A., Cranage, D.A., 2015. Why wait? impact of waiting lines on self-service technology use. *Int. J. Contemp. Hosp. Manag.* 27 (6), 1181–1197. <https://doi.org/10.1108/IJCHM-12-2013-0578>.
- Kokkinou, A., Quak, H., Mitás, O., Mandemakers, A., 2024. Should I wait or should I go? encouraging customers to make the more sustainable delivery choice. *Res. Transp. Econ.* 103, 101388. <https://doi.org/10.1016/j.retrec.2023.101388>.
- Mangiaracina, R., Perego, A., Seghezzi, A., Tumino, A., 2019. Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review. *Int. J. Phys. Distrib. Logist. Manag.* 49 (9), 901–920. <https://doi.org/10.1108/IJPDLM-02-2019-0048>.
- Niemeijer, R., Buijs, P., 2023. A greener last mile: reviewing the Carbon emission impact of pickup points in last-mile Parcel delivery. *Renew. Sustain. Energy Rev.* 186, 113630.
- Peppel, M., Spinler, S., 2022. The impact of optimal parcel locker locations on costs and the environment. *Int. J. Phys. Distrib. Logist. Manag.* 52 (4), 324–350. <https://doi.org/10.1108/IJPDLM-07-2021-0287>.
- Pieters, J.J., Kokkinou, A., van Kollenburg, T., 2022. Understanding blockchain technology adoption by non-experts: an application of the unified theory of acceptance and use of technology (UTAUT). *Oper. Res. Forum* 3 (1), 1. <https://doi.org/10.1007/s43069-021-00113-9>.
- Rose, W.J., Confente, I., Peinkofer, S.T., Russo, I., 2025. Unlocking the door: information disclosure framing and consumer characteristics in parcel locker adoption. *Int. J. Phys. Distrib. Logist. Manag.* 55 (11), 92–117. <https://doi.org/10.1108/IJPDLM-01-2024-0005>.
- Sallnäs, U., Björklund, M., 2020. Consumers' influence on the greening of distribution – exploring the communication between logistics service providers, e-tailers and consumers. *Int. J. Retail Distrib. Manag.* 48 (11), 1177–1193. <https://doi.org/10.1108/IJRDM-07-2019-0213>.
- Schmidt, S., Saraceni, A., 2024. Consumer acceptance of drone-based technology for last mile delivery. *Res. Transp. Econ.* 103, 101404. <https://doi.org/10.1016/j.retrec.2023.101404>.
- Sternberg, H., Mathiasen, L., Carnovale, S., Richey, R.G., Davis-Sramek, B., 2024. Conducting engaged logistics and supply chain research: from real-world problems to journal publication. *J. Bus. Logist.* 45 (2), e12380. <https://doi.org/10.1111/jbl.12380>.
- Stoltzfus, J.C., 2011. Logistic regression: a brief Primer. *Acad. Emerg. Med.* 18 (10), 1099–1104. <https://doi.org/10.1111/j.1553-2712.2011.01185.x>.
- Svanberg, M., 2020. Guidelines for establishing practical relevance in logistics and supply chain management research. *Int. J. Phys. Distrib. Logist. Manag.* 50 (2), 215–232. <https://doi.org/10.1108/IJPDLM-11-2018-0373>.
- The New York Times. (2019, October 27). *1.5 Million Packages a Day: The Internet Brings Chaos to N.Y. Streets*. <https://www.nytimes.com/2019/10/27/nyregion/nyc-amazon-delivery.html>.
- Financial Times. (2020, October 8). *Parcel groups seek to deliver greener 'last mile' processes*. <https://www.ft.com/content/d9c92785-ab97-499a-97a0-5b41d233209a>.
- Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). *Mediation: R package for causal mediation analysis*.
- Tsai, Y.-T., Tiwasing, P., 2021. Customers' intention to adopt smart lockers in last-mile delivery service: a multi-theory perspective. *J. Retail. Consum. Serv.* 61, 102514. <https://doi.org/10.1016/j.jretconser.2021.102514>.
- Vakulenko, Y., Hellström, D., Hjort, K., 2018. What's in the parcel locker? exploring customer value in e-commerce last mile delivery. *J. Bus. Res.* 88, 421–427. <https://doi.org/10.1016/j.jbusres.2017.11.033>.
- Vakulenko, Y., Shams, P., Hellström, D., Hjort, K., 2019. Service innovation in e-commerce last mile delivery: mapping the e-customer journey. *J. Bus. Res.* 101, 461–468. <https://doi.org/10.1016/j.jbusres.2019.01.016>.
- Venkatesh, V., 2022. Adoption and use of AI tools: a research agenda grounded in UTAUT. *Ann. Oper. Res.* 308 (1–2), 641–652. <https://doi.org/10.1007/s10479-020-03918-9>.
- Venkatesh, M., Davis, & Davis., 2003. User acceptance of information technology: Toward a unified view. *MIS Q.* 27 (3), 425. <https://doi.org/10.2307/30036540>.
- Venkatesh, Thong, Xu, 2012. Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS Q.* 36 (1), 157. <https://doi.org/10.2307/41410412>.
- Verslo zinios. (2023, October 19). „Omniva LT“ i paštomatus investuoja 2,2 mln. Eur, įrenginių skaičių didina iki 505. <https://www.vz.lt/transportas-logistika/2023/10/19/omniva-lt-i-pastomatus-investuoja-2-2-mln-eur-irenginiu-skaičiu-didina-iki-505>.
- Viet, N.Q., De Leeuw, S., Van Herpen, E., 2023. The impact of social vs environmental sustainability information disclosure on consumer choice of delivery time with varying sustainability concerns. *Int. J. Phys. Distrib. Logist. Manag.* 53 (11), 26–52. <https://doi.org/10.1108/IJPDLM-09-2021-0392>.
- Wang, X., Wong, Y.D., Shi, W., Yuen, K.F., 2024. An investigation on consumers' preferences for parcel deliveries: applying consumer logistics in omni-channel shopping. *Int. J. Logist. Manage.* 35 (2), 557–576. <https://doi.org/10.1108/IJLM-07-2022-0288>.
- Wang, X., Yuen, K.F., Wong, Y.D., Teo, C.C., 2018. An innovation diffusion perspective of e-consumers' initial adoption of self-collection service via automated parcel station. *Int. J. Logist. Manage.* 29 (1), 237–260. <https://doi.org/10.1108/IJLM-12-2016-0302>.
- Wang, X., Yuen, K.F., Wong, Y.D., Teo, C.-C., 2019. Consumer participation in last-mile logistics service: an investigation on cognitions and affects. *Int. J. Phys. Distrib. Logist. Manag.* 49 (2), 217–238. <https://doi.org/10.1108/IJPDLM-12-2017-0372>.
- World Economic Forum. (2024). *Transforming Urban Logistics: Sustainable and Efficient Last-Mile Delivery in Cities*. https://reports.weforum.org/docs/WEF_Transforming_Urban_Logistics_2024.pdf.
- Yuen, K.F., Wang, X., Ng, L.T.W., Wong, Y.D., 2018. An investigation of customers' intention to use self-collection services for last-mile delivery. *Transp. Policy* 66, 1–8. <https://doi.org/10.1016/j.tranpol.2018.03.001>.
- Zhong, S., Lomas, C., Worth, T., 2022. Understanding customers' adoption of express delivery service for last-mile delivery in the UK. *Int. J. Log. Res. Appl.* 25 (12), 1491–1508. <https://doi.org/10.1080/13675567.2021.1914563>.
- Zhou, M., Zhao, L., Kong, N., Campy, K.S., Xu, G., Zhu, G., Cao, X., Wang, S., 2020. Understanding consumers' behavior to adopt self-service parcel services for last-mile delivery. *J. Retail. Consum. Serv.* 52, 101911. <https://doi.org/10.1016/j.jretconser.2019.101911>.