Int. J. Production Economics 291 (2026) 109855

Contents lists available at ScienceDirect

International Journal of Production Economics

journal homepage: www.elsevier.com/locate/ijpe

# Nudging the last mile: Combining behavioral insights and monetary incentives for sustainable delivery choices☆

Eleonora Rizzitello [a], Giovanna Lo Nigro [a,*], Simona Mancini [a,b], Margaretha Gansterer [b]

[a] University of Palermo, Department of Engineering, Palermo, Italy
[b] University of Klagenfurt, Department of Operations, Energy, and Environmental Management, Klagenfurt, Austria

ARTICLE INFO

*Keywords:*
Behavioral operations management
Experimental economics
Optimization
Grocery industry
Last mile delivery
Vehicle routing

ABSTRACT

Last-mile delivery, the final leg of the supply chain to consumers, significantly impacts the environment, particularly in the grocery sector, due to the perishable nature of food items often necessitating expedited delivery methods. The role of consumer behavior in this process has been overlooked, and their preferences in a trade-off between the benefits of grocery home delivery and the environment have yet to be clarified. This paper bridges this gap by integrating behavioral logistics with key drivers of green consumer behavior to optimize grocery delivery, leveraging primary consumer data to enhance efficiency and minimize environmental impact. Using a two-part methodology, the research combines a controlled experiment and an optimization model. By partnering with an Italian supermarket, this research examines the impact of financial incentives, green nudges, and peer collaboration on consumer grocery delivery choices and routing optimization. The findings reveal that moral green nudges outweigh financial incentives and amplify the effect, and peer influence drives the adoption of shared and more sustainable delivery systems. The optimization model quantifies these behavioral insights, demonstrating cost reductions of up to 42.5% through flexible delivery scheduling and 76.8% via a shared cart mechanism. The findings provide valuable insights for practitioners and policymakers willing to intervene in the crossing of consumer choices and grocery delivery efficiency by presenting an innovative and ready-to-implement solution, which we denote as "the shared cart". In showing the importance of social pressure for collaborative pro-environmental behavior, the shared cart practically embodies the potential for safeguarding the environment, while enabling cost-saving for last-mile delivery in the grocery sector.

## 1. Introduction

In today's increasingly interconnected and e-commerce-driven world, the importance of last-mile delivery cannot be overstated. The last-mile delivery, representing the final leg of the supply chain, plays a pivotal role in ensuring that products reach consumers' doorsteps promptly and efficiently; however, this convenience comes at a cost, particularly in terms of its significant environmental impact. The transportation and logistics involved in last-mile delivery contribute to emissions, congestion, and resource consumption, all of which have far-reaching consequences for the environment (Melkonyan et al., 2020).

The consumer, as the ultimate recipient of these goods and services, plays a central but often overlooked role in the last-mile delivery process. Consumer choices, behaviors, and preferences profoundly impact the execution of last-mile delivery. Yet, these factors have received relatively limited attention in the broader discussion of supply chain logistics and sustainability. Understanding and influencing consumer behavior in the context of last-mile delivery is a critical dimension of behavioral operations management (Kirchoff et al., 2016; Fahimnia et al., 2019). The present research aims to contribute to this field by investigating how the supplier can influence consumer behavior in the context of last-mile delivery, and how it can, in turn, affect the supply chain sustainability.

In the grocery sector, the environmental impact of last-mile delivery is pronounced due to the perishable nature of food items, often necessitating expedited delivery methods. This urgency can lead to an over-reliance on fossil fuel-powered vehicles and inefficient routing, contributing to elevated carbon emissions and air pollution. The importance of home deliveries in the grocery sector has experienced a remarkable surge, particularly in the aftermath of the COVID-19 pandemic. Consumers who had never previously considered online grocery shopping became reliant on these services to ensure access to

☆ This article is part of a Special issue entitled: 'IWSPE 2024' published in International Journal of Production Economics.

* Corresponding author.
*E-mail addresses:* eleonora.rizzitello@unipa.it (E. Rizzitello), giovanna.lonigro@unipa.it (G. Lo Nigro), simona.mancini@unipa.it, simona.mancini@aau.at (S. Mancini), margaretha.gansterer@aau.at (M. Gansterer).

https://doi.org/10.1016/j.ijpe.2025.109855
Received 14 May 2024; Received in revised form 9 November 2025; Accepted 9 November 2025
Available online 11 November 2025

necessities while minimizing the risk of exposure to the virus (Hobbs, 2020).

While the surge in home deliveries in the grocery sector presents numerous opportunities, it also brings forth challenges that must be addressed; they span from logistical complexities (ensuring timely and efficient delivery routes, managing perishable items, and optimizing delivery personnel) to environmental concerns (Cachon and Terwiesch, 2019). The need to balance the convenience of home deliveries with sustainability imperatives arises. Consumer choices and behaviors significantly shape the landscape of last-mile grocery operations, as they dictate the frequency and nature of these deliveries. Yet, consumer influence in this context has received limited attention, with environmental concerns often taking a backseat to convenience and immediacy (Belhadi et al., 2021).

This research aims to determine whether consumers can strike a balance between the convenience and benefits of home grocery delivery and its environmental impact. If yes, what incentives or interventions are required to facilitate such behavior? In addition to financial incentives and sustainability-related nudges (Shubert et al., 2017; Capraro et al., 2019; Fehr and Schmidt, 1999), social effects and peer influence might play a role in the consumer delivery choice, especially in the grocery sector where consumers usually live in the same area. We explore the concept of "peer influence", which refers to the behavior of others that acts as a social norm, potentially shaping individual decisions. Peer influence plays a critical role in consumer behavior, as individuals often look to the actions and choices of others when forming their own preferences, especially in contexts that involve sustainability and collective actions. Understanding this dynamic is essential in assessing how collaborative mechanisms such as shared deliveries and sustainable practices can be effectively promoted. Social norms and the behavior of others can act as powerful nudges themselves (Cialdini, 2003). We can import the motivations of social norms to back our hypothesis that sustainable practices can be further strengthened by the proximity of other consumers. We investigate whether consumers are more likely to choose sustainable last-mile delivery options if they are adopted by others (neighbors, in particular). To test this, we introduced the "shared cart", a delivery option that consolidated orders, reducing the distance traveled and consequently the environmental impact.

In the second part of our study, we used the results obtained to include them in an optimization model for last-mile delivery in the grocery sector. The empirical study and optimization model are designed to work synergistically. The behavioral data from the experiments serve as critical inputs for the optimization model, creating a feedback loop that bridges the gap between theoretical insights and practical applications. While the two components could be independently presented, their combination offers a more holistic understanding of how sustainable consumer behavior can be encouraged and operationalized.

The experimental findings reveal that green nudges amplify the effect of financial incentives, particularly for less sustainability-oriented consumers, aligning extrinsic rewards with moral values (Thaler and Sustein, 2008; Benartzi et al., 2017). However, financial incentives following green nudges have a diminished incremental effect, highlighting the dominance of moral motivators in sustainability (Fanghella et al., 2021). Peer influence significantly drives the adoption of shared delivery mechanisms, with collective behavior playing a critical role in the promotion of sustainable choices (Cialdini, 2003).

The optimization model quantifies the operational benefits of these behavioral insights. Flexible delivery reduces costs by 20.3% for day-only flexibility, 37.5% for time-only flexibility, and 42.5% for both. The shared cart mechanism, rooted in peer influence dynamics, achieves additional savings of up to 57.2%, with optimal cart sizes reducing costs by 76.8%. This study tightly integrates behavioral and operational perspectives, offering a comprehensive framework for designing sustainable last-mile delivery systems. By combining behavioral interventions with operational strategies, the findings provide actionable pathways for enhancing efficiency and reducing environmental impact. This approach demonstrates the potential for leveraging consumer behavior to achieve broader sustainability goals in logistics. Experiments show that the slight increment of waiting time for the customers is totally compensated by a huge savings from both an economic and an environmental point of view.

The rest of the paper is structured as follows. Section 2 reviews literature on the main research topics, namely, nudging, financial incentives, and social norms as drivers in the last-mile delivery decisions and last-mile delivery optimization of consumers. Section 3 introduces the methodology while Section 4 presents the hypotheses development and the adopted methodologies for the empirical study. Section 5 presents and analyzes the empirical results while Section 6. describes the optimization models and the analyses on the benefit of nudging and monetary incentives. Section 7 summarizes the results and draws conclusions.

## 2. Literature review

Previous research, particularly in energy consumption and sustainability (Fanghella et al., 2021; Mi et al., 2021), has examined the interplay between nudges and financial incentives to motivate consumers toward sustainable behavior. While financial incentives are well-documented motivators for eco-friendly behavior (Gneezy and Rustichini, 2000; Sadiq et al., 2021), green nudges, as popularized by Thaler and Sustein (2008), represent a subtler, cost-effective, and potentially longer-lasting approach (Agatz et al., 2021). For example, experimental studies have shown that reframing of delivery options can effectively nudge consumers toward greener choices. (Polonsky et al., 2014; Alcott and Rogers, 2014; Huitink et al., 2020; Vermote et al., 2020). Alcott and Rogers (2014) and Loewenstein et al. (2007) provide foundational insights into the integration of nudges and financial incentives, showing how these mechanisms, when applied together, can shape consumer choices toward sustainability.

Within the grocery sector, Agatz et al. (2021) demonstrate that green labels significantly influence time-slot choices, maintaining effectiveness even when paired with price incentives. However, they note that price incentives add limited value beyond green labels alone and do not quantify the operational impact of more sustainable choices. Similarly, Otaki et al. (2024) examine the effects of combining financial incentives and nudges on water-saving behaviors, finding that while nudges generate urgency, their tangible behavioral impacts can differ across consumer segments. Buckley and Llerena (2022) further highlight that nudge-based interventions can perform as effectively as equivalent price-based measures. Quicker integration into decision-making and prevention of welfare losses are additional benefits. Overall, opinions on the standalone and combined effectiveness of financial incentives and nudges remain divided (Fiorillo and Sapio, 2019; Asensio and Delmas, 2016; Farrow et al., 2017; Fanghella et al., 2021; Mizobuchi and Takeuchi, 2013; Phipps et al., 2015). Yet, evidence of their combined impact is inconsistent across sectors, necessitating further exploration (Fanghella et al., 2021; Mizobuchi and Takeuchi, 2013; Yoeli et al., 2017).

Building on these findings, this research aims to address whether nudges emphasizing the environmental consequences of delivery choices can enhance consumer responsiveness to financial incentives for eco-friendly options. In practice, the first contribution of this paper is to explore the interplay between the two incentives and investigate whether nudges can enhance the effectiveness of financial incentives. It will also examine whether nudges alone can push toward sustainable delivery behavior. In addition to these direct incentives, the role of social dynamics, particularly peer influence, has emerged as a critical factor in shaping sustainable behavior. Peer influence, refers to the behavior of others that acts as a social norm, potentially shaping individual decisions. It plays a critical role in consumer behavior, as individuals often look to the actions and choices of others when forming their own preferences, especially in contexts that involve sustainability and collective actions. Peer influence has been identified as a powerful tool for fostering collective action (Capraro et al., 2019; Cialdini, 2003). By observing the eco-friendly behaviors of others, individuals may be nudged toward similar choices, creating a ripple effect that reinforces sustainable practices within communities. Understanding this dynamic is essential to assess how collaborative mechanisms such as shared deliveries and sustainable practices can be effectively promoted. This highlights the need for holistic strategies that integrate behavioral insights such as peer influence, with logistical interventions. The second contribution of this paper clarifies how the sustainable behavior of peers can influence consumers to improve operations in the last mile. To investigate this further, we propose an innovative delivery option defined as a "shared cart", which addresses the problem of repeated routes leveraging the customer cooperation attitude from pro-social norms behavior. It introduces the innovative concept of materializing a common good such as environmental benefits through the shared cart mechanism. This approach transforms a typically intangible and long-term goal (environment protection) into an actionable and daily decision (delivery choice). The shared cart leverages the behavior of proximate users (e.g., neighbors shopping at the same store) to nudge consumers toward responsible choices, visualizing cooperation to safeguard common goods. The third contribution of our study lies in its dual-methodological approach, which combines experimental investigations of consumer behavior with optimization modeling. While each component could potentially stand alone as independent research, their integration represents a unique contribution.

Indeed, logistical interventions for the optimization of home delivery routes for reducing CO2e emissions require an understanding of consumer behavior, especially regarding flexible delivery options and the adoption of shared delivery systems. Literature addressing operational optimization often focuses on technological solutions, such as vehicle design, dynamic routing, and driver behavior modification (Arroyo-López et al., 2021; Xiao and Konak, 2017; Mancini and Gansterer, 2021). While these studies clearly show the advantage of order bundles (see also Mancini et al., 2025b), these approaches frequently neglect the role of consumer behavior in shaping delivery efficiency. This impact can be high as customers might be incentivized to build orders by themselves.

Recent work in behavioral operations management has sought to address this gap by integrating insights from psychology and behavioral science into operational decision-making (Agatz et al., 2021; Boyer et al., 2009). This evolving field emphasizes the importance of understanding how consumer preferences — particularly for flexible delivery options and shared delivery systems — can shape logistical efficiency and sustainability. Behavioral data on preferences for delivery timing and peer-driven participation in mechanisms such as shared cart systems are increasingly recognized as valuable inputs for optimizing operational processes. Innovations such as dynamic slotting (Lang et al., 2021) and time-window pricing mechanisms (Zhou et al., 2022) offer promising pathways for aligning consumer incentives with environmental and logistical objectives. In Voigt et al. (2025), for instance, it is shown that consumer flexibility in terms of delivery days rather than time slots can lead to considerable reductions in both transportation costs and CO2e emissions. This flexibility is denoted as "some-day option" and it is also the basis for *Amazon's "free no-rush"* concept. The authors solve the respective routing problem and point out that in future research consolidation effects should be taken into account. Our study contributes to this field.

By leveraging these insights, research demonstrates the potential for integrating consumer behavior into logistical models to achieve both operational efficiency and sustainability. This approach reflects a broader shift toward holistic strategies that combine technological solutions with behavioral interventions to optimize last-mile delivery systems.

## 3. Methodology for the empirical study

Experiments in a controlled environment are recognized as a powerful methodology to test the effect of moral nudges and financial incentives. We develop a novel task that captures the choice of actual delivery options in grocery buying, represented by a trade-off between private and societal benefits. We implemented a two-part experiment, starting with a dictator game and finishing with a novel task series. The dictator game aimed to capture the individual propensity to the common good, measured by the choice of sustainable delivery options. Dictator games are well suited to reveal the allocator's true social preference (van Dijk and De Dreu, 2021). The first part can be framed, according to a classification of the behavioral paradigm in pro-environmental behavior (Lange, 2023). The class of behavioral paradigms involves assigning participants to a standardized task that can be completed by using resources (i.e., water, electricity, paper) in a relatively efficient way. However, they will have to select how their grocery is delivered (routine task) by reducing the CO2 emissions of the delivery itself. This behavioral paradigm is linked to personal costs in the form of effort made by participants to complete the task in more resource-efficient (or less impactful for the environment) ways.

The novel task series aims to capture the emergence of an individual's propensity to collaborate for a common good when others cooperate in real life. This second part can be framed in the social dilemma games category in Lange (2023)'s classification of the behavioral paradigm of pro-environmental behavior: participants make choices that affect their payoff and the state of a common pool (and thus the payoff of all players in the game).

To validate our experimental setting, we first performed a pilot test with 15 Ph.D. students in management and sustainability engineering before distributing it to the final sample of consumers. The sample was extracted from a pool of about 700 real consumers of an Italian supermarket's e-commerce channel *Maxistore Deco' Conigliaro1* and a group of potential customers of the same supermarket (people living near the store) to obtain a similar number of answers for randomization of the sample. After comprehension and attention checks on participants, we removed answers from 11 participants who failed the tests and created a dataset of 112 completed responses. Out of this, 61 were from existing consumers and 51 were from potential customers. Similar samples were used in studies by Agatz et al. (2021) to draw generalizable conclusions for the time slot choices in delivery services.

### 3.1. Task design

We designed an experiment that simulated the delivery options for the online purchase of groceries through an online Google form. The experiment is divided into two parts. In the first part, consumers were required to choose a delivery type among four options. They vary in the possibility of a customer choosing the time and date of delivery (1 - choose date and time, 2 - choose time, 3 - choose date, 4 - don't choose time or date). Option 1a is defined as a low-flexibility option, Options 2 and 3 as medium-flexibility options, and Option 4 as a high-flexibility option. Options 2 and 3 were grouped into medium flexibility levels to account for the practical constraints faced by consumers such as fixed schedules due to work commitments or personal obligations (Voigt et al., 2025). For example, some consumers might be available for delivery all day long on some days and not others because they work from home on specific days of the week, or because they have a doorman service on some days. Oppositely, other consumers might be available every day buy only on specific hours, because they have fixed office working hours throughout the week. These constraints often limit the ability of individuals to accommodate highly flexible delivery options. Setting day flexibility within fixed hours (option 2) and hour flexibility within fixed days (option 3) as equally flexible is coherent with previous studies who demonstrate that these two delivery attributes are chosen with comparable frequency as preferable options by

**Table 1**
CO2e emissions reduction for each delivery option as nudge.

| Delivery option | Environmental impact reduction |
|---|---|
| (1) choose the delivery time and date | 0% |
| (2) choose the delivery time | 30% |
| (3) choose the delivery date | 30% |
| (4) do not choose the time or date of delivery | 60% |

**Table 2**
Discount value for each delivery option as a financial incentive.

| Delivery option | Discount value |
|---|---|
| (1) choose the delivery time and date | €0 |
| (2) choose the delivery time | €1 |
| (3) choose the delivery date | €1 |
| (4) do not choose the time or date of delivery | €2 |

consumers (Nguyen et al., 2019). By offering these intermediate levels of flexibility, we aimed to strike a balance that captured meaningful variations in consumer preferences compatible with their realistic time and scheduling limitations.

The environmental benefit measured by CO2 equivalent (CO2e) reduction increased with greater flexibility in delivery time and date. CO2e emission reductions were as follows: 0% for the least flexible option (Option 1), 30% for medium flexibility (Options 2 and 3), and 60% for the most flexible option (Option 4), as shown in Table 1. The 60% CO2e emission reduction for Option 4 was based on Kemp et al. (2022), where grocery deliveries using a V125 vehicle resulted in a 60% reduction in vehicle distance traveled, equivalent to 4.6 km.

For the sake of realism, we included a set of financial incentives as discounts in the design of the experiment (see Table 2). The financial incentive consisted of a discount on grocery delivery: the monetary discount was equal to the real-life grocery delivery price of *Maxistore Deco' Conigliaro*, which is € 2 for deliveries in the area near the supermarket. This choice is coherent with the optimization-based analysis of this paper, which takes into account areas near the supermarket or warehouse. Choosing a flexible schedule delivery produces an environmentally positive externality; the uncertainty of time and/or date delivery requires an effort for the consumer to make themselves available that is proportional to its environmentally positive externality.

For the sake of realism, we included a set of financial incentives as discounts in the design of the experiment (see Table 2). In real life, choosing a flexible schedule delivery produces an environmentally positive externality. The uncertainty of time and/or date delivery requires an effort for the consumer to make themselves available. In this case, it is proportional to its environmentally positive externality. Option 1a has low flexibility, options 2 and 3 have medium flexibility, and option 4 has the maximum flexibility.

The second part of the experiment builds on the idea that a flexible delivery not only reduces CO2e emissions but is also a positive externality to supermarket operations by enabling cost cuts. To foster such operational cost-cutting we developed a novel concept called the "shared cart". The concept of shared cart extends the concept that is recognized in the literature as bundle delivery (e.g., Mancini and Gansterer, 2021). The shared cart is then a virtual grocery cart filled with a few different clients' orders and is delivered home to each client. The shared cart allows an estimated 60% CO2e reduction and needs four average orders to be placed with the collective cart to be activated. When the threshold is met, the shared cart will deliver the groceries to the four consumers. If it isn't met by the next day, the collected groceries are delivered anyway. In this second part of the experiment, consumers are required to choose delivery options among two choices. One is the regular delivery (choose date and time) and the other is the shared cart.

For rapidly filling the collective cart, cooperation among consumers is required to the extent that if one last order is needed for the shared cart to be filled and delivered, the last consumer must cooperate to renounce the choice of an individual delivery, and choose the shared cart instead. If this consumer is cooperative and chooses the shared cart, then the cart is filled sooner and the grocery delivery will be done sooner as well, achieving a common benefit. This common benefit is threefold: the delivery is prompt so that the consumer can receive their grocery soon and the CO2e emissions are reduced so that the environment where the consumer lives is healthier and the company cuts delivery costs.

In particular, cooperation occurs when two conditions are met according to the goal-expectation theory (Pruitt and Kimmel, 1977). First, participants should have cooperative beliefs that they need to trust interdependent persons to make cooperative decisions. We measured this in the first part of the game through the Dictator Game. Under the influence of the green nudge alone, we measured the willingness of the consumer to renounce a personal need or comfort, for example by changing schedules to adapt to a delivery time, for a public benefit, which is environmental protection. Second, participants must have cooperative goals, which in our case is the prompt filling of the collective cart.

### 3.2. Treatments

The experiment was conducted with a between-subject design and encompassed the manipulation of the type of incentive. The participants were all provided with the same instructions. In the first part of the game, we designed two treatments (T1 and T2) called the financial incentive and the green nudge. By separating the application of a financial or green nudge incentive, the experiment aimed to clarify controversial insights in the literature about their interplay.Each participant was randomly assigned to only one treatment (T1 or T2), and experienced two stages within that treatment. Both treatments are structured into two questions, Q1 and Q2, i.e. the first and second presented question for each treatment respectively. Hence, the questions are named Q1.T1 and Q2.T1 for T1 and Q1.T2 and Q2.T2 for T2. In all questions, consumers were asked to choose their preferred delivery option among the four possible ones (a, b, c, or d) as listed in the left column of Tables 1 and 2. The four questions, differ only on the basis of the information provided about the economic reward (Table 2) or the environmental impact (Table 1) associated with each delivery option. In fact, T1 and T2 presented such information in reversed order. In Treatment 1 (T1), participants first faced a financial incentive alone, and then a combination of financial incentive and nudge. In Treatment 2 (T2), participants first faced a nudge alone, followed by the combination of nudge and financial incentive. T1 and T2 are described as follows.

**Financial incentive (T1):** in the financial incentive treatment consumers were first asked to choose the preferred delivery option, while first presented with an economic reward for each of them. The economic reward is structured as a discount on future purchases from the same grocery store (Rajapaksa et al., 2019) as described in Table 2. Next, participants were asked to answer the same question, while presented, in addition to the economic reward, the environmental impact (i.e. the CO2e emissions reduction) for each delivery option, as described in Table 1.

**Green nudge (T2)**: in the green nudge treatment consumers were first asked to choose the preferred delivery option, while first presented with the environmental impact for each of them. It is designed as a moral nudge used in economic games for a public good. It consists of the four delivery options being associated with their respective CO2e emissions reduction, as described in Table 1. According to recent studies, informing participants about climate change-related information could improve environment-friendly choices in grocery buying

(Kurowski et al., 2022), and asking the participants about the morally right thing increased pro-sociality in the choice immediately after, and in subsequent choices, even when the social context changed (Capraro et al., 2019; Mi et al., 2021). Coherently with the structure of T1, the consumers in the green nudge treatment T2 were consequently asked to answer the same question, while presented, in addition to the environmental impact for each delivery option, with the discounts associated with each option, as described in Table 2.

More details on the experimental setup are presented in Section 3.3.

### 3.3. Experimental procedure

At the beginning of the experiment, all the participants were informed that prizes could be accumulated during the game and would be awarded only after the completion of the experiment. The maximum obtainable prize was €4 in the financial incentive treatment (T1) and €2 in the green nudge treatment (T2). The maximum obtainable prize differed across treatments: in the financial incentive treatment (T1), both questions entailed a monetary reward, leading to a maximum of €4, while in the green nudge treatment (T2) only one question entailed a monetary reward, leading to a maximum of €2. When entering the experiment, all participants were first asked to complete a survey to gather their demographic and lifetime-flexibility data. All invited participants were equally and randomly divided into the two treatments (T1 and T2). At the beginning of either treatment, they were asked a comprehension question (part 1), and only those who answered correctly were allowed to start the game. Participants who passed the comprehension test started the game in their assigned trance. They were asked about their delivery choices. In treatment T1, consumers were initially asked to select their preferred delivery option from the four available choices, with the associated discounts (Q1.T1) on future purchases outlined in Table 2 — right column. In the subsequent question, consumers were presented with the same delivery options, and the same discounts shown in Table 2, but this time, along with the financial incentive, they were also informed about the corresponding CO2e emissions reduction for each option (Q2.T1), as detailed in Table 1 — right column. In treatment T2, the nudge and financial incentive were presented in the opposite order. First, participants were asked to choose their preferred delivery option among the four available, while presented with the CO2e emissions reduction corresponding to each of them (Q1.T2), as shown in Table 1 — right column. Then, the same question is asked and, along with the CO2e emission reduction shown in Table 1, they were also informed about the discount associated with each option (Q2.T2), as shown in Table 2 — right column. All the questions (Q1 and Q2 in both T1 and T2) are framed as follows: "*You have chosen to shop online on Connie.it. Once you have filled your cart, it's time to choose your home delivery option, even if different from the one indicated in the previous question, according to your real preferences. Which delivery method do you choose?*" Before that (Q1 and Q2), they are asked a comprehension question (part 1), and only those who answered correctly were allowed to start the game. After the first part of the experiment, all participants performed the same tasks with equal treatment. They were asked another comprehension question (part 2) that required correct answers to continue with the game. In this second part, participants were asked to choose between the shared cart or individual delivery in four rounds (questions Q3a, Q3b, Q3c, and Q3d) of the full experiment document. In each of the rounds, a different level of cart filling is presented in a random order (levels are $\frac{0}{4}$, $\frac{1}{4}$, $\frac{2}{4}$, and $\frac{3}{4}$, respectively, meaning that none, one, two, or three orders are already in the cart). This is to identify the peer influence, i.e., how the different levels of filling, corresponding to the different number of consumers that behaved cooperatively, influenced the customer's decision on the delivery option. The repeated decision-making aimed to explore how the history of cooperative peer behavior contributed to the emergence of cooperation (Fehr and Schurtenberger, 2018). At the end of the second part, participants were asked to fill out a survey

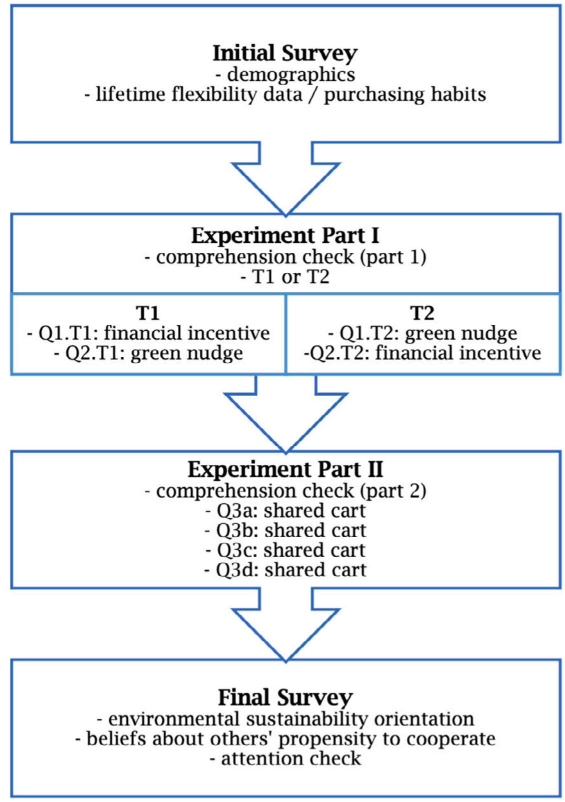


**Fig. 1.** The experimental procedure.

gathering data about their environmental sustainability orientation and their beliefs about others' propensity to cooperate. In fact, in public good provision games, the decision to cooperate depended on beliefs about others' propensity to cooperate or free-ride instead (Fehr and Schurtenberger, 2018). Finally, the experiment included an attention check (Oppenheimer et al., 2009). The full procedure is shown in Fig. 1. We would like to remark that only questions with the financial incentive are rewarded (€2 each). Participants answered two questions: in T1 both questions entail the financial incentive and are rewarded (maximum €4), while in T2 only one is rewarded, as the other entails a green incentive (non financial) (maximum €2).

## 4. Hypotheses

The literature reveals varying perspectives on the individual and synergistic impacts of financial incentives and green nudges in influencing consumer behavior. Studies have shown that financial incentives such as discounts and rewards are potent motivators in nudging consumers toward eco-friendly choices (Gneezy and Rustichini, 2000; Sadiq et al., 2021). While the standalone effects of these strategies are well-documented, their combined impact is less understood. In other sectors, studies diverge in their findings (Fanghella et al., 2021; Mizobuchi and Takeuchi, 2013; Yoeli et al., 2017; Benartzi et al., 2017). This lack of clarity in the interplay of incentives forms the basis of our Hypothesis 1. For this in practice, we expect a higher choice of flexible delivery options when the two incentives coexist, which leads to Hypothesis H1.

H1: *Green nudges and financial incentives synergically push consumers toward green grocery delivery.*

Further, our research explores the dominance, if any, between green nudges and financial incentives. The concept of green nudges, introduced by Thaler and Sustein (2008), suggests a subtle and sophisticated approach. Experimental evidence within the grocery sector demonstrates that nudges, particularly those that frame delivery choices effectively, can lead consumers to opt for greener options (Sadiq et al., 2021; Kurowski et al., 2022; Agatz et al., 2021). This evidence suggests that while financial incentives are potent motivators, green nudges might have a more profound impact on steering consumers toward green grocery buying, with nudges being less costly and having a longer-lasting effect than financial ones (Agatz et al., 2021). Their compared effectiveness is less understood (Benartzi et al., 2017; Yoeli et al., 2017) and controversial (Otaki et al., 2024; Buckley and Llerena, 2022).

Hypothesis 1a examines whether the presence of a green nudge could enhance the effectiveness of financial incentives. Since the investment in the two incentives are very different in terms of perdurance (financial incentives require a continuous investment, while the green nudge does not), this aspect is crucial for investigation. The hypothesis suggests that a green nudge enhances the effectiveness of financial incentives by providing a contextual framework that aligns extrinsic rewards (financial incentives) with intrinsic values (sustainability). This relationship is particularly evident among consumers who are less intrinsically motivated by sustainability. For these consumers, financial incentives alone may not be sufficient to encourage sustainable behavior, as they lack an emotional or moral dimension. However, when paired with a green nudge, financial incentives gain additional persuasive power, making sustainable choices more appealing. The rationale is that nudges could prime consumers to value sustainability more, thereby making financial incentives more appealing if they are offered along with a nudge than alone. In practice, we expect a higher choice of flexible delivery options for those individuals who have been first offered the financial incentive, followed by the green nudge (Q2.T1) than the financial incentive alone (Q1.T1), which leads to Hypothesis H1a.

H1a: *the presence of a green nudge reinforces the effectiveness of financial incentives.*

Evidence suggests that green nudges might have a more profound impact on steering consumers toward green grocery buying than financial incentives (Agatz et al., 2021) because they are inherently more motivating for consumers. As such, there is the possibility that financial incentives might not reinforce the power of green nudges. This suggests that the impact of a green nudge is already strong enough to drive consumer behavior, and adding a financial incentive does not significantly enhance this effect. Green nudges create moral resonance: they effectively connect consumer behavior with broader moral or ethical goals such as sustainability. Financial incentives, by contrast, appeal to short-term cost–benefit calculations. This hypothesis is further informed by the limited evidence on the synergistic effects of combining these approaches (Fanghella et al., 2021; Mizobuchi and Takeuchi, 2013; Phipps et al., 2015) and on the logic that moral (green in our case) incentives dominate financial ones in the sustainability domain. In practice, we expect that the choice of flexible delivery options, if stimulated by nudging first, cannot be further strengthened by adding a financial incentive. Therefore, we do not expect a higher choice of flexible delivery options for those individuals who have been offered a financial incentive after the green nudge (Q2.T2) as compared to the flexibility choice under the influence of the green nudge alone (Q1.T2), which leads to our Hypothesis H1b.

H1b: *the financial incentives do not reinforce the power of green nudge, the green nudge being more motivating than the financial incentives.*

Additionally, this study delves into the social dynamics of consumer behavior, an aspect not extensively covered in existing literature. The sustainable behavior of other consumers, particularly in the context of the choice of environmentally sustainable delivery options, could have a significant peer influence on individual consumer decisions (Capraro et al., 2019). This observation leads to the formulation of Hypothesis 2.

H2: *consumers will be influenced by the sustainable behavior of other consumers, opting for the shared cart under increasing levels of peer influence.*

Hypothesis H2 is further nuanced by examining the first part of the game responses under the influence of financial incentives, green nudges, and both. While both environmental awareness and social pressure are critical drivers of sustainable behavior, our hypothesis investigates whether individuals are more likely to be influenced by intrinsic values, such as concern for the environment (H2a), financial remuneration (H2c), or by external social expectations and norms (H2b and H2d).

Hypothesis 2a posits that consumers who are initially motivated by a green nudge — meaning they respond positively to an environmentally friendly prompt or incentive during the first part of the game (in both T1 and T2) — demonstrate a strong intrinsic commitment to sustainable behavior. As a result, their decision-making is independent of external social factors such as the sustainable actions of other consumers. Their sustainable behavior is indifferent to peer influence, as they would opt for green delivery regardless of whether others are participating in the shared-cart system. This highlights that the green nudge effectively targets the internal motivations of these consumers (Kurowski et al., 2022), making their behavior less dependent on external factors like social pressure. We define these consumers as “green-sensitive”. In practice, we expect these consumers to consistently choose the green delivery option, regardless of the shared cart’s filling level (i.e., how many other consumers have also opted for sustainable choices). This leads to Hypothesis H2a.

*H2a: green-sensitive consumers will not be influenced by the sustainable behavior of other consumers and will anyway opt for the shared cart.*

In contrast, Hypothesis 2b suggests that consumers who do not initially respond positively to the green nudge, meaning they are not directly motivated by the environmental message or incentive during the first part of the game (in both T1 and T2), are generally less sensitive to sustainability issues. We define these consumers as “green insensitive”. We posit that their decision-making might be influenced by the behavior of their peers or the collective actions of other consumers instead. In this context, these consumers are more socially driven than intrinsically motivated. If they observe the other participants making sustainable choices (e.g., contributing to the fulfillment of a shared cart for green delivery), they are more likely to follow suit, even though sustainability itself may not be their primary concern. This behavior indicates that peer influence or social norms play a significant role in shaping their delivery decisions. The rationale is that the behavior of others is a stronger incentive than the green nudge: the neighbors’ willingness to commit to a common good (such as the environment) acts as a moral persuasion tool (Sadiq et al., 2021). Essentially, while the green nudge alone does not change their behavior, the visible actions of others act as a social signal or behavioral cue that nudges them toward choosing a sustainable delivery option. This highlights the importance of leveraging social dynamics and collective behavior to encourage sustainability among individuals who are less intrinsically motivated by environmental considerations. In practice, we expect the selection of a shared cart option with varying levels of cart filling by the consumers that responded positively to the green nudge (select flexible delivery in Q1.T2 or change for a more flexible delivery in Q2.T1 if compared with the Q1.T1’s answer) as we put forward in H1a. To the contrary, for the consumers who did not respond positively to the green nudge (do not opt for more flexible delivery moving from Q1.T1 to Q2.T1 or do not show any flexibility in the delivery in Q2.T1), we expect a growing participation in the shared cart as the level of cart filling grows. This leads to Hypothesis H1b.

H2b: *green-insensitive consumers will be influenced by the sustainable behavior of other consumers, and will opt for the shared cart under increasing levels of peer influence.*

It is to be specified that the shared cart embeds a financial incentive. The shared cart grocery delivery is free, whereas the conventional delivery, for which the consumer can choose its exact time and day, comes at a regular fee of €3. Therefore, to appreciate the influence of the financial incentive in the decision of the shared cart delivery option, we test how consumers who reacted positively to the financial incentives in the first part of the game, react to the sustainable behavior of other consumers. In essence, we test whether those consumers who chose the flexible delivery option with increasing cart levels under increasing financial incentives in both T1 and T2, will adhere more to the shared cart, for increasing levels of shared cart filling by other consumers. We define these consumers as “financially sensitive”. The rationale is that these consumers are intrinsically motivated by financial incentives and are insensitive to other incentives when their financial need is already met, which leads to Hypothesis H1c. In practice, we expect these financially sensitive consumers not to be influenced by peer behavior.

H2c: *financially sensitive consumers will not be influenced by the sustainable behavior of other consumers and will anyway opt for the shared cart.*

In contrast, we test how consumers who did not react to the financial incentives in the first part of the game, react to the sustainable behavior of other consumers. In essence, we test whether those consumers who did not choose increasing flexible delivery option under financial incentives in both T1 and T2, adhere more to the shared cart, for increasing levels of shared cart filling by other consumers. We define these consumers as “financially insensitive”. The rationale is that these consumers are not intrinsically motivated by financial incentives and, therefore, their joining the shared cart is based on other-than-financial reasons, due to their sensitivity to peer sustainable behavior. In practice, we expect these financially sensitive consumers to indeed be influenced by the behavior of peers. This leads to Hypothesis H2d.

H2d: *financially insensitive consumers will be influenced by the sustainable behavior of other consumers, opting for the shared cart under increasing levels of peer influence.*

## 5. Empirical results and analysis

The analysis of the experiment (for both the first and second part of the game) was conducted in two steps. First, a frequency analysis, and second an econometric analysis. The frequency analysis represents an initial step to identify patterns and trends, while the regression model provides a more robust and controlled analysis to test the hypotheses. The frequency analysis provides a preliminary analysis (percentage-based insights), which is helpful in explaining the rationale and highlighting key findings. Its results are described as follows. Fig. 2 reports the choices made by participants in Q1 and Q2 for all treatments (Fig. 2a), T1 treatment only (Fig. 2b), and T2 Treatment only (Fig. 2c). In particular, the percentages represent the ratio of total participants choosing delivery options characterized by low, medium, or high levels of flexibility. Such options are reported in Tables 1 and 2. Option 1 has low flexibility, options 2 and 3 have medium flexibility, and option 4 has high flexibility.

While percentage-based analyses provide visually intuitive and useful preliminary insights, they are inherently limited in their capacity to control for confounding factors. The use of statistical analysis mitigates this limitation by offering a more rigorous evaluation of the hypotheses. The econometric analysis corroborates the previous analysis by providing consumer behavior variance-based evidence and gives statistical validation to the preliminary analysis. For statistical analysis, an econometric model has been applied to the three hypotheses, H1, H1a, and H1b, using an ologit regression.

The econometric model shown in Eq. (1) is an ologit regression, which is often employed by similar experiment-based studies using ordinal categorical outcome variables (Fiorillo and Sapio, 2019). Eq. (1) includes *delta_flex* and *delta_4options* as outcome variables. Both are ordinal categorical. While *delta_flex* represents the absolute change in flexibility between demand Q1 and demand Q2, based on three levels of flexibility: Level 1 (option 1 in Table 1), level 2 (options 2 and 3 in Table 1), and level 3 (option 4 in Table 1), *delta_4options* measures the same change using four levels of flexibility instead: Level 1 (option 1 in Table 1), level 2 (option 2 in Table 1), level 3 (option 3 in Table 1), and level 4 (option 4 in Table 1). Regarding *delta_flex*, *delta_4options* considers choosing the delivery date more flexible than choosing the delivery time, rather than equally flexible. Q1 and Q2 are two independent dummy variables to account for the question the participant is responding to (either Q1 or Q2). Finally, the model includes control variables age, gender, and level of education as in Rajapaksa et al. (2019), *job_type* (removed from the model for high correlation), *job_flex* to account for the level of job/time flexibility, *purch_freq* to account for the participant’s online purchasing habits, *online_purch_freq* to account for the participant’s grocery online purchase habits, the participant’s average grocery purchase amount (*purch_avg_am*), the participant’s trust in other’s cooperative behavior measured as the average of five questions (*trust_avg*), and the participant’s environmental orientation measured as the average of questions (*eco_avg*) extracted from Sadiq et al. (2021). The estimation is performed through an ologit regression.

$$\begin{aligned} log(p(flex > j)/p(flex \leq j)) = \theta_j - \beta_1 Q - \beta_2 age - \beta_3 gender \\ - \beta_4 education - \beta_5 job\_flex \\ - \beta_6 purch\_freq - \beta_7 online\_purch\_freq - \beta_8 purch\_avg\_am \\ - \beta_9 eco\_avg - \beta_1\_0 trust\_avg \end{aligned} \tag{1}$$

**Table 3**
Panel ologit regression results on full sample T1 and T2, using as dependent variable the three levels (low, medium, and high) scale (t statistics in parentheses. Significance levels: *p < 0.05, **p < 0.01, ***p < 0.001).

| | (delta_flex) | (delta_4options ) |
|---|---|---|
| **Main** | | |
| Q2 | 0.488* | 0.454* |
| | **2.36** | **2.28** |
| **Cut-points** | | |
| cut1 | −0.851 | −2.116** |
| | (−1.45) | (−3.02) |
| cut2 | 2.935*** | −0.836 |
| | (4.31) | (−1.46) |
| cut3 | 5.453*** | 2.833*** |
| | (5.55) | (4.32) |
| cut4 | | 3.348*** |
| | | (4.93) |
| cut5 | | 5.343*** |
| | | (5.67) |
| **Sample size** | | |
| **N** | **110** | **110** |

The investigation of the efficacy of the interplay between financial incentives and green nudges on consumer delivery option choices has yielded notable results. The experiment’s sequential treatment design has allowed us to parse out the distinct and combined effects of these two types of interventions. Hypothesis H1 posited that the combination of green nudges and financial incentives, in no specific order of implementation, act synergically in encouraging consumers toward flexible and then green grocery delivery options. As demonstrated in the frequency analysis (Fig. 2a), the percentage of consumers choosing delivery options with low levels of flexibility decreased from 24% to 12%, and consumers choosing delivery options with medium levels of flexibility increased from 41% to 57% from Q1 to Q2, i.e., after the green nudge is added to the financial incentive (T1) or vice versa (T2). However, it is worth noting that the percentage of consumers opting for high flexibility decreased from 35% in Q1 to 31% Q2. We reason that this effect might be mainly attributable to the distinct behaviors of T1 and T2 participants, and we further unfold this phenomenon in the H1a and H1b discussion. All things considered, H1, based on this analysis, is confirmed because of the systematic increase of environmentally friendly consumer choices for the combination of financial incentives and nudges in both consequent orders.

The synergic effect of nudges and financial incentives on consumers’ flexible choices is further confirmed by the regression analysis results. In Table 3, the coefficients for the dependent variables are 0.488 for

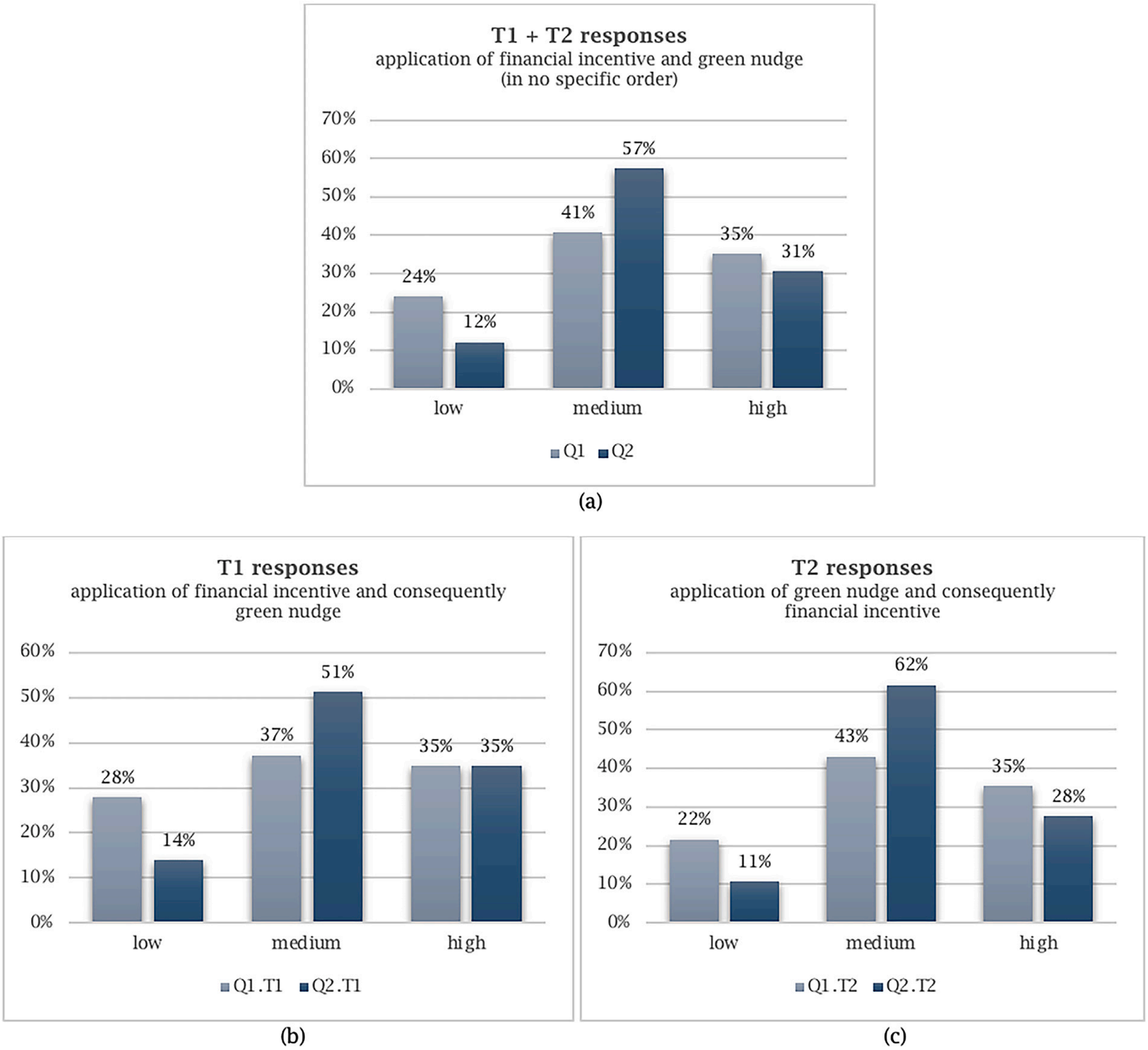


**Fig. 2.** Percentage of participants who chose low, medium, or high flexibility level, in question Q1 and question Q2 in both treatments T1 and T2 (a), in treatment T1 (b), and in treatment T2 (c).

*delta_flex* and 0.454 for *delta_4options*, both of which are statistically significant ($p$-value $< 0.05$). These coefficients are measured concerning question Q2 (both Q2.T1 and Q2.T2), which corresponds to asking consumers to choose the delivery method after having received both the nudge and the financial incentive in no specific order. From these coefficients, the odds ratios are calculated using the formula Odds ratio $= e^{0.488} \approx 1.629$ and Odds ratio $= e^{0.454} \approx 1.575$. Hence, for *delta_flex*, an increase in the predictive variable (in this case, the application of Q2, is associated with a 62.9% higher likelihood of an increase in the participant's flexibility). Similarly, for *delta_4options*, the application of Q2 is associated with a 57.5% higher likelihood of an increase in the participant's flexibility. Hence, when the participant is subject to both financial incentives and green nudges, the odds of choosing the more flexible delivery options increase by 63% or 57%. Thus H1 is confirmed, as the combination of moral and financial motivators appears to have a compounded effect potentially, by increasing the percentage of consumers who choose more flexible and sustainable delivery options. This finding is particularly relevant because it adds to the recent discussions about the non-synergistic effect of the two instruments, financial and nudge (Fanghella et al., 2021).

Hypothesis H1a proposed that the presence of a green nudge reinforced the effectiveness of financial incentives. This relationship was preliminarily demonstrated in the frequency analysis through the leap in medium flexibility choices from 37% in Q1.T1 (financial incentive alone) to 51% in Q2.T1 (financial incentive combined with green nudge; Fig. 2b). However, the percentage of consumers opting for a high level of flexibility remained constant from Q1.T1 to Q2.T1. This outcome could be attributed to certain constraints that limit some consumers to a medium level of flexibility, preventing them from adopting a higher flexibility level. For example, fixed working hours or predetermined work schedules may render it impractical for individuals to be available for grocery deliveries. To summarize, since the addition of green nudges to financial incentives augments the overall flexibility levels, the frequency analysis confirms H1a.

We further validated the frequency analysis results through statistical analysis. The regression analysis in Table 4 under column T1, while having low significance, further confirms the synergistic effect proposed in hypothesis H1a. The size of the sample was 48 participants. When considering *delta_flex* as the dependent variable, the coefficient of 0.531 corresponded to an odds ratio of approximately 1.701, indicating that the application of the nudge after the incentive increased the likelihood of participants increasing their flexibility by 70% (as shown in Table 4). When considering the alternative dependent variable *delta_4options*, the coefficient was 0.451, corresponding to an odds ratio of approximately 1.570. Thus, under this measure, the nudge after the financial incentive increased the likelihood of participants increasing their flexibility by 57%. Cut point coefficients are significant, demonstrating the appropriateness of the model and the reliability of the positive statistical relationship between Q2 (i.e., the addition of a green nudge to the financial incentive) and the increase in participants' flexible delivery choices.

These results suggest a synergistic relationship where the green nudge can augment the impact of the financial incentive, offering a more nuanced understanding of consumer behavior in delivery choices in the context of environmental sustainability. These findings highlight the potential for integrating economic and moral considerations in promoting pro-environmental consumer behaviors. At the same time, the dominance of green nudges and their higher persistence pose the urgency of an economic assessment from a longer perspective (Mi et al., 2021). Hypothesis H1b considered the possibility that green nudges are more effective than financial incentives and that financial incentives do not reinforce the power of green nudges. The evidence supports this hypothesis. While green nudges seem to motivate more toward a sustainable behavior, the frequency analysis in Fig. 2c suggests that financial incentives may weaken the influence of green nudges, as demonstrated by the lower proportion of consumers selecting highly flexible delivery options when both incentives are applied in Q2.T2 regarding Q1.T2. While the green nudge alone encouraged a shift toward more flexible delivery options, evidenced by 35% of participants choosing the high flexibility option in Q1.T2, the addition of financial incentives seemed to divert this effect, as seen in the decrease to 28% in Q2.T2 (Fig. 2c). This suggests that green nudges are effective, but their impact is fostered when added with financial incentives only for medium flexibility levels, and that financial incentives may divert the effect of green nudges for high levels of flexibility. To summarize, the findings indicate that introducing a financial incentive in conjunction with a green nudge may not increase consumer flexibility as already observed in T1. Furthermore, in T2, adding a financial incentive to a green nudge may decrease high flexibility levels. We reason that this decrease in high flexibility could be due to overstimulation as argued in previous studies (Fanghella et al., 2021).

We performed the regression analysis to further validate our frequency analysis results for H1b. The regression analysis in Table 4 under column T2, while it has low significance, further confirmed the weaker synergistic effect of adding financial incentives to green nudges proposed in hypothesis H1b. The sample size was 62 participants. The coefficient was 0.450 for *delta_flex*, which corresponds to an odds ratio of approximately 1.568, showing that applying the nudge after the incentive increased the likelihood of participants opting for more flexible options by 56%. For the alternative dependent variable *delta_4options*, the coefficient was 0.462, which translates to an odds ratio of approximately 1.587. This indicates a 58.7% increase in the likelihood of participants increasing their flexibility due to the financial incentive applied after the green nudge. In addition, cut point coefficients are significant in this case, demonstrating the appropriateness of the model and the reliability of the statistical relationship between Q2 (i.e., the addition of the financial incentive to the green nudge) and the increase in participants' flexible delivery choices. To summarize, by confirming that adding a financial incentive to a green nudge increased the odds of consumers choosing a more flexible option compared to adding a green nudge to the financial incentive, this analysis partially supports H1b. When comparing the regression analysis results of H1a and H1b (Fig. 2b and c, and Table 4 columns T1 and T2), we can see how the shift to more sustainable delivery choices is more prominent in T1 participants. The expected likelihood of an increase in flexibility is 70% in T1, while it is 56% in T2.

To summarize, the increase in medium flexibility choices and the decrease in low flexibility choices in both T1 and T2, though modest, still point toward the effectiveness of financial incentives combined

**Table 4**
The ologit regression results for T1 and T2 separate sub-samples, using as dependent variable both 4 (see Table 2) and 3 levels (low, medium, and high) scale. (t statistics in parentheses. Significance levels: *p < 0.05, **p < 0.01, *** p < 0.001).

| | (T1) delta_flex | (T1) delta_4options | (T2) delta_flex | (T2) delta_4options |
|---|---|---|---|---|
| **Main** | | | | |
| Q2 | 0.531 | 0.451 | 0.45 | 0.462 |
| | (−1.91) | (−1.73) | (−1.45) | (−1.5) |
| **Cut-points** | | | | |
| cut1 | −0.671 | −2.035* | −1.027 | −2.178* |
| | (−0.88) | (−2.16) | (−1.14) | (−2.07) |
| cut2 | 2.713** | −0.66 | 3.123** | −0.995 |
| | (−3.03) | (−0.90) | (−3.03) | (−1.12) |
| cut3 | 5.424*** | 2.486** | 5.472*** | 3.153** |
| | (−4.07) | (−2.95) | (−3.91) | (−3.09) |
| cut4 | | 3.457*** | | 3.291** |
| | | (−3.77) | | (−3.2) |
| cut5 | | 5.169*** | | 5.509*** |
| | | (−4.02) | | (−3.95) |
| **Sample size** | | | | |
| **N** | **48** | **48** | **62** | **62** |

with green nudges. However, it suggests that green nudges alone already significantly promoted high flexibility choices and that the financial incentive might cannibalize the positive effect of green nudges. Hence, while both financial incentives and green nudges individually promote sustainable choices, their combination could be more potent, and some combinations such as adding a nudge after a financial incentive can be more effective than the opposite sequence.

Hypothesis H2 proposes that the sustainable behavior of other consumers encourages an individual consumer to behave similarly. Its framework is represented in Fig. 3.

The data from the "shared cart" option strongly supports this hypothesis. As the level of cart filling increased, so did the percentage of consumers who chose the shared cart option. This trend was observed across both T1 and T2 conditions, with the highest levels of shared cart selection correlating with the highest levels of cart filling ($\frac{3}{4}$ levels of filling yielded 90% for T1 and 96% for T2). Fig. 4 reports the percentage of consumers opting for the shared cart and individual delivery for any of the four given levels of cart filling. The results suggest a clear pattern of peer influence, where consumers are more inclined to choose a sustainable delivery option (the shared cart) when they perceive others also making similar sustainable choices. This behavior aligns well with social proof and conformity theories, where individuals tend to follow the majority, especially when they are unsure of the correct behavior.

$$\begin{aligned} log(p/1-p) &= \beta_0 + \beta_1 fill\_level + \beta_2 age + \beta_3 gender + \beta_4 education \\ &+ \beta_5 job\_flex \\ &+ \beta_6 purch\_freq + \beta_7 online\_purch\_freq + \beta_8 eco\_avg \\ &+ \beta_9 trust\_avg \end{aligned} \tag{2}$$

The panel ologit regression results, reported in Table 5, confirm the H2 hypothesis by reporting an increase in the log-odds of choosing the shared cart by 0.581 points, equivalent to an odds ratio of 1.79. An increase in the odds of choosing the shared cart for increasing filling levels is 79% with a highly significant (p-value = 0.000) increase in the likelihood of choosing the shared cart over the individual delivery. In addition, *trust_avg* is positive and significant, indicating that higher levels of trust in others' cooperative behavior led to higher shared cart choice (the cooperative choice). Finally, age is weakly significant indicating that older consumers are less prone to opt for the shared cart option.

H2 is further explored by considering the sub-groups of consumers, categorized according to their reactions to financial incentives and

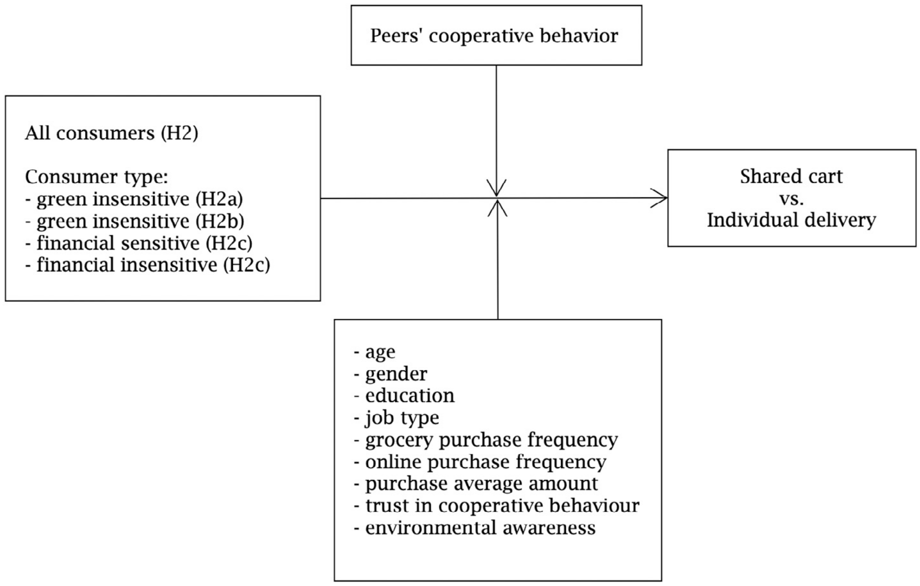


**Fig. 3.** Framework H2, H2a, H2b, H2c, H2d.

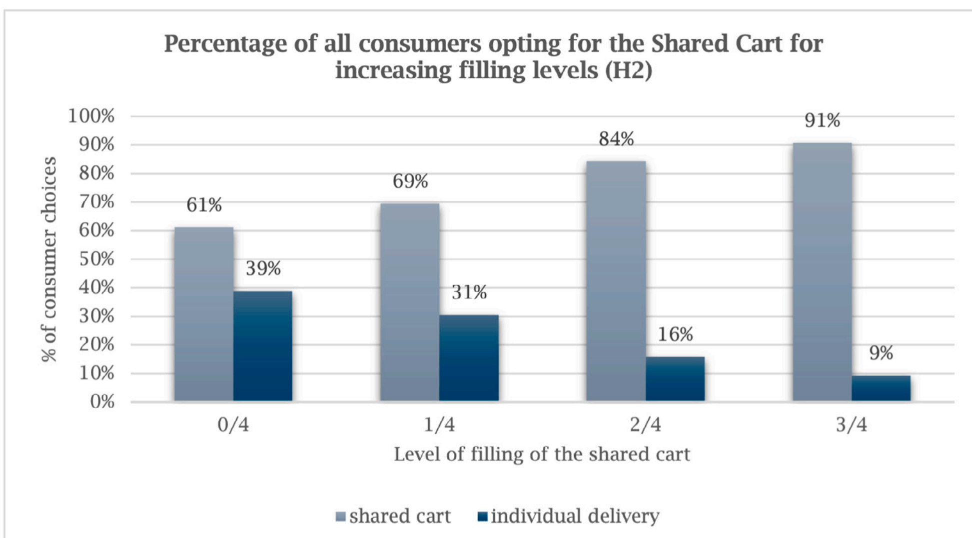


**Fig. 4.** H2 responses as a percentage of consumers opting for the shared cart.

green nudges. The subgroups of respondents considered in H2a, H2b, H2c, and H2d are represented in Table 6. The subgroups are built based on the individual consumer's responses given in Part 1 of the experiment for both T1 and T2. Options are reported in Tables 1 and 2, and option 1 has low flexibility (L), options 2 and 3 have medium flexibility (M), and option 4 has high flexibility (H). For example, the green-sensitive consumer subgroup comprises consumers who have been subject to T1 and chose a low flexibility option in T1.Q1, followed by either a medium or high flexibility option in Q2.T2, or a medium flexibility option in Q1.T1 and then a high flexibility option in Q2.T1, for those subject to T1. It also comprises consumers subject to T2 who chose a medium or high flexibility option in Q1.T2, followed by a low, medium, or high flexibility option in Q2.T2. Figs. 5a–d report the percentage of consumers opting for the shared cart and individual delivery for any of the four given levels of cart filling, for each of the consumer's subsamples — green-sensitive, green insensitive, financially sensitive, and financially insensitive — to test H2a, H2b, H2c, and H2d, respectively. Table 7 reports the logit regression results.

Hypothesis H2a suggests that consumers who initially responded positively to a green nudge, which we categorize as "green-sensitive", will not be influenced by the sustainable behavior of their peers because they are already intrinsically motivated toward sustainable behavior (see Table 6). Fig. 5a reports the choices of the green-sensitive consumers. The high percentage of consumers opting for the shared cart even at lower levels of cart filling (68% at $\frac{0}{4}$ level for the green nudge), compared to the 53% of the financially sensitive respondents choosing the shared cart at filling level of 0, and 63% of the financially insensitive respondents, might suggest that these consumers are indeed less influenced by the behavior of others and more by their own sustainable values. However, the results of the econometric analysis, which are based on the ologit estimation, confirm the H2a hypothesis by reporting a 90% ($p$-value = 0.000) increase in the adoption of the shared cart for every unit of increasing filling of the shared cart for the green-sensitive consumers. Thus, H1a is rejected because green-sensitive consumers also responded positively to peers' cooperative behavior.

**Table 5**
The ologit regression results use a dependent binary variable (1) for choosing the shared cart and 0 for choosing individual delivery. (*t statistics in parentheses. Significance levels: *p < 0.05, ** p < 0.01, *** p < 0.001).

| Variable | Coefficient | p-value |
|---|---|---|
| **Shared cart** | | |
| Full level | 0.581*** | 0.0001 |
| **Demographics** | | |
| Age | −0.0159+ | 0.085 |
| Education | 0.0377 | 0.872 |
| Job flexibility | 0.00874 | 0.934 |
| **Purchasing** | | |
| Purchase frequency | 0.0457 | 0.751 |
| Online purchase frequency | −0.166 | 0.15 |
| Purchase Avg amount | −0.0961 | 0.47 |
| **Environmental factors** | | |
| Eco Avg | 0.0403 | 0.778 |
| **Trust** | | |
| Trust Avg | 0.270** | 0.002 |
| **Model Info** | | |
| Cut1 | 0.245 | 0.841 |
| **Observations** | | |
| N | 440 | |

Hypothesis H2b posits that consumers who do not initially respond positively to the green nudge, which we categorize as "green-insensitive", will be influenced by peer behavior (see Table 6). Hypothesis H2b is not supported by the results, as they show the same increase in the percentage of consumers choosing the shared cart with increasing levels of cart filling as in the case of H2a with green-sensitive consumers. The econometric analysis, conducted similarly to H2a, shows a 62% ($p$-value = 0.000) increase in the shared cart adoption by consumers for each increase in cart filling. This result indicates that even those who showed a mild inclination toward sustainability in the first part of the experiment, are swayed by observing the choices of their peers for high levels of cart filling, demonstrating the impact of social dynamics on consumer behavior. Thus, H2b is not rejected. Hypothesis H2c states that consumers who initially respond positively to a financial incentive, which we categorize as "financially sensitive", will not be influenced by the sustainable behavior of the peer consumers because they are already intrinsically motivated by their financial needs (see Table 6). The increasing percentage of consumers opting for the shared cart even for increasing levels of cart filling (from 53% at $\frac{0}{4}$ level to 93% at $\frac{3}{4}$ level), might suggest that these consumers are indeed influenced by the behavior of others more than by their own sustainable values, and that we should reject H2c. The econometric analysis shows an 85% increase in shared cart choice for every unit of cart filling increase ($p$-value = 0.000). Therefore, H2c is rejected.

Finally, Hypothesis H2d states that consumers who initially do not respond positively to a financial incentive, which we categorize as "financially insensitive", will be influenced by the sustainable behavior of other consumers because they do not have the intrinsic motivation to financial savings and might imitate the choices of others when their decisions impact others (see Table 6). The increasing percentage of consumers opting for the shared cart for increasing levels of cart filling (from 63% at 04 to 99% at the $\frac{3}{4}$ level) might suggest that these consumers are indeed influenced by peers' behavior. The econometric analysis shows a 62% increase in shared cart choice for every unit of cart filling increase ($p$-value = 0.000). Therefore, H2d is confirmed.

In essence, irrespective of the consumer sensitivity to environmental protection or financial rewards, they are all influenced by their peer behavior when making a grocery delivery choice, acknowledging that the shared cart is substantially more eco-friendly than individual behavior. The influence appears to vary based on the consumer's initial response to sustainability and financial cues. Green-sensitive and financially sensitive consumers, who prioritize environmental sustainability or financial considerations respectively, are influenced the most by

**Table 6**
Composition of the subgroups of consumers for H2a, H2b, H2c, and H2d, based on the participants' responses given in Part 1 of the experiment for both T1- and T2-based low (L), medium (M), and high (H) flexibility choices made. Options are reported in Tables 1 and 2, and option 1 has low flexibility, options 2 and 3 have medium flexibility, and option 4 has the maximum flexibility.

**H2a – green sensitive consumers**

| | Q1 | Q2 |
|---|---|---|
| T1 | L | M or H |
| | M | H |
| T2 | M | L or M or H |
| | H | L or M or H |

**H2b - green insensitive consumers**

| | Q1 | Q2 |
|---|---|---|
| T1 | L | L |
| | M | L or M |
| | H | L or M |
| T2 | L | L or M or H |

**H2c – financial sensitive consumers**

| | Q1 | Q2 |
|---|---|---|
| T1 | L | L or M or H |
| | M | L or M or H |
| T2 | L | M or H |
| | M | H |

**H2d – financial insensitive consumers**

| | Q1 | Q2 |
|---|---|---|
| T1 | L | L or M or H |
| T2 | L | L |
| | M | L or M |
| | H | L or M |

peer behavior (*fill_level*), with $\beta$ coefficients of +90% and +85%. This indicates that consumers with strong initial preferences in these areas are particularly susceptible to the actions and choices of their peers. In contrast, green-insensitive and financially-insensitive consumers, who exhibit less concern for environmental or financial factors, are less influenced by peer behavior, as shown by their lower $\beta$ coefficients of +61% and +61%. When controlling for consumer trust in others' cooperative behavior (*trust_avg*), results indicate a positive and significant influence on financially insensitive consumers more than any other category. This may imply that individuals who are less financially motivated and have higher levels of trust in others' cooperative behavior are strongly pushed by peer influence toward sustainable choices. Interestingly, *trust_avg* does not appear to influence green-sensitive consumers, suggesting that their behavior may be guided more by intrinsic environmental values than trust considerations.

Age emerges as an important factor, negatively influencing shared cart choices among green- and financially insensitive consumers. This finding suggests that older individuals in these categories may be less inclined to adopt shared or cooperative purchasing behaviors. One possible explanation is that older green- and financially insensitive consumers might exhibit stronger resistance to change or skepticism

**Table 7**
The logit regression results to test H2a, H2b, H2c, and H2d, using shared cart as dependent dummy variable.

| | H2a | H2b | H2c | H2d |
|---|---|---|---|---|
| | *sharedcart* | | | |
| *fill_level* | 0.900*** | 0.629*** | 0.855*** | 0.623*** |
| | (0.204) | (0.176) | (0.192) | (0.175) |
| *age* | -0.00518 | -0.0282+ | -0.00535 | -0.0457* |
| | (0.0196) | (0.0153) | (0.0156) | (0.0177) |
| *gender* | -0.210 | 0.693+ | 0.295 | -0.192 |
| | (0.434) | (0.406) | (0.521) | (0.437) |
| *education* | -0.259 | -0.111 | 0.00608 | -0.417 |
| | (0.523) | (0.432) | (0.422) | (0.517) |
| *job_flexibility* | 0.00402 | 0.0403 | -0.329 | 0.215 |
| | (0.223) | (0.187) | (0.214) | (0.202) |
| *purch_freq* | 0.264 | 0.102 | 0.463* | -0.0794 |
| | (0.317) | (0.218) | (0.230) | (0.267) |
| *online_purch_freq* | 0.166 | -0.303 | -0.107 | -0.141 |
| | (0.223) | (0.194) | (0.223) | (0.184) |
| *purch_avg_am* | 0.0770 | -0.396+ | -0.174 | -0.280 |
| | (0.249) | (0.215) | (0.249) | (0.238) |
| *eco_avg* | 0.719*** | -0.749* | 0.276 | -0.347 |
| | (0.217) | (0.295) | (0.280) | (0.269) |
| *trust_avg* | 0.141 | 0.302* | 0.325* | 1.015*** |
| | (0.221) | (0.145) | (0.152) | (0.206) |
| _cons | -3.139 | 3.700 | -3.192 | 1.001 |
| | -2.125 | -2.758 | -2.562 | -2.078 |
| N | 236 | 160 | 168 | 208 |

Standard errors in parentheses + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

toward newer and shared systems, stemming from ingrained habits or traditional purchasing preferences. Additionally, older individuals might perceive shared purchasing as more effortful or less trustworthy compared to their established shopping routines. Gender shows a slight, positive significance only for green-insensitive consumers, indicating that green-insensitive women are more likely to opt for the shared cart. This could reflect a greater tendency among women in this subgroup to value convenience, community-oriented solutions, or cost-sharing benefits compared to their male counterparts. Women might also be more open to exploring non-environmental reasons for cooperative behaviors such as social engagement or practical advantages. The variable *purch_avg_am*, which represents the average amount spent on groceries, is slightly significant and has a negative effect only for green-insensitive consumers. This suggests that green-insensitive consumers who typically spend more on groceries are less inclined to choose the shared cart. One explanation could be that higher-spending individuals in this category prioritize immediacy over cost savings or shared benefits. These consumers may be unwilling to wait for shared cart arrangements to finalize and are indifferent to incentives like free delivery. Conversely, *purch_freq*, representing purchase frequency, positively influences financially-sensitive consumers. This suggests that individuals motivated by financial considerations are more likely to purchase frequently. For this group, the potential savings of even small amounts such as €2 may carry significant weight due to their frequent shopping habits. Over time, these cumulative savings can add up, making the shared cart option particularly appealing as a cost-optimization strategy. Surprisingly, job flexibility, online purchase frequency, and education do not significantly affect any of the consumer subgroups. This lack of significance might indicate that shared cart adoption is driven more by intrinsic consumer preferences and specific behavioral patterns than broader lifestyle or socioeconomic factors. It could also reflect a threshold effect where these variables only matter under certain conditions not captured in this analysis.

Finally, the variable *eco_avg*, which represents the average level of ecological awareness or attitudes, has a dual effect. It positively influences green-sensitive consumers, encouraging cooperative green behavior, while negatively influencing green-insensitive consumers, potentially reinforcing their resistance to environmentally friendly practices. This divergence highlights the polarizing impact of ecological attitudes on consumer decision-making. These intriguing and nuanced results lay the foundation for a deeper understanding of green consumer behavior concerning their behavioral profiles. Furthermore, they provide a valuable opportunity to leverage this information to significantly enhance the delivery efficiency of supermarkets and reduce their environmental impact. By aligning marketing strategies with these behavioral insights, businesses can better cater to diverse consumer profiles while promoting sustainability.

Our findings, hypotheses, and related equations/framework reported in Table 8 offer a global view of our study and results.

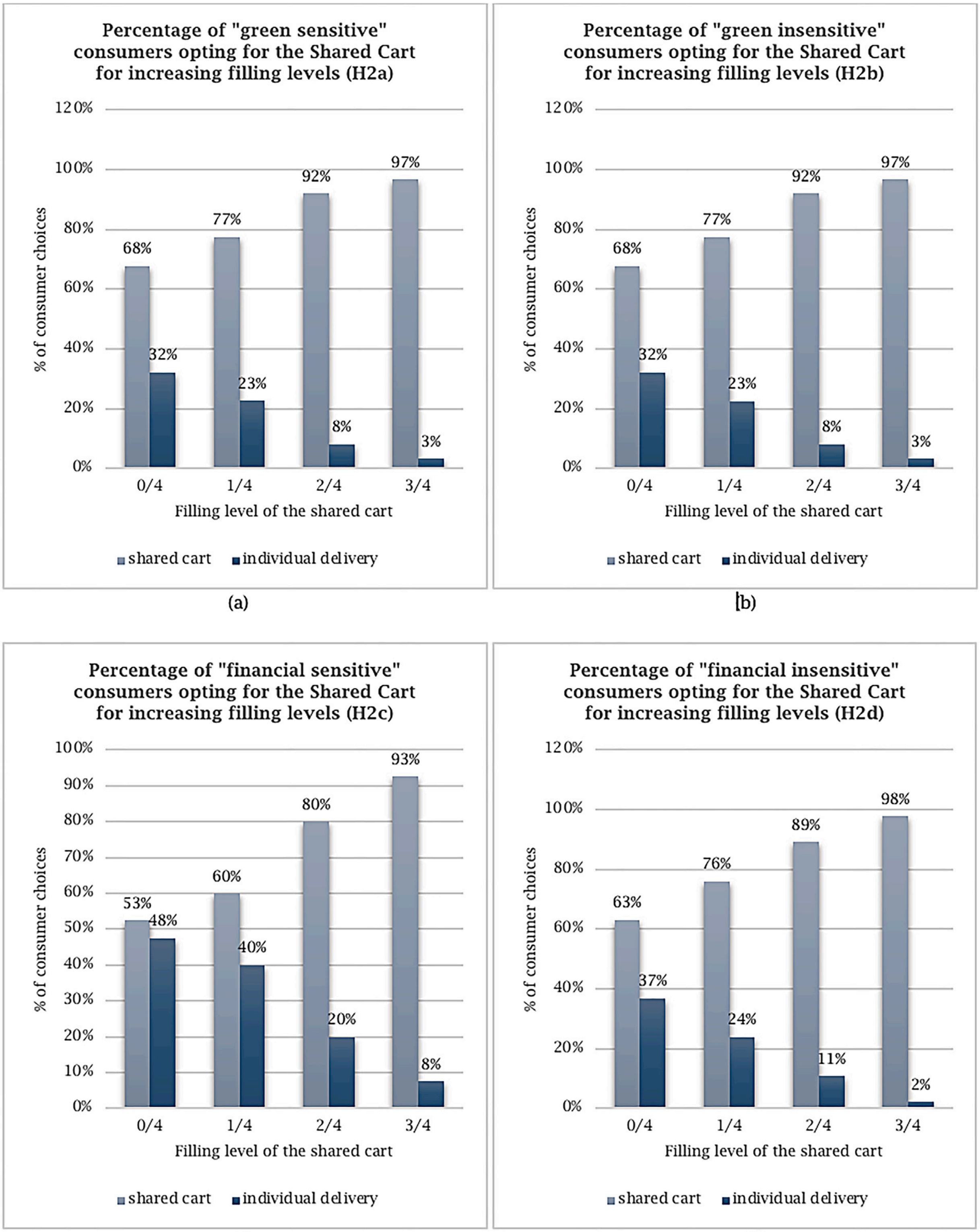


**Fig. 5.** Responses to shared cart delivery choices for H2a, H2b, H2c, and H2d.

## 6. The benefit of nudges: An optimization-based approach

We present two analyses to assess the benefits of nudges in last-mile deliveries. First, we assess the impact of the customers' flexibility on the total cost for the company. The second part assesses the shared cart concept.

### 6.1. Impact of customers' flexibility

In this analysis, we use the output of the previously described behavioral experiments to determine the percentage of customers being (i) not flexible; (ii) flexible on the day of delivery but not on the time of delivery; (iii) flexible on the time but not on the day; and (iv) flexible

**Table 8**
An overview of the hypotheses with their description, related elements (framework and equations), and results.

| Hypothesis | Definition | Further explanation (framework, equation, subgroups) | Confirmation (Y/N) and evidence (frequency, statistical analysis) |
|---|---|---|---|
| H1 | Green nudges and financial incentives synergically push consumers towards green grocery delivery. | Equation 1, Table 1, Table 2 | Y - Figure 2a (frequency analysis), Table 3 (statistical analysis) |
| H1a | The presence of a green nudge reinforces the effectiveness of financial incentives. | Equation 1, Table 1, Table 2 | Y - Figure 2b (frequency analysis) |
| H1b | Financial incentives do not reinforce the power of green nudge, being the green nudge being more motivating than financial incentives. | Equation 1 Table 1, Table 2 | Y - Figure 2c (frequency analysis) |
| H2 | Consumers will be influenced by the sustainable behavior of other consumers, opting for the shared cart under increasing levels of peer influence. | Figure 3, Equation 2 | Y - Figure 4 (frequency analysis results), Table 5 (statistical analysis results) |
| H2a | Green sensitive consumers will not be influenced by the sustainable behavior of other consumers, opting anyway for the shared cart. | Figure 3, Equation 2, Table 6 | N - Figure 5a (frequency analysis), Table 7 (statistical analysis) |
| H2b | Green insensitive consumers will be influenced by the sustainable behavior of other consumers, opting for the shared cart under increasing levels of peer influence. | Figure 3, Equation 2, Table 6 | Y - Figure 5b (frequency analysis), Table 7 (statistical analysis) |
| H2c | Financial sensitive consumers will not be influenced by the sustainable behavior of other consumers, opting anyway for the shared cart. | Figure 3, Equation 2, Table 6 | N - Figure 5c (frequency analysis), Table 7 (statistical analysis) |
| H2d | Financial insensitive consumers will be influenced by the sustainable behavior of other consumers, opting for the shared cart under increasing levels of peer influence. | Figure 3, Equation 2, Table 6 | Y - Figure 5d (frequency analysis), Table 7 (statistical analysis) |

on both. Customers who choose options (ii) and (iii) will receive €1, while those who select option (iv) will receive €2. To generate realistic instances, we use the data collected from the experiment described in Section 3 to derive a distribution of customer flexibility (on delivery day, delivery time, and both) per age group (18–30, 31–45, 45–65, +65). We cross-reference this data with the population distribution per age group for the districts in Turin, Italy, to compute the probability that a customer with a given flexibility preference could be located in a given district. Then, we designed an ad-hoc generator which creates instances base on these probabilities. This integrates the two methodologies by exploiting information extracted from the survey conducted in order to create realistic instances and simulate customers' behavior, to make the optimization experiments results more significant.

We suppose that the store is located slightly south of the city and that customers are located in the southern part of the city. The probabilities derived so far indicate 10 instances with 100 customers each. The preferred day and time of delivery are randomly chosen for each customer. The time horizon consists of five days (Monday–Friday) and five delivery time slots (9 am–11 am, 11 am–1 pm, 1 pm–3 pm, 3 pm–5 pm, and 5 pm–7 pm). The respective compensation is paid only if the preferred time and/or day is not respected.

Since we consider several customers, we do not explicitly model the vehicle routes. However, we assign a fixed cost for each district based on the distance from the grocery store. Each customer is assigned a day and a time slot. A district must be visited on a specific day and within a time slot if at least one customer living in the district has been assigned that day and time slot. We assume that a vehicle visits (delivers in) at least one district per time slot. The objective is to minimize the overall cost, which is the sum of delivery costs and compensation for customers.

The resulting problem is formulated as an integer programming model. The set of customers is indicated with $I$, the set of districts with $J$, the set of days with $D$, and the set of time slots with $T$. The preferred time and day for customer $i$ is defined as $\tau_i$ and $\delta_i$, respectively. The cost of serving a zone $j$ is known as $c_j$. The district in which customer $i$ is located is $a_i$, while $\psi_i^D$ and $\psi_i^T$ are constants equal to 1 if $i$ is not flexible concerning the day and time of delivery, respectively, and 0 otherwise. For customers belonging to category (i) both $\Psi_i^D$ and $\Psi_i^T$ are equal to 0, for those belonging to category (ii) $\Psi_i^D$ is set to 1 and $\Psi_i^T$ to 0. Conversely, for category (iii) $\Psi_i^D$ is 0 and $\Psi_i^T$ is 1, whereas for category (iv) both parameters take value 1.

Finally, the maximum number of available vehicles, corresponding to the maximum number of districts that can be simultaneously visited is referred to as $m$. We define four types of binary decision variables. The first, $y_{idt}$, indicates whether customer $i$ is assigned day $d$ and time slot $t$. Analogously, $x_{jdt}$ represents zone $j$, day $d$, and time slot $t$, while $z_i$ and $w_i$ are binary variables indicating if customer $i$ is served on a day and in a time slot different from the preferred ones, respectively. With $\gamma^D$ and $\gamma^T$ we refer to the incentives offered for ensuring flexibility on delivery day and time slots, respectively. A resuming table illustrating

**Table 9**
Notation used in the analysis on the impact of customers' flexibility.

| Notation | Description |
|---|---|
| $I$ | Set of customers |
| $J$ | Set of districts |
| $D$ | Set of days |
| $T$ | Set of time slots |
| $\tau_i$ | Preferred time slot of customer $i$ |
| $\delta_i$ | Preferred delivery day of customer $i$ |
| $c_j$ | Cost of serving district $j$ |
| $a_i$ | District of customer $i$ |
| $\psi_i^D$ | Binary parameter, which equals 1 if customer $i$ is not flexible on to the day, 0 otherwise |
| $\psi_i^T$ | Binary parameter, which equals 1 if customer $i$ is not flexible on the time slot, 0 otherwise |
| $\gamma_i^D$ | Monetary incentive for delivery day flexibility |
| $\gamma_i^T$ | Monetary incentive for delivery time slot flexibility |
| $m$ | Maximum number of available vehicles |
| $y_{idt}$ | Binary variable, which equals 1 if customer $i$ is assigned to day $d$ and time slot $t$ |
| $x_{jdt}$ | Binary variable, which equals 1 if district $j$ is served on day $d$ and time slot $t$ |
| $z_i$ | Binary variable, which equals 1 if customer $i$ is served on a day different from $\delta_i$ |
| $w_i$ | Binary variable, which equals 1 if customer $i$ is served in a time slot different from $\tau_i$ |

the notation used is reported in Table 9. The resulting problem can be described as a deterministic mixed integer linear programming model as follows.

$$\min \sum_{j\in J}\sum_{d\in D}\sum_{t\in T} c_j x_{jdt} + \sum_{i\in I}\gamma^T w_i + \sum_{i\in I}\gamma^D z_i \tag{3}$$

$$\sum_{d\in D}\sum_{t\in T} y_{idt} = 1 \quad \forall i \in I \tag{4}$$

$$z_i = 1 - \sum_{t\in T} y_{i\delta_i t} \quad \forall i \in I \tag{5}$$

$$w_i = 1 - \sum_{t\in T} y_{id\tau_i} \quad \forall i \in I \tag{6}$$

$$x_{jdt} \geq \frac{1}{N_i}\sum_{i\in I|a_i=j} y_{idt} \quad \forall j \in J \tag{7}$$

$$\sum_{j\in J} x_{jdt} \leq m \quad \forall j \in J \tag{8}$$

$$z_i = 0 \quad \forall i \in I|\psi_i^D = 0 \tag{9}$$

$$w_i = 0 \quad \forall i \in I|\psi_i^T = 0 \tag{10}$$

The objective function reported in (3) minimizes the total costs expressed as the sum of delivery cost if zone $j$ is served plus compensation costs. Each customer must be assigned a specific day and time slot, which is ensured by Constraint (4), while Constraints (5) and (6) detect whether a preferred time slot or day is violated. By Constraints (7), we define whether a district must be visited in a specific time slot and day. Constraint (8) limits the number of vehicles that can be simultaneously used, that is, the number of districts that can be simultaneously visited. Finally, Constraints (9) and (10) impose that preferred time slots and days can be violated only for customers who expressed flexibility.

The incentives offered for ensuring delivery day and time slot flexibility, $\gamma_i^T$ and $\gamma_i^D$, are fixed equal to €1.

Results of the experiments show that considering only flexibility on the day of the delivery reduces costs on average by 27.6%. If we consider only flexibility on the day of the delivery (while respecting all the preferred days), the gain increases to 27.5%. If we consider flexibility in both time slots and days, we can reduce costs by 48.7%. The maximum benefit achievable, in case, where all the customers provide flexibility on both day and time, is 72.6%.

These results indicate that both types of flexibility can considerably reduce last-mile delivery costs. The monetary compensation incentivizes the customers to be flexible and the associated costs are widely covered by the savings on the delivery costs. Hence, the concept could increase customer satisfaction, while reducing costs.

### 6.2. Analysis of the newly proposed shared cart concept

For this analysis, we used data extracted from the behavioral experiments to generate a sample of customers' arrivals and whether they joined the shared cart or insisted on individual delivery. The location and preference of customers were expressed as the minimum filling percentage of the cart for which they accepted to join were generated based on the probabilities computed by combining the data from the experiment with those related to the population of Turin. The store is located south of the city as in the previous experiment.

The choice of customers was influenced by the choice of previous customers from the same district, since it modified the filling level of the cart. Once a cart is complete, the order is delivered the next day. Even if the cart is incomplete, the orders are shipped within two days.

Customers joining the cart were rewarded with a compensation, $\gamma^c$, equal to €2. In this system, customer choices are influenced by the other customers, joining the shared cart, and contributing to increasing the filling level of the cart, making it more attractive for future customers. The company has to decide on the time slot for delivering a full shared cart, trying to combine this delivery with individual deliveries scheduled for the same day. Furthermore, they can decide to deliver a shared cart even if it is not full yet, if this is more efficient for the overall system. This is the case if, for instance, the company is already obliged to visit that district on that day for individual deliveries. This decision problem can be modeled as a bi-level optimization problem, in which the leader (the company) wants to minimize the total travel cost, and the followers (the customers) choose the delivery option that maximizes their satisfaction. This is the shared cart option if the current filling level is greater or equal to the minimum level for which they are willing to join it, $\sigma_i$, or the individual delivery in case the minimum level is not achieved. For customers not interested in joining the shared cart, the optimal choice is always to select the individual delivery. Due to its particular structure, the problem can be transformed into a single-level problem, by introducing variables representing customer choices and forcing them to assume the value that maximizes customer satisfaction. The resulting optimization problem is described below.

Variables $u_i$ are binary, taking value 1 if customer $i$ joins the shared cart and 0 otherwise. $Q_{dji}$ represents the filling level of the shared cart in zone $j$ on day $d$ after the $i$th customer made a delivery choice. Variables $x_{jdt}$ indicate that zone $j$ is visited in time slot $t$ of day $d$. $S_{jd}$ states if the shared cart in zone $j$ is filled up on day $d$. Note that a cart is considered full if it reaches a minimum number of orders $C$. However, the number of orders associated with this cart can be larger than $C$. This means that all customers joining this cart will be served the next day by a collective delivery. $A_{jd}$ allows to track if the cart of zone $j$ received at least one order on day $d$. All the mentioned variables are binary.

The additional notation introduced for this model is reported in Table 10.

The resulting problem can be described as a deterministic mixed integer linear model as follows.

$$\min \sum_{j\in J}\sum_{d\in D}\sum_{t\in T} c_j x_{jdt} + \sum_{i\in I}\gamma^c u_i \tag{11}$$

$$u_i \geq \frac{Q_{\delta_i a_i i-1} - \sigma_i + 1}{|I|} \quad \forall i \in I \tag{12}$$

$$u_i \leq 1 - \frac{-Q_{\delta_i a_i i-1} + \sigma_i}{|I|} \quad \forall i \in I \tag{13}$$

$$Q_{dj0} \leq |I|(1 - S_{jd-1}) \quad \forall j \in J \quad d \in D \tag{14}$$

**Table 10**
Notation used in the shared cart model.

| Notation | Description |
|---|---|
| $\gamma^c$ | Compensation for customers joining the shared cart (equals €2) |
| $\sigma_i$ | Minimum filling level of the shared cart that customer $i$ is willing to join |
| $u_i$ | Binary variable, which equals 1 if customer $i$ joins the shared cart, 0 otherwise |
| $Q_{dji}$ | Fill level of the shared cart in zone $j$ on day $d$ after the $i$th customer makes a delivery choice |
| $x_{jdt}$ | Binary variable, which equals 1 if zone $j$ is visited in time slot $t$ of day $d$ |
| $S_{jd}$ | Binary variable, which equals 1 if the shared cart in zone $j$ is full on day $d$ |
| $C$ | Minimum number of orders required for a cart to be considered full |
| $A_{jd}$ | Binary variable, which equals 1 if the cart in zone $j$ received at least one order on day $d$ |

$$Q_{da_i i} = Q_{da_i i-1} + u_i \quad \forall i \in I \;\; d \in 2 \ldots |D| \tag{15}$$

$$Q_{dli} = Q_{dli-1} \quad \forall i \in I \;\; l \in J | a_i \neq j d \in D \tag{16}$$

$$S_{jd} \geq (Q_{dji} - C_j)/|I| \quad \forall i \in I \;\; j \in J | a_i = j \;\; d \in D \tag{17}$$

$$A_{jd} \leq 1 + (Q_{dji} - 0.5)/|I| \quad \forall i \in I \;\; j \in J | a_i = j \;\; d \in D \tag{18}$$

$$S_{jd} \geq A_{jd-1} - S_{jd-1} \quad \forall j \in J \;\; d \in D \tag{19}$$

$$S_{j|D|} \geq A_{j|D|} \quad \forall j \in J \tag{20}$$

$$Q_{dj0} \leq |I| A_{jd-1} \quad \forall j \in J \;\; d \in D \tag{21}$$

$$\sum_{t \in T} y_{jdt} \geq S_{jd-1} \quad \forall j \in J \;\; d \in D \tag{22}$$

$$y_{jdt} \geq \sum_{i \in I | a(i)=j \wedge \delta_i = d \wedge \tau_i = t} (1 - u_i)/|I| \quad j \in J \;\; d \in D \;\; t \in T \tag{23}$$

$$\sum_{t \in T} y_{j|D|t} \geq \sum_{i \in I | \delta_i = |D|} u_i/|D| \quad \forall j \in J \;\; d \in D \tag{24}$$

The objective is to minimize the total delivery costs, as stated in (11). Constraints (12) and (13) simulate the customer choice processes and identify customers who join the cart. Constraints (14) reset the filling level of the cart after delivery. Constraints (15) and (16) allow to update the filling level of the cart based on customer choices. Constraints (17) check whether the cart has been filled up on a specific day. Similarly, Constraints (18) detect if a cart receives at least one order on a specific day. If not, the fulfillment level of that cart on the next day is forced to be 0 (21). Constraints (19) ensure that a cart is delivered within 2 days from the first received order. Constraints (20) force carts which are open on the last day to be delivered even if they are not full. This is to ensure that all the customers are served. Constraints (22) imply that if a cart is full it must be delivered on the next day, while constraints (23) impose that individual customers must be served on the day and in the time slot selected. Finally, constraints (24) ensure that also orders received on the last day of the time horizon are served.

We conduct a study on 10 instances with 100 customers, 16 zones, five days, and five time slots per day, and report average results. We tested the model with different cart sizes, $C = [0, 8]$, where $C = 0$ represents a scenario in which all customers must be served individually on their preferred day and time slot, meaning that the cart option does not exist. If $C = 1$, the cart is activated at the first order that arrives. This corresponds to the case in which a customer can decide to select the day and the time slot or receive the incentive, join the cart and be served on the next day but without the possibility of choosing the time window (this corresponds to the flexibility given in the first part of the study). In the case of $C = n$, where $n \geq 2$, the cart is delivered the next day if at least $n$ orders are placed; otherwise, it is delivered the next day. All data is provided in a publicly available repository (Mancini et al., 2025a). Both optimization problems can be solved by the commercial solver FICO Xpress 7.9, within seconds.

**Table 11**
Average cost, number of visits, and traveled distance for different cart sizes.

| Cart_Size | Cost | # Visits | Traveled distance |
|---|---|---|---|
| 0 | 1165 | 5.49 | 726 |
| 1 | 845 | 3.06 | 400 |
| 2 | 655 | 2.40 | 318 |
| 3 | 632 | 2.29 | 304 |
| 4 | 500 | 1.59 | 207 |
| 5 | 461 | 1.37 | 179 |
| 6 | 457 | 1.35 | 177 |
| 7 | 456 | 1.34 | 176 |
| 8 | 456 | 1.34 | 176 |

**Table 12**
Average number of customers served on the same day on which the order is made, on the next day, and after 2 days (for different cart sizes).

| Cart_Size | Same day | Next day | 2 days |
|---|---|---|---|
| 0 | 100 | 0 | 0 |
| 1 | 0 | 100 | 0 |
| 2 | 26.4 | 56.9 | 15.7 |
| 3 | 27.8 | 51.8 | 20.4 |
| 4 | 16.6 | 39.6 | 43.8 |
| 5 | 13.8 | 33.9 | 52.3 |
| 6 | 13.6 | 32.6 | 53.8 |
| 7 | 13.5 | 31.8 | 54.7 |
| 8 | 13.5 | 31.8 | 54.7 |

In Table 11 we report the average delivery cost, the number of visits per district, and the distance traveled. From this table, we can observe that respecting all the customer requests about preferred day and time slots yields a very inefficient delivery plan, requiring a visit to each zone more than 5.49 times within the five days. We can considerably reduce costs by 27.5% guaranteeing that customers are all served the day after they place their order but letting the company decide the time slot for delivery (obtainable by exploiting a cart size equal to 1). The gain can be increased by increasing the size of the cart up to 7, for which we reach the minimum cost achievable corresponding to savings of 60.9%. Values of cart size 8 does not provide any further improvement. It is worth noting that, from size 5 on, the marginal improvement is very little.

In Table 12, we report the percentage of customers served (i) on the same day on which the order is performed, (ii) on the next day, and (iii) in 2 days. Obviously, without the cart option, every customer is served on the same day, which is the maximum level of service achievable. However, the delivery costs for the company are so high that this option is not economically viable as well as not sustainable from an environmental perspective as almost all the zones are visited every day, and some of them even more than once per day. With the increase of the cart size, average waiting times increase since the percentage of customers served in 2 days strongly increases. However, this waiting time increment is fully compensated by the savings from both an economic and an environmental point of view. Based on these observations, a cart size of 4 turns out to be the most reasonable one as it provides a considerable improvement in terms of cost, while the majority of the customers (57.2%) is served within 1 day. A cart of size 5 still produces a significant improvement of costs (around 8%) but also increases waiting times. Larger sizes provide only very marginal economic improvements combined with very waiting times.

It is worth noting that the distance traveled and consequently the emissions can also be considerably reduced (75.75%) by exploiting the collective cart approach. This indicates the high potential of this delivery option both in terms of environmental impact and cost for the company.

## 7. Conclusions

The first part of the study demonstrated that green nudges and financial incentives, when used separately, had a noticeable impact on consumer behavior. Green nudges, encompassing eco-friendly messaging and social norms, led to significant shifts in consumer choices toward environmentally friendly options. Financial incentives also encouraged more flexible behavior, as seen in the 28% of customers who opted for medium flexibility with financial incentives alone. When financial incentives were combined with green nudges, a synergistic effect emerged, leading to a significant increase in flexible and eco-friendly delivery options. The combined incentives resulted in 51% of customers choosing medium flexibility, a notable jump from 28% with financial incentives alone. This suggests that a combination of moral and financial motivators could drive more sustainable consumer behavior. The study also highlighted the impact of cooperation among consumers, particularly in the context of the shared cart concept. When customers saw others joining the shared cart, they were more likely to do the same, influenced by social proof and collective behavior. This cooperative approach, where customers opted for shared delivery, increased cost savings up to 57.2% and reduced environmental impact. Trust in others played a crucial role in consumer behavior. Customers who trusted the cooperative behavior of others were more inclined to choose shared delivery options. This trust fostered a community-oriented approach to last-mile delivery, encouraging consumers to make eco-friendly choices based on collective behavior. The second part explored operational optimization, focusing on the benefits of customer flexibility in delivery timing and the concept of shared carts The findings showed that flexibility in delivery, with compensations, reduced costs significantly. Offering flexibility on the day of delivery led to a 20.3% to 42.5% reduction in costs. The concept of shared carts, where customers shared delivery slots, saved up to 57.2% in costs, demonstrating the effectiveness of cooperation in reducing operational costs. The concept of shared carts emerged as a significant factor in reducing operational costs and environmental impact in last-mile grocery delivery. By allowing customers to combine orders and share delivery slots, this approach significantly cuts costs for the company while encouraging eco-friendly behavior among customers. The study revealed that customers' willingness to join the shared cart was influenced by the cart's filling level. If the cart was already 75% full, 92% of customers opted to join, while only 73% joined if it was empty. This dynamic showcases the impact of social proof and cooperative behavior on customer decisions. The company can optimize delivery by choosing the time slots and days to deliver full shared carts, further reducing costs. This approach also had a positive environmental impact by reducing the number of trips and vehicle emissions. From an analysis conducted on the size of the shared cart, it has emerged that a size equal to 4 guarantees the best balance among operational costs and customers satisfaction expressed in terms of waiting times for the sampled population.

When the findings from both parts are combined, a unique opportunity arises to promote sustainable behavior while reducing operational costs. The synergistic relation between financial incentives and green nudges leads to more flexible and eco-friendly delivery options. This synergy, combined with the cost-saving benefits of customer flexibility and shared carts, creates a comprehensive approach to promoting sustainability in last-mile delivery. The study contributes to the existing literature by filling several gaps. It demonstrates the effectiveness of green nudges and financial incentives in driving sustainable consumer behavior, addressing the question of which strategy is more effective in promoting flexibility. The findings also highlight the role of cooperation and trust in others in influencing consumer choices. The results from the second part add to the literature by showing that operational optimization through customer flexibility and shared carts can lead to significant cost savings and environmental benefits. These insights are a valuable addition to the growing body of research on sustainability in last-mile delivery. Managers in the grocery delivery industry can leverage these findings to design strategies that promote sustainability while reducing operational costs. For example, supermarkets operating in contexts with similar consumer characteristics, can apply the solution provided in our study, while in context with different consumer characteristics can replicate the same methodology to find an optimal solution appropriate to their context. Implementing green nudges and financial incentives, along with shared cart concepts, can lead to significant cost savings and improved customer satisfaction. Managers must also consider fostering cooperation and trust among consumers to encourage collective eco-friendly behavior. Policymakers can use these insights to design regulations that support sustainable last-mile delivery practices. By encouraging businesses to adopt green nudges and shared cart strategies, policymakers can help reduce the environmental impact of delivery operations. Promoting flexibility in delivery schedules and supporting cooperation among consumers can further enhance sustainability in last-mile delivery.

The shared cart concept could be applied to general e-commerce platforms by incentivizing consumers to consolidate their purchases to reduce delivery emissions. This could involve bundling orders or aligning delivery times for multiple customers in the same area. Similar principles could encourage carpooling or ride-sharing, where financial incentives and nudges promote shared rides over single-occupancy trips, reducing traffic congestion and emissions. The concept might also inspire behavioral interventions in energy management such as shared energy usage plans or nudges to shift consumption to off-peak hours to optimize grid sustainability. The findings of our study not only reveal significant cost-saving opportunities for companies but also underscore the imperative for policy interventions at various levels, ranging from policymakers to individual companies, to foster sustainable behavior. Through our research, we demonstrate the compatibility of sustainability and profitability objectives, while highlighting the efficacy of nudges as cost-effective and enduring mechanisms for achieving sustainability goals. This challenges the prevailing notion that sustainable practices inherently compromise a company's bottom line.

While our study contributes to existing studies, we acknowledge the following limitations. While the sample encompasses participants with varying characteristics, it may not fully capture the diversity of consumers from different cultural or economic backgrounds. Moreover, we acknowledge that the sampling method used for the group of non-customers represents a limitation. However, our intent was to ensure the inclusion of potential customers who are generally situated within the area where the supermarket operates, as they represent a relevant segment for assessing delivery preferences and behaviors. The study focuses on financial incentives and nudging, potentially overlooking other behavioral or psychological factors that influence consumer decisions. Moreover, although we used nudges to raise awareness that a customized delivery impacts negatively on the environment, there are other types of nudges that could be explored. Thus, we cannot definitively conclude on the effectiveness of nudges or their synergistic effects without examining other methods in the future. As far as the cart-sharing option is concerned, the level of the shared cart partially reflects the behavior of peers, but they may have chosen it solely for the financial incentive. Similarly, the participant might be driven purely by economic motivations. It would therefore be advisable to include an unequivocal signal of sustainable behavior from peers to ensure that the participant perceives this specific aspect, rather than others. This would allow for a clearer understanding of whether their decision is influenced by the pressure exerted by the genuinely sustainable behavior of others. Another limitation concerns the amount of the financial incentive. Given that these are frequent purchases, the amount cannot deviate significantly from the realistic assumptions of the experiment.

However, consumers' sensitivity to the value of the financial incentive should be tested or directly elicited by asking: "how much would you be willing to give up customized delivery for?". The novel approach of this is highly encouraging for future research. In particular, it paves the way for future research to model the optimal financial incentives, for given levels of consumer flexibility, to achieve a specific cost-saving target, and the optimal ratio between financial incentives and cost-saving. Future research could explore the effects of different types of nudges or variations in the level of financial incentives across different demographic groups. Furthermore, the concept of shared carts could be extended to other sectors of urban logistics such as last-mile delivery for e-commerce companies such as Amazon.

## CRediT authorship contribution statement

**Eleonora Rizzitello:** Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation. **Giovanna Lo Nigro:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Simona Mancini:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology. **Margaretha Gansterer:** Writing – review & editing, Writing – original draft, Validation.

## Data availability

Data will be made available on request.

## References

Agatz, N., Fan, Y., Stam, D., 2021. The impact of green labels on time slot choice and operational sustainability. Prod. Oper. Manage. 30 (7), 2285–2303.
Alcott, H., Rogers, T., 2014. The short-run and long-run effects of behavioral interventions: Experimental evidence from energy conservation. Am. Econ. Rev. 104 (10), 3003–3037.
Arroyo-López, P., Velázquez-Martínez, J.C., Gámez-Pérez, K.M., 2021. Past behavior as a predictor of eco-driving practices: The case of a sustained intervention in a Mexican transportation company. Int. J. Sustain. Transp. 16 (11), 989–1002.
Asensio, O., Delmas, M., 2016. The dynamics of behavior change: evidence from energy conservation. J. Econ. Behav. Organ. 126, 196–212.
Belhadi, A., Kamble, S.S., Mani, V., Shi, Y., 2021. Behavioral mechanisms influencing sustainable supply chain governance decision-making from a dyadic buyer-supplier perspective. Int. J. Prod. Econ. 236, 108136.
Benartzi, S., Beshears, J., Milkman, K., Sunstein, C., Thaler, R., Shankar, M., Tucker-Ray, W., Congdon, W., Galing, S., 2017. Should governments invest more in nudging? Psychol. Sci. 28, 1041–1055.
Boyer, K.K., Prud'homme, A.M., Chung, W., 2009. The last mile challenge: Evaluating the effects of customer density and delivery window patterns. J. Bus. Logist. 30 (1), 185–201.
Buckley, P., Llerena, D., 2022. Nudges and peak pricing: A common pool resource energy conservation experiment. J. Behav. Exp. Econ. 101, 101928.
Cachon, G.P., Terwiesch, C., 2019. Matching Supply with Demand: An Introduction to Operations Management, third ed. McGraw-Hill Education.
Capraro, V., Jagfeld, G., Klein, R., Mul, M., De Pol, I., 2019. Increasing altruistic and cooperative behaviour with simple moral nudges. Sci. Rep. 9, 11880.
Cialdini, R., 2003. Crafting normative messages to protect the environment. Curr. Dir. Psychol. Sci. 12 (4), 105–109.
Fahimnia, B., Pournader, M., Siemsen, E., Bendoly, E., Wang, C., 2019. Behavioral operations and supply chain management–A review and literature mapping. Decis. Sci. 50 (6), 1127–1183.
Fanghella, V., Ploner, M., Tavoni, M., 2021. Energy saving in a simulated environment: An online experiment of the interplay between nudges and financial incentives. J. Behav. Exp. Econ. 93, 101709.
Farrow, K., Grolleau, G., Ibanez, L., 2017. Social norms and pro-environmental behavior: a review of the evidence. Ecol. Econom. 140, 1–13.
Fehr, E., Schmidt, K., 1999. A theory of fairness, competition, and cooperation. Q. J. Econ. 114, 817–868.
Fehr, E., Schurtenberger, I., 2018. Normative foundations of human cooperation. Nat. Hum. Behav. 2, 458–468.
Fiorillo, D., Sapio, A., 2019. Energy saving in Italy in the late 1990s: which role for non-monetary motivations? Ecol. Econom. 165, 106386.
Gneezy, U., Rustichini, A., 2000. A fine is a price. J. Leg. Stud. 29 (1), 1–18.
Hobbs, J., 2020. Food supply chains during the COVID-19 pandemic. Can. J. Agric. Econ./Rev. Can. D'Agroecon. 68 (2), 171–176.
Huitink, M., Poelman, M.P., van den Eynde, E., Seidell, J.C., Dijkstra, S.C., 2020. Social norm nudges in shopping trolleys to promote vegetable purchases: A quasi-experimental study in a supermarket in a deprived urban area in the netherlands. Appetite 151, 104655.
Kemp, L., Xu, C., Depledge, J., Ebi, K., Gibbins, G., Kohler, T., Röckstrom, J., Scheffer, M., Schellnhuber, H., Steffen, W., Lenton, T., 2022. Climate endgame: Exploring catastrophic climate change scenarios. Proc. Natl. Acad. Sci. 119.
Kirchoff, J.F., Omar, A., Fugate, B.S., 2016. A behavioral theory of sustainable supply chain management decision making in non-exemplar firms. J. Supply Chain Manag. 52 (1), 41–65.
Kurowski, L., Rutecka-Góra, J., Smaga, P., 2022. Is knowledge on climate change a driver of consumer purchase decisions in Poland? The case of grocery goods and green banking. J. Clean. Prod. 369, 133444.
Lang, M., Cleophas, C., Ehmke, J.F., 2021. Multi-criteria decision making in dynamic slotting for attended home deliveries. Omega 102, 102305.
Lange, F., 2023. Behavioral paradigms for studying pro-environmental behavior: A systematic review. Behav. Res. Methods 55, 600–622.
Loewenstein, G., Brennan, T., Volpp, K.G., 2007. Asymmetric paternalism to improve health behaviors. JAMA 298 (20), 2415–2417.
Mancini, S., Gansterer, M., 2021. Vehicle Routing with private and shared delivery locations. Comput. Oper. Res. 133, 105–361.
Mancini, S., Gansterer, M., Rizzitello, E., Nigro, G., 2025a. Instances for nudging the last mile: Combining behavioral insights and monetary incentives for sustainable delivery choices. Mendeley Data V1, http://dx.doi.org/10.17632/yv9kvj48bc.1.
Mancini, S., Ulmer, M.W., Gansterer, M., 2025b. Dynamic assignment of delivery order bundles to in-store customers. Omega 133, 103246.
Melkonyan, A., Gruchmann, T., Lohmar, F., Kamath, V., Spinler, S., 2020. Sustainability assessment of last-mile logistics and distribution strategies: The case of local food networks. Int. J. Prod. Econ. 228), 107746.
Mi, L., Gan, X., Sun, Y., Lv, T., Qiao, L., Xu, T., 2021. Effects of monetary and nonmonetary interventions on energy conservation: A meta-analysis of experimental studies. Renew. Sustain. Energy Rev. 149, 111342.
Mizobuchi, K., Takeuchi, K., 2013. The influences of financial and non-financial factors on energy-saving behaviour: A field experiment in Japan. Energy Policy 63, 775–787.
Nguyen, D.H., De Leeuw, S., Dullaert, W., Foubert, B.P., 2019. What is the right delivery option for you? Consumer preferences for delivery attributes in online retailing. J. Bus. Logist. 40, 299–321.
Oppenheimer, D.M., Meyvis, T., Davidenko, N., 2009. Instructional manipulation checks: Detecting satisficing to increase statistical power. J. Exp. Soc. Psychol. 45 (4), 867–872.
Otaki, Y., Onuki, Y., Hosokawa, Y., 2024. Influence of financial incentive and nudge, alone and combined, on water-saving behaviors. Sustain. Future 7, 100224.
Phipps, E.J., Braitman, L.E., Stites, S.D., Singletary, S.B., Wallace, S.L., Hunt, L., Axelrod, S., Glanz, K., Uplinger, N., 2015. Impact of a Rewards-Based incentive program on promoting fruit and vegetable purchases. Am. J. Public Health 105 (1), 166–172.
Polonsky, M., Vocino, A., Grimmer, M., Miles, M., 2014. The interrelationship between temporal and environmental orientation and pro-environmental consumer behaviour. Int. J. Consum. Stud. 38, 612–619.
Pruitt, D., Kimmel, M., 1977. Twenty years of experimental gaming: Critique, synthesis, and suggestions for the future. Annu. Rev. Psychol. 28, 363–392.
Rajapaksa, D., Gifford, R., Torgler, B., Garcia-Valinas, M., Athukorala, W., Managi, S., Wilson, C., 2019. Do monetary and non-monetary incentives influence environmental attitudes and behavior? Evidence from an experimental analysis. Resour. Conserv. Recycl. 149, 168–176.
Sadiq, M., Bharti, K., Adil, M., Singh, R., 2021. Why do consumers buy green apparel? The role of dispositional traits, environmental orientation, environmental knowledge, and monetary incentive. J. Retail. Consum. Serv. 62, 102643.
Shubert, T., Goto, L., Smith, M., Jiang, L., Rudman, H., Ory, M., 2017. The Otago Exercise Program: Innovative delivery models to maximize sustained outcomes for high risk, homebound older adults. Front. Public Health 5.
Thaler, R., Sustein, C., 2008. Nudge: Improving Decisions About Health, Wealth, and Happiness. Yale University Press.
van Dijk, E., De Dreu, C., 2021. Experimental games and social decision making. Annu. Rev. Psychol. 72, 415–438.
Vermote, B., Aelterman, N., Beyers, W., Aper, L., Buysschaert, F., Vansteenkiste, M., 2020. The role of teachers' motivation and mindsets in predicting a (de)motivating teaching style in higher education: a circumplex approach. Motiv. Emot. 44 (2), 270–294.
Voigt, S., Frank, M., Kuhn, H., 2025. Last mile delivery routing problem with some-day option. European J. Oper. Res. 324 (2), 477–491.
Xiao, Y., Konak, A., 2017. A genetic algorithm with exact dynamic programming for the green vehicle routing & scheduling problem. J. Clean. Prod. 167, 1450–1463.
Yoeli, E., Budescu, D., Carrico, A., Delmas, M., DeShazo, J., Ferraro, P., Forster, H., Kunreuther, H., Larrick, R., Lubell, M., Markowitz, E., Tonn, B., Vandenbergh, M., Weber, E., 2017. Behavioral science tools to strengthen energy & environmental policy. Behav. Sci. Policy 369, 133444.
Zhou, Y., Mandania, R., Liu, J., 2022. Green vehicle routing and dynamic pricing for scheduling on-site services. Int. J. Prod. Econ. 25a, 108602.