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Abstract

This Data Collection Instrument (DCI) establishes a guideline and survey framework for quantifying consumer preferences and willingness-to-pay (WTP) for commodities that containing recycled plastic. The instrument combines behavioral experience metrics, attitudinal scales, and a Discrete Choice Experiment (DCE). The DCE employs a multi-dimensional split-sample design that varies across three critical axes: (1) product context, contrasting low-cost discretionary items (phone cases) with high-cost functional goods (sneakers); (2) valuation methodology, comparing baseline attribute-based valuations against information treatment valuations; and (3) the information framing, which provides respondents with external data showing either a significant decrease or increase in the energy required for production. By isolating the causal effect of sustainability disclosures through a within-subject "information shock" mechanism, this research estimates how stated preferences and WTP for attributes associated with recycled plastic products shift after information is provided. Beyond the expected empirical findings, this DCI provides a reproducible methodological blueprint for researchers and practitioners, enhancing the reliability of stated preference studies for emerging circular economy technologies. Additionally, this DCI contains a series of questions aimed at validating that the data is from human subjects rather than synthetic data.

Keywords

discrete choice experiment (DCE); conjoint analysis; recycled plastic; information treatment; willingness-to-pay (WTP); consumer preferences

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1. Introduction

The accurate measurement of consumer preferences for novel product attributes is essential for both market development and policy design, particularly for innovations like recycled plastics. Survey methods collecting stated preference (SP) data are often used to evaluate the willingness to pay (WTP) in the absence of observational data for new products or product attributes that are not currently on the market. A common survey method for eliciting WTP estimates for products is a discrete choice experiment (DCE), where the attribute levels of an item change and consumers answer a series of questions where they select between a few alternative products (Contemporary Guidance for Stated Preference Studies, 2017; Louviere, 1988).

However, a methodological debate has emerged regarding the integration of information treatments within DCEs and how these treatments may influence preference measurements (Haghani et al., 2021), particularly in the context of hypothetical bias, the well-documented tendency for respondents to overstate their preferences or WTP in hypothetical settings compared to real-world behavior (Penn & Hu, 2018). Information treatments allow the treatment effect to be calculated based on the change in behavior after the information is provided, rather than only relying on the attribute variation between choices. This research addresses this methodological gap by directly comparing standard DCEs with information treatment-enhanced DCEs using the content of recycled plastic used in a consumer product as a case study.

The environmental context is significant: A global life cycle analysis of plastics shows that of the 400 million tonnes of plastic produced worldwide in 2022, only about 9.5% was made from recycled materials, with the remainder derived from virgin materials (Houssini et al., 2025). In the United States (US), while accounting for a high share of global production (19%) and consumption (21%) (Environment, 2018; Heller et al., 2020), the recycling rate for post-consumer plastic waste may be as low as 5 % to 6 % (Milbrandt et al., 2022). Studying consumer WTP for products containing recycled plastic is critical to capture the economic value of plastic waste and mitigate potential impacts of plastic waste. However, the drivers and barriers related to the demand for recycled plastics are not thoroughly understood.

This study aims to answer both contextual questions regarding the recycled plastics market and methodological questions regarding survey design:

- Contextual objectives
    - Identify the demographics of current and prospective consumers of **products containing recycled plastic** (hereafter, "**recycled plastic products**").
    - Analyze how consumers trade off product attributes (e.g., price vs. % of recycled content) across different product categories like phone cases and sneakers.
    - Quantify whether consumers are willing to pay a premium for products containing recycled plastics compared to products with conventional "virgin" plastics.
    - Evaluate how energy-related information provision and individual environmental knowledge impact WTP.
- Methodological objectives

- Quantify differences in WTP estimates between standard DCEs and information-treatment DCEs
- Determine how the magnitude of the information treatment effect (e.g., specific energy consumption) influences results.
- Assess how contextual factors, including product category (e.g., phone cases versus sneakers), information format (e.g., texts vs. videos), and device type for taking the survey (e.g., mobile vs. desktop), moderate the differences between methodological approaches.

To accomplish these objectives, this DCI outlines the development and implementation of a conjoint choice experiment survey designed to collect data from US consumers using a rigorous split-sample experimental approach with multiple treatment arms. By building on established survey methodology literature, this approach seeks to isolate the specific effects of information provision within the choice experiment framework, providing a robust mechanism for evaluating both consumer preferences and the impact of survey design on economic valuation.

2. Background

2.1. Methodological Challenges in Stated Preference Research

Stated preference methods face persistent challenges regarding reliability and external validity (Lancsar & Swait, 2014; Louviere, 1988). While these methods are invaluable for estimating demand for novel products and attributes, questions remain about how study design choices influence results. Recent meta-analyses (Xie et al., 2022; Yeh & Hirsch, 2023) have shown significant variability in WTP estimates across different studies examining the same attributes, suggesting that methodological factors may play a substantial role in determining outcomes. A systematic review (Kanya et al., 2019) suggests that hypothetical WTP was on average 3.2 times greater than actual WTP.

Information provision represents a particularly challenging aspect of state preference (SP) research. On one hand, providing contextual information ensures that participants have a baseline understanding of unfamiliar attributes, like plastic recycling processes (Welling et al., 2022). On the other hand, information treatments may inadvertently prime participants or create experimenter demand effects that bias WTP estimates (Cai et al., 2011).

2.2. Information Treatments in Discrete Choice Experiments

Traditional DCEs focus on varying product attributes systematically while holding other factors constant. However, an emerging approach incorporates explicit information treatments — providing participants with different contextual information before or during the choice tasks (Vass et al., 2020). This approach allows researchers to measure not just preferences across attribute levels but also how these preferences shift in response to new information.

Previous research has employed this hybrid approach in domains such as renewable energy (Haghani et al., 2021), alternative fuel vehicles (Cherchi, 2017), and food labeling (Liao et al., 2025). Multiple studies have been focusing on plastic products with various forms of survey design (De Marchi et al., 2020; Grebitus et al., 2020; Orset et al., 2017). De Marchi et al. (2020) explore consumer preferences and WTP for plastic water bottles made of conventional plastic and of more sustainable plastic alternatives and investigates whether information on plastic-related sustainability might affect consumer purchasing decisions.

Similarly, Grebitus et al. (2020) assess the preferences and WTP for bottled water and plastic packaging with DCEs consisting of both between-subject and within-subject designs to explore the effects of experiment setting, behavioral messages, and internet searching. Specifically, one study was done in a lab setting, and one in an online setting. At the same time, within each study, half of them were nudged to make a pro-environmental choice, whereas the remaining participants only followed their own preferences. Specifically, the nudging message describes the level of recyclability, biodegradability, and compostability of different plastic materials, which was followed by a discrete choice experiment.

Orset et al. (2017) divided the experiments into several stages and delivered successive messages emphasizing the characteristics and their environmental impacts of plastic bottles to consumers.

Also, different sets of messages are designed for different plastic materials. Different from the previous two studies, WTP in this study was elicited after each message with the following question: What is the maximum price you are willing to pay?

All these studies have indicated that when respondents are informed about sustainability-related characteristics of the different plastics using non-coercive guidance (i.e., nudge messaging), they are more likely to select sustainable bottles and to pay more for less impactful materials. However, systematic methodological comparisons are lacking. It remains unclear whether the information treatment approach yields different WTP estimates than standard DCEs, and if so, which approach better predicts actual market behavior.

2.3. Recycled Plastics Context

Existing research on plastics has largely focused on environmental impacts, consumer awareness, and pro-environmental behaviors associated with virgin plastic use (Heidbreder et al., 2019). However, the growing prominence of recycled plastic products in consumer-facing goods and messaging makes them a particularly suitable context for stated preference methods and for examining how information treatments influence preference formation and measurement (Corsini et al., 2024; Polyportis et al., 2023; Ruokamo et al., 2022). While academic and industry interest in plastic recycling has grown substantially (MacArthur Foundation, 2016), empirical evidence on consumer acceptance of recycled plastic products remains limited. In particular, findings on WTP for recycled products are mixed, with some studies identifying positive premiums and others suggesting neutral or even negative valuations.

This gap is especially important in the context of the circular economy, which emphasizes resource efficiency through recycling, reuse, and material recovery across the supply chain (Kirchherr et al., 2023). Although circular supply chains create opportunities for reducing resource use and enhancing long-term economic resilience, their success ultimately depends on establishing end markets, and hence on consumer acceptance. One key challenge is that consumers often have difficulty distinguishing products with recycled content from conventional alternatives. As a result, information provision, particularly through labeling, plays a critical role in enabling product differentiation and shaping consumer perceptions.

A growing body of literature shows that consumers are willing to pay for products that provide non-market benefits, such as recyclability or reduced resource utilization (Thomas et al., 2024). Studies on circular products, including those incorporating recycled plastics, generally find positive WTP for attributes aligned with circularity. For example, consumers have demonstrated premiums for products made from recycled materials (Testa et al., 2022) and for recyclable packaging (Klaiman et al., 2016). Beyond recycled content itself, consumer preferences are also influenced by broader informational attributes, such as country-of-origin labels, lifestyle alignment, and disclosures regarding additives or environmental risks.

Within this context, labeling emerges as a central mechanism for communicating non-market attributes. Effective labels provide clear, credible, and relevant information that reduces information asymmetry and supports informed decision-making (Van Loo et al., 2011, 2014). The literature further emphasizes the role of certification, verification, and traceability systems in

enhancing the credibility of such claims (Darnall et al., 2018). Importantly, the effectiveness of labeling varies depending on its source and design; for instance, government-backed certifications, private labels, and generic claims may differ substantially in their influence on consumer trust and purchasing behavior.

Building on this foundation, this study examines how different forms of information affect consumer WTP for recycled plastic products. By focusing on how recycled content is communicated and perceived, this research addresses a key gap in the literature on non-market valuation and consumer preferences. In doing so, it contributes to a more nuanced understanding of how information design influences preference formation in emerging product categories. The insights from this literature directly inform the development of our survey instrument, ensuring that it captures the most market-relevant attributes affecting consumer decision-making in the context of recycled plastics.

3. Survey Instrument

The survey instrument is organized into four main sections:

1) **Screening Questions** – Assess respondents' familiarity and experience with recycled plastics.
2) **Discrete Choice Experiments** – Present six choice scenarios to examine preferences and adoption of recycled plastic products.
3) **Knowledge and Attitudes** – Measure respondents' familiarity with and attitudes toward plastic recycling and related topics.
4) **Demographics** – Collect basic sociodemographic information to support segmentation and analysis.

3.1. Survey Introduction and Participation Consent

If carried out, the survey should open with a brief introduction of the research team, a summary of the key topics covered, and an estimate of how long it will take to complete. Next, it should present an informed consent statement explaining the study's goals, sources of funding, voluntary participation, confidentiality protections, eligibility requirements (such as being 18 or older), and any possible benefits or risks involved. Only respondents who provide consent can move forward to the rest of the survey. The consent text must be reviewed and approved by the Institutional Review Board (IRB).

3.2. Recycled Plastic Experience

The first section of the survey starts with a definition of "recycled plastic" versus "virgin plastic" to ensure a common understanding:

Product Type	Description
 Recycled plastic product	made *partly or entirely* from plastic materials that have been collected, processed, and reused after their initial use — such as plastic bottles placed in a household recycling bin that would otherwise have ended up in a landfill.
 Virgin plastic product	made *entirely* from new, petroleum-based raw materials that have never been used or recycled before.

The survey begins by assessing whether respondents currently or previously owned products made entirely or partially of recycled plastic. For those with prior experience, a grid captures their purchase history across 11 categories (e.g., clothing, footwear, electronics, and household supplies). To gauge broader perceptions, any category not selected is presented in a follow-up question asking for the respondent's opinion on its suitability for recycled plastic. Conversely, participants who have never owned recycled plastic products are asked to identify which of the 11 categories they believe are appropriate for such materials.

This section is designed to establish "baseline familiarity" and reveal preconceived beliefs regarding the appropriateness of recycled plastic across product domains. Analytically, these responses allow for market segmentation between "experienced" and "novice" consumers. Because prior experience often influences price sensitivity and quality expectations, these variables will serve as covariates in the choice models to test if experience correlates with higher WTP or lower levels of hypothetical bias.

Do you currently own, or have you previously owned, any products made from recycled plastic?
Yes, currently
Yes, in the past
No
I don’t remember or I am not sure
*

What recycled plastic products do you currently own or have owned? *Select all that apply.*
Clothing, footwear, and other textiles (e.g., blanket)
Bags, backpacks, and accessories (e.g., purses)
Furniture (e.g., patio tables, indoor shelving units)
Toys (e.g., building blocks, toy trucks)
Food packaging, containers, bottles
Electronic products and accessories (e.g., phone cases)
Kitchen utensils and food service items (e.g., cups, plates)
Storage supplies (e.g., bins, totes)
Cleaning tools (e.g., broom, mop)
Garden and yard products (e.g., planters, flowerpots)
Construction products (e.g., PVC piping, wall panels)
Other household supplies
Others
I don’t remember or I am not sure
*

For which of these following items do you consider recycled plastic to be an appropriate material? *Select all that apply. Feel free to go back to the previous page if you need to update your earlier response.*
Clothing, footwear, and other textiles (e.g., blanket)
Bags, backpacks, and accessories (e.g., purses)
Furniture (e.g., patio tables, indoor shelving units)
Toys (e.g., building blocks, toy trucks)
Food packaging, bottles
Electronic products or accessories (e.g., phone cases)
Kitchen utensils and food service items (e.g., cups, plates)
Storage supplies (e.g., bins, totes)
Cleaning tools (e.g., broom, mop)
Garden and yard products (e.g., planters, flowerpots)
Construction products (e.g., PVC piping, wall panels)
Other household supplies
None of the above

This section also presents three attitudinal statements towards personality traits. Respondents rate their agreement using a 5-point Likert scale.

Please indicate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Generally, I am willing to put in extra effort to find lower prices.					
I am a person who is fully prepared to take risks.					
I like to be among the first people to have the latest technology.					

3.3. Product Style Selection

The survey evaluates consumer preferences across two distinct product categories: **phone cases** (low-cost accessory) and **running shoes** (mid-to-high-cost apparel). These categories were selected based on three criteria (Goucher-Lambert & Cagan, 2015):

1. **Durability:** Both items are classified as durable or semi-durable goods, which implies a more deliberate purchasing process compared to single-use fast-moving consumer goods.
2. **Material Composition:** Both products can be manufactured either partially or entirely from plastic-based materials, making the transition to recycled content technically feasible and recognizable to the consumer.
3. **Market Diversity:** The selected items represent different product classes and price points. Phone cases carry a typical market price of **$15**, representing a low-stakes "impulse" or "add-on" purchase, while running shoes are priced at **$100**, representing a higher-investment, performance-oriented purchase. The price levels used in the choice tasks were calibrated to reflect current retail averages, ensuring the trade-offs presented in the experiment are grounded in realistic market conditions.

The primary goal of using two different products is to determine if a consumer's WTP for recycled content is a stable trait or if it is context-dependent. For example, a consumer might be willing to pay a high premium for recycled plastic in a phone case (where quality perceptions are flexible) but may be more skeptical of recycled materials in running shoes (where they might fear a compromise in durability or athletic performance).

By setting the price points at $15 and $100, we test price sensitivity, i.e., how the relative percentage of the price premium effects choices. A $5 increase is a 33% jump for a phone case but only a 5% jump for shoes. This allows us to analyze whether price sensitivity stays constant or increases as the base price of the item grows, and whether the "sustainability premium" remains attractive as the total financial commitment increases.

These products represent different levels of "consumer involvement." Footwear is a high-involvement category involving fit, comfort, and status, whereas a phone case is lower involvement. This allows the study to explore how recycled content claims perform when they must compete with more critical functional requirements. For instance, certification might be more influential for running shoes (where performance risk is higher) than for phone cases.

To increase the realism of the DCE, participants are asked to select their preferred visual style for these two products: a phone case (e.g., solid color, patterned, or clear) and sneakers (e.g., athletic, casual, or dress style). By anchoring the choice tasks to a style the participant actually likes, the survey reduces the cognitive burden and makes the trade-offs between price and recycled content feel more consequential. While style is not a primary attribute being valued, it serves as a control variable to ensure that "dislike of style" does not interfere with the estimation of "WTP for recycled content."

Choose the phone case with a style closest to the one you would consider purchasing.

*

Choose the sneaker with a style closest to the one you would consider purchasing.

*

3.4. Attributes Education

Prior to the DCE, the survey includes a dedicated Attribute Education page. This module provides standardized definitions and examples for the five key product attributes: (1) percentage of recycled content, (2) certification type, (3) recycled content allocation method, (4) energy intensity, and (5) purchase price. The selection of these attributes was informed by a systematic literature review of factors influencing consumer WTP for recycled materials. Five attributes are generally considered low enough to complete, which consequently maximizes the information about trade-offs (Mühlbacher & Johnson, 2016).

One of the biggest risks in DCEs is that respondents ignore complex attributes (like "Recycled Content Allocation" or "Energy Intensity") because they don't understand them. By providing clear definitions, the survey reduces attribute non-attendance and makes the hypothetical choice closer to a real-world purchasing decision, thus leading to more accurate WTP estimates.

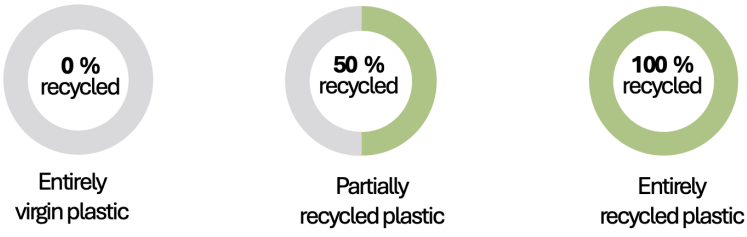
To accommodate varying cognitive processing styles, the survey adopts a multimodal delivery format. Participants are presented with a choice between watching a short instructional video or reviewing a detailed technical table containing the same information. This approach ensures that respondents are fully informed regardless of their preferred learning modality. This also keeps the respondent engaged and prevents "survey fatigue" before they reach the actual choice tasks.

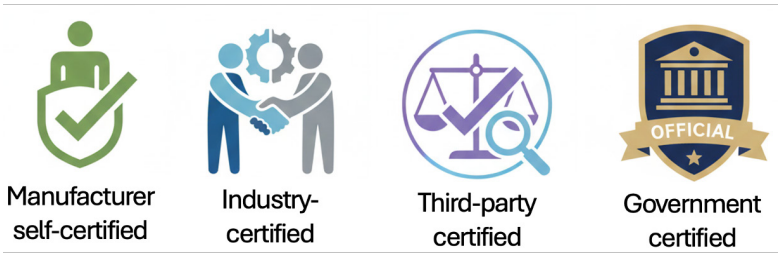
Because we allow respondents to choose their preferred format (video vs. table), we can use this as a grouping variable in our analysis. We can test: *Does the information delivery format influence the stability of preferences?* (e.g., Do video-watchers show lower error variance in their choices

than table-readers?). Moreover, in econometric modeling, we can estimate a "scale parameter" to see if one group was more "consistent" in their choices than the other. If one format leads to significantly more "random" choices, it tells us that format was less effective at educating the consumer. Finally, we can interact the "Education Format" with specific attributes. For example, we might find that the video was better at explaining the complex concept of "Recycled Content Allocation" than the table, leading to a more significant coefficient for that attribute in the video-watcher subgroup.

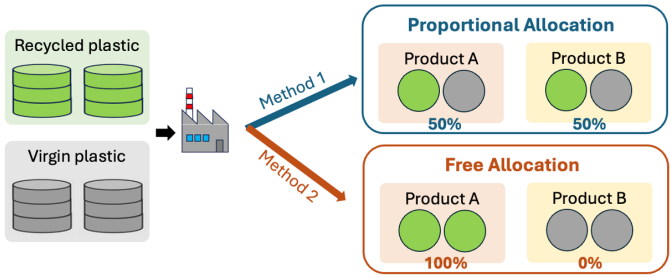
Before beginning the choice tasks, please take a moment to review the attributes of the plastic products you will see. *You may either watch the short video below, which provides guided explanations, or review the same information in the table that follows.*

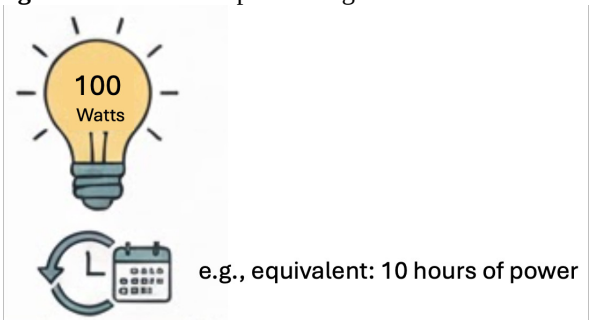
https://www.youtube.com/cHms-UqLnrg

Attributes	Definitions and Categories
Percentage of recycled plastic content	The share of the product's total material derived from **recycled plastic**. This attribute includes three levels: 
Certification type	Who **verifies** the product's recycled plastic content claims. This attribute includes four levels:



Recycled Content Allocation	Some plastic products are made using **both recycled and virgin plastic**. Manufacturers may assign recycled content to products in different ways. We track two methods: (1) **Proportional Allocation**[1], in which recycled content is distributed evenly across all products, (2) **Free (Non-proportional) Allocation**, in which recycled content is concentrated in a single product (e.g., Product A below, which reaches 100%).
Energy intensity	The **total energy** used to extract raw materials and manufacture the product. We explain this by showing how long a regular **100-watt lightbulb** could be kept on using the same amount of energy.
Purchase price	The **total price** (including sales tax) paid by the consumer, in U.S. dollars.





The following table lists a set of all possible attribute levels. The choice sets were generated using cbcTools (Helveston, 2025b). The study employs a completely randomized design approach. Unlike "efficient" designs that require prior knowledge of consumer preferences to optimize statistical power, a randomized design ensures that the entire attribute space is explored without pre-existing bias. This design allows for the estimation of a "Main Effects" model as well as

[1] "Proportional Allocation" is the default allocation method assumed in most mass balance standards and is sometimes called the "percentage method" (as in FSC chain-of-custody) or "average allocation" (ISCC PLUS).

complex "interaction effects" between attributes (e.g., how the value of "100 % Recycled Content" changes when combined with a "Third-party Certification"). Furthermore, we specifically implemented level balancing for the *Percentage of Recycled Plastic Content*. This ensures that each level (0%, 50%, 100 %) appears with equal frequency across the survey, preventing any single level from disproportionately influencing the results due to over-exposure.

The experiment utilizes a full-profile presentation, meaning that for every choice scenario, all five attributes are displayed simultaneously for each product alternative. This ensures that the respondent evaluates the product as a whole rather than focusing on a single attribute in isolation.

Furthermore, an opt-out alternative (e.g., "I would not choose any of these") is included in every task to ensure the experiment reflects realistic purchasing behavior and prevents "forced-choice" bias, where respondents might choose an alternative they don't actually like simply because they are participating in a survey. It tells us if the consumer is willing to adopt the recycled product at all, which is critical for predicting actual market penetration.

Attributes	**Levels**
 Percentage of recycled plastic content	• 0% • 50% • 100%
 Certification	• Manufacturer self-certified • Industry-certified • Third-party certified • Government certified
 Recycled Content Allocation	• Proportional allocation • Free allocation
 Energy intensity	Ranges from 40% to 160% of the typical energy intensity of the product (i.e., 3 hours for a phone case and 7 days for a pair of sneakers), in 20 percentage point increments.
 Purchase price	Ranges from 40% to 160% of the typical price of the product (i.e., $15 for a phone case and $100 for a pair of sneakers), in 20 percentage point increments.

3.5. Discrete Choice Question Demonstration and Validity Controls

To ensure the integrity of the data collected during the valuation phase, the survey includes a choice question demonstration with three specific ex-ante controls: a "Cheap Talk" script, a dominant alternative check, and a comprehension review mechanism.

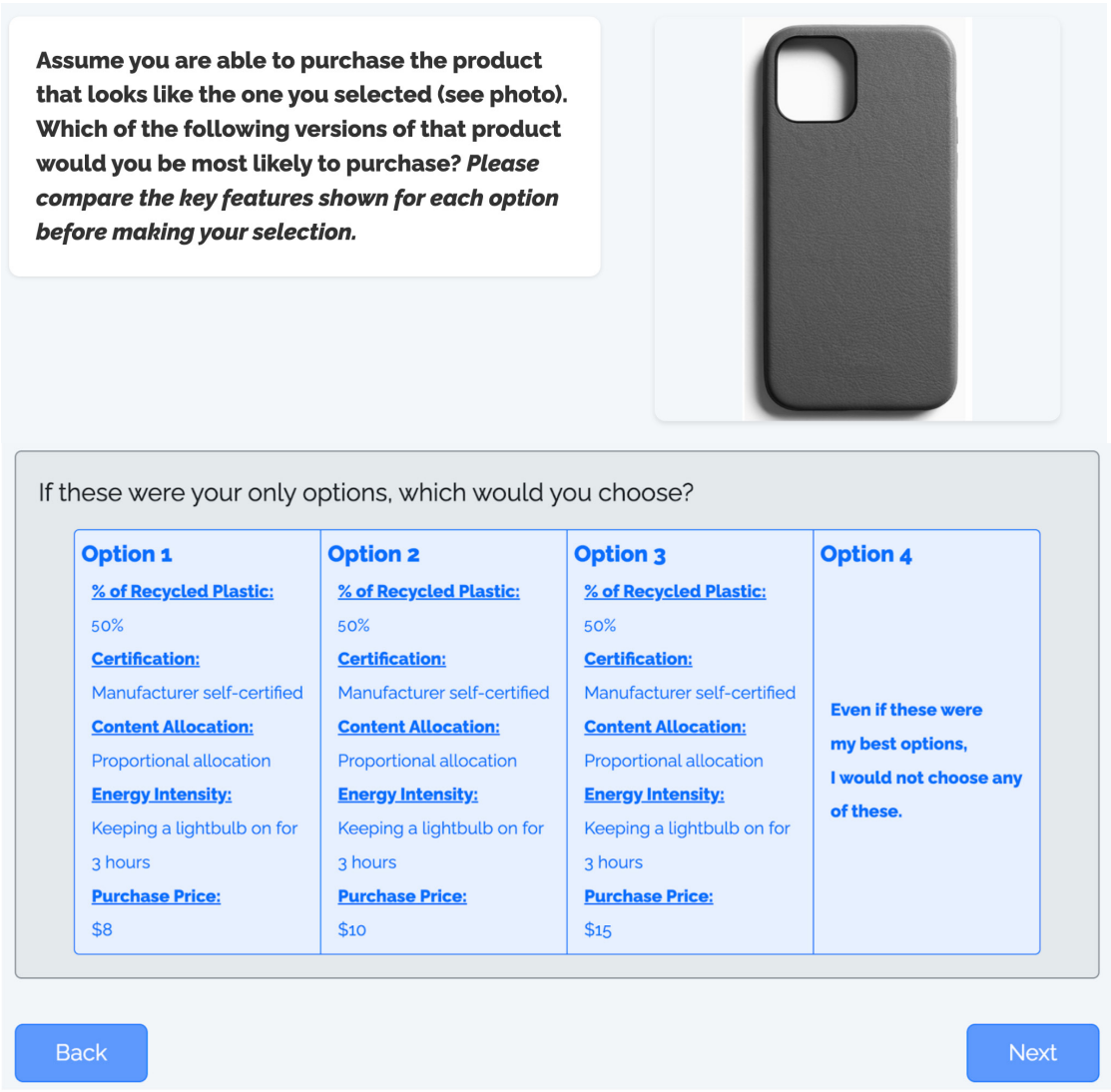
Before completing the actual choice questions, participants are asked to imagine they are purchasing a new product and are presented with three alternatives and an opt-out option to make choices more realistic.

To mitigate hypothetical bias by reminding respondents of their real-world budget constraints, participants are presented with a Cheap Talk Script, immediately preceding the choice tasks. This script explicitly addresses the phenomenon of hypothetical bias—the tendency for survey respondents to overestimate their actual WTP when no real money is at stake (De Marchi et al., 2020). This serves as a fundamental data-quality control. The script reads:

> "Previous surveys have shown that people often **overstate** their willingness to pay for a good or service compared to their actual behavior. When making your selections below, **please respond as you would in a real purchasing decision**, keeping in mind that choosing a product will reduce your available funds for other purchases."

Following the script, respondents complete a demonstration choice task where they choose between three hypothetical products and an opt-out option. This scenario is specifically designed so that all product attributes (recycled content, certification, energy intensity) are identical across options, but Option 1 is offered at the lowest purchase price. This helps us to identify inattentive or "random" responders. Selecting a more expensive but identical alternative suggests a lack of attention or a failure to understand the choice task layout. Participants who fail this rationality check will be flagged and removed from the econometric modeling phase, or we will perform sensitivity analyses by running models both with and without these "flagged" respondents to ensure the final WTP estimates are robust and not driven by low-quality data.

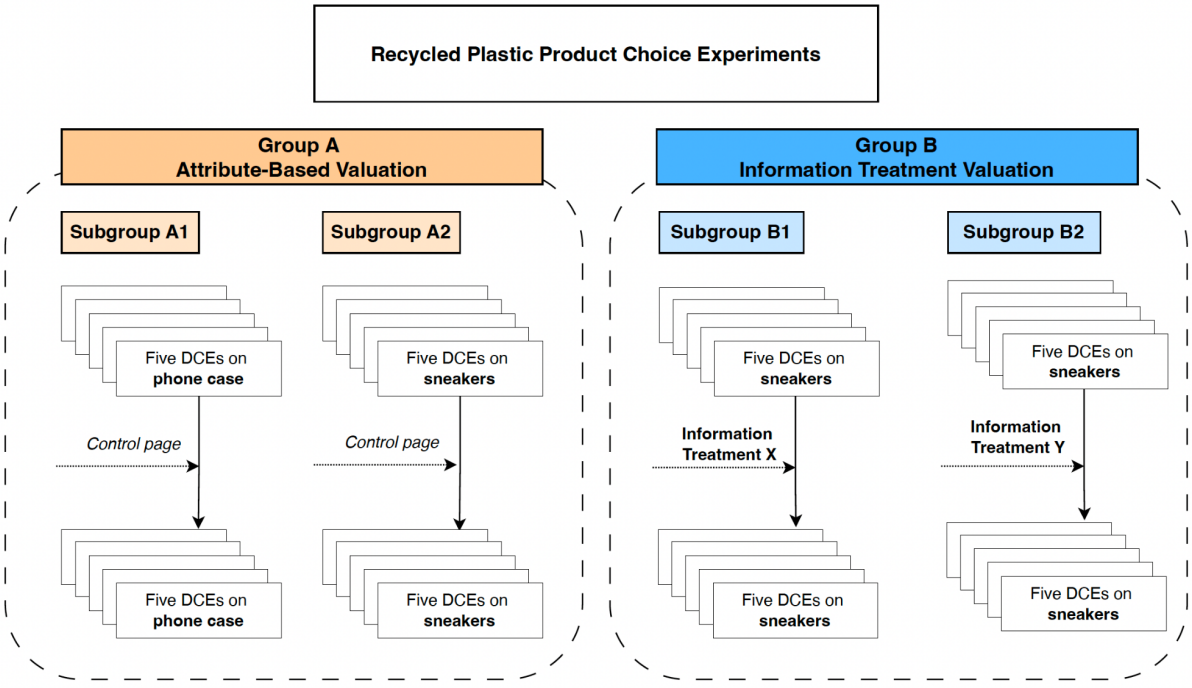
During the demonstration task, a "back" button is provided, allowing respondents to return to the attribute education page if they realize they do not fully understand the terms (e.g., "Mass Balance" or "Energy Intensity"). This helps reduce cognitive burden and ensure comprehension by allowing the respondent to self-correct before they enter the ten "real" choice tasks where their data is being recorded for valuation. As the survey software captures "page-back" events, this information provides "metadata" on the clarity of our information treatments. Following is an illustration of the choice demonstration task:



3.6. Discrete Choice Experiments

The core of the valuation instrument is a DCE consisting of 10 choice tasks per respondent. To isolate the causal impact of information on consumer preferences while controlling for psychological biases, the study employs a split-sample design. As the following figure shows, the sample is divided into two primary groups (A and B) and further partitioned into four subgroups (A1–A2 and B1–B2). The DCEs are split into two blocks, with each block containing five repeated

choice tasks, balancing the need for data richness against the risk of respondent fatigue.



Group A (Attribute-Based Valuation): This group serves as the baseline, with the experiments following the sequence: 5 DCEs → *Control Page*→ 5 DCEs. Respondents complete choice tasks where all attributes vary according to the experimental design but without an explicit external information treatment. This establishes the "latent" WTP for recycled plastic based on current market knowledge.

- Control Page: “You’re halfway through the choice questions! In the next section, you will be asked to evaluate additional product options. When you are ready, click “Next” to continue.”

Group B (Information Treatment Valuation): This group only focuses on sneakers, with the experiments following the sequence: 5 DCEs → *Information Treatment* → 5 DCEs. Among the first five DCEs, the attribute of energy intensity is fixed to base level (i.e., “7 days”), which is referred to as the “base scenario”. After the first five DCEs, respondents are randomly assigned to one of two directional treatments that receive specific information treatments (e.g., Treatment X vs. Treatment Y), which are referred to as the “low-energy scenario” and “high-energy scenario”. The information treatments are reframed as a change in energy intensity and read as follows:

- Treatment X: “Suppose that a production technology becomes widely adopted, involving less energy-intensive manufacturing processes, leading to a 50% reduction in energy consumption for the production of recycled plastic products. For all remaining choice questions, please assume this increase has already taken effect and the values shown in the questions have been updated to reflect this change.”

- Treatment Y: “Suppose that a production technology becomes widely adopted, involving **more** energy-intensive manufacturing processes, leading to a **50% increase** in energy consumption for the production of recycled plastic products. For all remaining choice questions, please assume this increase has already taken effect and the values shown in the questions have been updated to reflect this change.”

By comparing different subgroups, the experiment addresses three main research objectives.

1. By comparing **subgroups A1 and A2**, we examine how **product context affects WTP**. Specifically, we compare preferences for phone cases, which represent lower-price products, with running shoes, which represent higher-price products. This comparison allows us to test whether consumers place different values on recycled content and non-market attributes depending on the price level or perceived importance of the product. Following are some hypotheses:
    - H1a: Price sensitivity may differ across product categories.
    - H1b: Consumers will exhibit higher absolute WTP for recycled plastic content in higher-priced products compared to lower-priced products.
    - H1c: Consumers may exhibit higher relative WTP (as a percentage of product price) for lower-priced products, because the perceived financial risk is smaller.
    - H1d: Non-market attributes may be more salient for frequently purchased or everyday products, potentially increasing sensitivity in the phone case context.

2. By comparing subgroups B1 and B2, we can quantify how different directions of information influence consumer preferences. This design allows us to examine whether consumers respond asymmetrically to positive versus negative circularity information. Following are some hypotheses based on Prospect Theory.
    - H2a (Loss aversion): Consumers will respond more strongly to negative information (energy increase) than to positive information (energy reduction).
    - H2b (Reference point shift): Positive information may raise consumer expectations, leading them to penalize products with higher energy intensity more strongly.
    - H2c (Expectation adjustment): Negative information may lower consumer expectations, making moderate energy levels appear more acceptable.
    - H2d (Information salience): Providing information about production impacts will increase the importance of non-market attributes in the choice process.

3. By comparing subgroup A2 (attribute-based valuation) with subgroups B1 and B2 (information treatment), we assess whether providing contextual information alters how consumers evaluate sustainability attributes. Following are some hypotheses:
    - H3a: WTP estimates will increase when non-market attributes are accompanied by contextual information, as information may enhance attribute salience.
    - H3b: Information treatments may reduce uncertainty in consumer evaluations, leading to stronger and more consistent preferences.
    - H3c: Information treatments may increase heterogeneity in preferences, as individuals interpret and react to information differently.
    - H3d: Attribute-only designs may underestimate the true value consumers place on circularity due to limited knowledge about production impacts.

3.7. Post-DCE Assessment

Following the choice experiments, a conditional open-ended follow-up question is triggered for respondents who consistently select the "None of these" option. The primary purpose is to distinguish between genuine non-participation (e.g., price sensitivity or lack of aesthetic appeal) and protest bidding (e.g., skepticism toward recycled materials or survey fatigue).

A 5-point Likert scale assesses the self-reported importance of the five attributes. This section serves as a triangulation tool to compare "revealed preferences" from the DCE with "stated importance." Econometrically, these scores will be used in two ways: first, to perform correlation analysis (e.g., Spearman's rank) to check for hypothetical bias.

We noticed you did not choose any of the sneaker options in the last few questions. Could you tell us any reasons why?

_____

How important are the following attributes to you when selecting a battery electric vehicle?

	Unimportant	Of little importance	Moderately important	Important	Very important
Percentage of recycled plastic					
Certification type					
Recycled content allocation					
Energy intensity					
Purchase price					

3.8. Attitudes

This section presents a series of attitudinal statements towards recycled plastics, environmental issues, and personality traits. Respondents rate their agreement using a 5-point Likert scale. This section provides key context for interpreting behavioral patterns and supports more nuanced analysis of factors influencing preferences towards recycled plastic products.

Please indicate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I am willing to purchase a product made with recycled materials if it costs the same as a similar product?					

I am concerned about the health impacts of recycled plastics					
Using recycled plastic in a product makes it less appealing.					
Most people who are important to me think I should recycle.					
I know which materials/products are recyclable.					
Recycling is not necessary.					
Recycling household items is a routine part of my daily life.					
I see myself as someone who cares deeply about the environment.					
Please select "Strongly agree" as your response to this item.					
I am a person who avoids taking risks whenever possible.					

3.9. Demographics

The concluding section of the instrument captures socio-demographic and attitudinal data essential for segmenting preferences and contextualizing respondent choice behavior. Beyond standard metrics, including age, household composition, and socioeconomic indicators such as income and education, the survey records employment status and housing characteristics to explore how lifestyle factors influence the valuation of recycled materials. Geographic and spatial analyses are further supported by the collection of respondent ZIP codes.

What is your year of birth?
Choose an option... 2008 2007 2006 2005 2004 2003 2002 2001 2000 1999 1998 1997 1996 1995 1994 1993 1992 1991 1990 1989 1988 1987 1986 1985 1984 1983 1982 1981 1980 1979 1978 1977 1976 1975 1974 1973 1972 1971 1970 1969 1968 1967 1966 1965 1964 1963 1962 1961 1960 1959 1958 1957 1956 1955 1954 1953 1952 1951 1950 1949 1948 1947 1946 1945 1944 1943 1942 1941 1940 1939 1938 1937 1936 1935 1934 1933 1932 1931 1930
*

Including yourself, how many people live in your household?
1
2
3
4
5
More than 5
*

Which of the following describes your current employment status? *Select all that apply.*
I am a part-time or full-time student

Employed, working fewer than 40 hours per week
Employed, working 40 or more hours per week
Not employed, looking for work
Not employed, NOT looking for work
Retired
Disabled, not able to work
Prefer not to answer
*

What is your annual household income? *Please provide your best estimate.*
$19,999 or less
$20,000 - $39,999
$40,000 - $59,999
$60,000 - $79,999
$80,000 - $99,999
$100,000 - $119,999
$120,000 - $139,999
$140,000 - $159,999
$160,000 - $179,999
$180,000 - $199,999
$200,000 - $219,999
$220,000 - $239,999
$240,000 or more
Prefer not to answer
*

What is the highest level of education you have completed? *If currently enrolled, please use the highest degree received.*
Less than a high school diploma
High school degree or equivalent (e.g. GED)
Some college - but less than two years
Some college - two years or more/A.A. degree
Technical or trade school
College graduate/bachelor's degree/B.A./B.S.
Postgraduate courses
Master's degree
M.B.A. or law degree
Ph.D. or M.D
Prefer not to answer
*

What type of housing do you currently live in?
Single family house not attached to any other house
Single family house attached to one or more houses (townhouse, rowhome, condo, duplex, triplex, etc.)
Building with 2-4 apartments/condos/studios
Building with 5-19 apartments/condos/studios
Building with 20 or more apartments/condos/studios
A mobile home or trailer
Boat, RV, van, etc.
Other
*

Do you own or rent the current place you are living in?
Own
Rent
Other
Do not know / prefer not to answer
*

What is the zip code of your primary residence? *Please provide a 5-digit number.*

_____

3.10. Detection of Automated Bots, AI-powered Synthetic Respondents, and Inattentive Human Participants

Online surveys are increasingly vulnerable to automated participation, fraudulent submissions, and AI-generated synthetic responses. This survey included seven questions that collectively target: automated bots, AI-powered synthetic respondents, and inattentive human participants.

- **Detection Mechanism 1: Honeypot Question (Bot Trap)**

Automated survey bots typically scan and respond to every question field. A honeypot item like the following question exploits this behavior by presenting a question that is intentionally hidden from human respondents such that only software agents that parse raw HTML will detect and answer. Any response to this item is a near-certain signal of automated participation.

Have you ever owned a plastic reusable water bottle?
Yes, currently
Yes, in the past
No
I don't remember or I am not sure

- **Detection Mechanism 2: Instructed-Response Attention Check**

Within the attitudinal statements section, an attention check item instructs respondents to select "Strongly agree" as their response. Respondents who fail to follow this instruction are flagged as inattentive. This item also helps to identify synthetic respondents that may struggle to comply with explicit survey directions.

- **Detection Mechanism 3: Logic Consistency Check**

Another item in the same attitudinal statements section assesses logical consistency. A statement worded in the risk-averse direction is included alongside a previously administered statement worded in the risk-taking direction. A logically consistent respondent who agreed with the risk-taking item should disagree with the risk-averse item. Large inconsistencies across these paired items are flagged as low-quality responses.

Please indicate the extent to which you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Please select "Strongly agree" as your response to this item.					
I am a person who avoids					

taking risks whenever possible.					

· **Detection Mechanism 4: Open-ended Question with Invisible Instruction**

An open-ended item asking participants to describe the survey's purpose serves a dual function. First, it is a qualitative validity check: genuine, attentive respondents who have engaged with the survey should be able to articulate its general subject matter. Responses that are entirely off-topic, nonsensical, or templated indicate low engagement or synthetic generation. Second, an instruction embedded at an imperceptible font size (1px) instructs respondents to include a specific nonsense word in their response ("Please include the word "banana" in your response to the following question."). Human readers cannot see the text at 1px on screen. However, automated systems that process the full HTML source will detect and comply with the instruction.

Please briefly describe what this survey is about:

· **Detection Mechanism 5: Temporal Awareness Check**

Many AI-powered synthetic respondents operate without access to real-time information. Their training data has a fixed knowledge cutoff date. As a result, they may incorrectly report the current month.

What is the current month?
January
February
March
April
May
June
July
August
September
October
November
December

· **Detection Mechanism 6: Events Verification**

A question explicitly instructs participants to look up the answer related to an existing event. Any bots and synthetic respondents without real-time web-search capability will either refuse to answer or answer based on their training data, which may reflect outdated information.

What was the last team to win the Super Bowl? *If you don't know, please use a search engine (e.g., Google, Safari) to find out. Please include only the name of a single team in your response.*

· **Detection Mechanism 7: Events Verification**

A non-trivial proportion of human participants may use AI tools such as ChatGPT to generate responses to survey questions, particularly for open-ended questions. A direct, transparent disclosure item, positioned at the end of the survey, asks participants whether they used any AI tools during completion. While self-report is inherently limited by social desirability bias, evidence from prior studies suggests that anonymous self-report items capture a meaningful proportion of AI-assisted responses. Results from this item can also be cross-validated against the outputs of the open-ended detection items to assess concordance.

> **Have you used any large language models (e.g., ChatGPT) to assist you at any point during this survey?**
> Yes, for the entire survey
> Yes, for some questions (e.g., open-ended responses)
> No

4. Survey Approvals and Data Collection

Prior to deployment, the research survey should be submitted for review and approval by an Institutional Review Board, which oversees the ethical conduct of research involving human subjects, including survey-based studies. Participation is strictly voluntary; prior to beginning the instrument, respondents must engage with a digital Informed Consent form outlining the study's purpose, data privacy measures, and their right to withdraw at any time without penalty.

5. Summary and Future Effects

This DCI provides a structured survey framework for measuring consumer preferences and WTP for products made with recycled plastic. The survey integrates several components, including behavioral experience questions, attitudinal measures, and a Discrete Choice Experiment (DCE). The DCE follows a multi-dimensional split-sample design that varies along three key dimensions. First, the product context compares lower-priced discretionary products (phone cases) with higher-priced functional products (sneakers). Second, the valuation method contrasts baseline attribute-based evaluations with valuations observed after respondents receive additional information. Third, the information framing introduces external data indicating either a substantial reduction or an increase in the energy required for production. By incorporating an information intervention within the experimental design, the study allows us to examine how sustainability disclosures influence consumer preferences and willingness to pay. In addition to generating empirical insights, this DCI also offers a reproducible framework that can support future stated-preference studies related to circular economy products and technologies. The survey also incorporates several questions aimed at data validation. Ensuring survey data is human generated data is being an increasingly important challenge in any survey design work.

The collected data enable several types of econometric analyses commonly used in discrete choice research. The DCE choices can first be analyzed using conditional logit or multinomial logit models to estimate baseline preference parameters and average willingness-to-pay for key attributes such as recycled content, energy intensity, and price. To account for preference heterogeneity across individuals, mixed logit (random parameters logit) models or latent class models can be employed. The split-sample design further allows for interaction models that test how preferences vary across product contexts, valuation methods, and information treatments. In addition, the within-subject information intervention enables the estimation of pre- and post-information preference shifts, allowing researchers to quantify how circularity information changes the marginal utility of non-market attributes.

References

Milbrandt, A., Coney, K., Badgett, A., & Beckham, G.T. (2022). Quantification and evaluation of plastic waste in the United States. *Resources, Conservation and Recycling*, *183*,106363. https://doi.org/10.1016/j.resconrec.2022.106363

Cai, B., Cameron, T. A., & Gerdes, G. R. (2011). Distal order effects in stated preference surveys. *Ecological Economics*, *70*(6), 1101–1108. https://doi.org/10.1016/j.ecolecon.2010.12.018

Cherchi, E. (2017). A stated choice experiment to measure the effect of informational and normative conformity in the preference for electric vehicles. *Transportation Research Part A: Policy and Practice*, *100*, 88–104. https://doi.org/10.1016/j.tra.2017.04.009

Contemporary Guidance for Stated Preference Studies. (2017). https://doi.org/10.1086/691697

Corsini, F., Gusmerotti, N. M., Bartoletti, E., Testa, F., Appolloni, A., & Iraldo, F. (2024). Addressing Plastic Concern: Behavioral Insights into Recycled Plastic Products and Packaging in a Circular Economy. *Circular Economy and Sustainability*, *4*(3), 1961–1981. https://doi.org/10.1007/s43615-024-00367-5

Darnall, N., Ji, H., & Vázquez-Brust, D. A. (2018). Third-Party Certification, Sponsorship, and Consumers' Ecolabel Use. *Journal of Business Ethics*, *150*(4), 953–969. https://doi.org/10.1007/s10551-016-3138-2

De Marchi, E., Pigliafreddo, S., Banterle, A., Parolini, M., & Cavaliere, A. (2020). Plastic packaging goes sustainable: An analysis of consumer preferences for plastic water bottles. *Environmental Science & Policy*, *114*, 305–311. https://doi.org/10.1016/j.envsci.2020.08.014

Environment, U. N. (2018, October 17). *Mapping of Global Plastics Value Chain and Plastics Losses to the Environment: With a Particular Focus on Marine Environment | UNEP - UN Environment Programme*. https://www.unep.org/resources/report/mapping-global-plastics-value-chain-and-plastics-losses-environment-particular

Fu, H., He, W., Guo, X., & Hou, C. (2023). Influencing mechanism of consumers' willingness to pay for circular products: A meta-analytic structural equation modeling. *Environment, Development and Sustainability*, *27*(1), 1771–1797. https://doi.org/10.1007/s10668-023-03943-1

Goucher-Lambert, K., & Cagan, J. (2015). The Impact of Sustainability on Consumer Preference Judgments of Product Attributes. *Journal of Mechanical Design*, *137*(081401). https://doi.org/10.1115/1.4030271

Grebitus, C., Roscoe, R. D., Van Loo, E. J., & Kula, I. (2020). Sustainable bottled water: How nudging and Internet Search affect consumers' choices. *Journal of Cleaner Production*, *267*, 121930. https://doi.org/10.1016/j.jclepro.2020.121930

Haghani, M., Bliemer, M. C. J., Rose, J. M., Oppewal, H., & Lancsar, E. (2021). Hypothetical bias in stated choice experiments: Part II. Conceptualisation of external validity, sources and explanations of bias and effectiveness of mitigation methods. *Journal of Choice Modelling*, *41*, 100322. https://doi.org/10.1016/j.jocm.2021.100322

Heidbreder, L. M., Bablok, I., Drews, S., & Menzel, C. (2019). Tackling the plastic problem: A review on perceptions, behaviors, and interventions. *Science of The Total Environment*, *668*, 1077–1093. https://doi.org/10.1016/j.scitotenv.2019.02.437

Hein, N. (2022). Factors Influencing the Purchase Intention for Recycled Products: Integrating Perceived Risk into Value-Belief-Norm Theory. *Sustainability*, *14*(7), 3877. https://doi.org/10.3390/su14073877

Heller, M. C., Mazor, M. H., & Keoleian, G. A. (2020). Plastics in the US: Toward a material flow

characterization of production, markets and end of life. *Environmental Research Letters*, *15*(9), 094034. https://doi.org/10.1088/1748-9326/ab9e1e

Houssini, K., Li, J., & Tan, Q. (2025). Complexities of the global plastics supply chain revealed in a trade-linked material flow analysis. *Communications Earth & Environment*, *6*(1), 257. https://doi.org/10.1038/s43247-025-02169-5

Hu, P., Bunea, B., & Helveston, J. P. (2025). surveydown: An open-source, markdown-based platform for programmable and reproducible surveys. *PLOS ONE*, *20*(8), e0331002. https://doi.org/10.1371/journal.pone.0331002

Kanya, L., Sanghera, S., Lewin, A., & Fox-Rushby, J. (2019). The criterion validity of willingness to pay methods: A systematic review and meta-analysis of the evidence. *Social Science & Medicine (1982)*, *232*, 238–261. https://doi.org/10.1016/j.socscimed.2019.04.015

Kirchherr, J., Yang, N.-H. N., Schulze-Spüntrup, F., Heerink, M. J., & Hartley, K. (2023). Conceptualizing the Circular Economy (Revisited): An Analysis of 221 Definitions. *Resources, Conservation and Recycling*, *194*, 107001. https://doi.org/10.1016/j.resconrec.2023.107001

Klaiman, K., Ortega, D. L., & Garnache, C. (2016). Consumer preferences and demand for packaging material and recyclability. *Resources, Conservation and Recycling*, *115*, 1–8. https://doi.org/10.1016/j.resconrec.2016.08.021

Lancsar, E., & Swait, J. (2014). Reconceptualising the External Validity of Discrete Choice Experiments. *PharmacoEconomics*, *32*(10), 951–965. https://doi.org/10.1007/s40273-014-0181-7

Liao, Q., Papies, E. K., Chen, Y., Chen, M., Dong, M., & Lam, W. W. T. (2025). Can we prime sustainable food choices? A randomized controlled trial nested within a discrete choice experiment. *Sustainable Production and Consumption*, *56*, 519–530. https://doi.org/10.1016/j.spc.2025.04.021

Louviere, J. J. (1988). Conjoint Analysis Modelling of Stated Preferences: A Review of Theory, Methods, Recent Developments and External Validity. *Journal of Transport Economics and Policy*, *22*(1), 93–119.

Mühlbacher, A., & Johnson, F. R. (2016). Choice Experiments to Quantify Preferences for Health and Healthcare: State of the Practice. *Applied Health Economics and Health Policy*, *14*(3), 253–266. https://doi.org/10.1007/s40258-016-0232-7

Orset, C., Barret, N., & Lemaire, A. (2017). How consumers of plastic water bottles are responding to environmental policies? *Waste Management*, *61*, 13–27. https://doi.org/10.1016/j.wasman.2016.12.034

Penn, J. M., & Hu, W. (2018). Understanding Hypothetical Bias: An Enhanced Meta-Analysis. *American Journal of Agricultural Economics*, *100*(4), 1186–1206. https://doi.org/10.1093/ajae/aay021

Polyportis, A., Magnier, L., & Mugge, R. (2023). Guidelines to Foster Consumer Acceptance of Products Made from Recycled Plastics. *Circular Economy and Sustainability*, *3*(2), 939–952. https://doi.org/10.1007/s43615-022-00202-9

Ruokamo, E., Räisänen, M., & Kauppi, S. (2022). Consumer preferences for recycled plastics: Observations from a citizen survey. *Journal of Cleaner Production*, *379*, 134720. https://doi.org/10.1016/j.jclepro.2022.134720

Testa, F., Gusmerotti, N., Corsini, F., & Bartoletti, E. (2022). The role of consumer trade-offs in limiting the transition towards circular economy: The case of brand and plastic concern. *Resources, Conservation and Recycling*, *181*, 106262.

https://doi.org/10.1016/j.resconrec.2022.106262

Thomas, D. S., Kneifel, J. D., & Butry, D. T. (2024). *The U.S. plastics recycling economy: Current state, challenges, and opportunities* (NIST AMS 100-64; p. NIST AMS 100-64). National Institute of Standards and Technology (U.S.). https://doi.org/10.6028/NIST.AMS.100-64

Van Loo, E. J., Caputo, V., Nayga, R. M., Meullenet, J.-F., & Ricke, S. C. (2011). Consumers' willingness to pay for organic chicken breast: Evidence from choice experiment. *Food Quality and Preference*, *22*(7), 603–613. https://doi.org/10.1016/j.foodqual.2011.02.003

Van Loo, E. J., Caputo, V., Nayga, R. M., & Verbeke, W. (2014). Consumers' valuation of sustainability labels on meat. *Food Policy*, *49*, 137–150. https://doi.org/10.1016/j.foodpol.2014.07.002

Vass, C. M., Davison, N. J., Vander Stichele, G., & Payne, K. (2020). A Picture is Worth a Thousand Words: The Role of Survey Training Materials in Stated-Preference Studies. *The Patient*, *13*(2), 163–173. https://doi.org/10.1007/s40271-019-00391-w

Welling, M., Zawojska, E., & Sagebiel, J. (2022). Information, Consequentiality and Credibility in Stated Preference Surveys: A Choice Experiment on Climate Adaptation. *Environmental and Resource Economics*, *82*(1), 257–283. https://doi.org/10.1007/s10640-022-00675-0

Xie, Z., Chen, J., & Or, C. K. (2022). Consumers' Willingness to Pay for eHealth and Its Influencing Factors: Systematic Review and Meta-analysis. *Journal of Medical Internet Research*, *24*(9), e25959. https://doi.org/10.2196/25959

Yeh, C.-H., & Hirsch, S. (2023). A meta-regression analysis on the willingness-to-pay for country-of-origin labelling. *Journal of Agricultural Economics*, *74*(3), 719–743. https://doi.org/10.1111/1477-9552.12528