Business Strategy and the Environment

WILEY | Business Strategy and the Environment

RESEARCH ARTICLE OPEN ACCESS

Consumers' Willingness to Pay for Sustainable Mobile Phones: An Adaptive Choice-Based Conjoint and Market Simulation Approach Testing a Multi-Level Eco-Score

Jens Bergener[1] | Kathleen Jacobs[2] | Marek Veneny[3] | Maike Gossen[1]

[1]Department of Economic Education and Sustainable Consumption, Technical University Berlin, Berlin, Germany | [2]Research Division Circular Economy, Wuppertal Institute for Climate, Environment and Energy, Wuppertal, Germany | [3]Institute of Nursing Science, Department of Public Health, University of Basel, Basel, Switzerland

Correspondence: Maike Gossen (maike.gossen@tu-berlin.de)

Received: 27 July 2024 | **Revised:** 22 August 2025 | **Accepted:** 13 September 2025

Funding: This work was supported by Bundesministerium für Umwelt, Naturschutz, Nukleare Sicherheit und Verbraucherschutz, 67KI2022A.

Keywords: adaptive choice-based conjoint analysis | eco-score | mobile phones | sustainability label | sustainable consumption | willingness to pay

ABSTRACT

This study investigates the impact of a multi-level eco-score on willingness to pay for sustainable mobile phones. Using adaptive choice-based conjoint analysis and market simulation, the study evaluates the effectiveness of a traffic light-colored multi-level eco-score in a realistic market scenario. Results reveal that higher eco-score levels significantly enhance consumer preferences and willingness to pay for sustainable mobile phones, with top-tier eco-scores ("A" and "B") being notably preferred. The study highlights that improvements in eco-score levels lead to a stronger increase in consumer preference shares compared to other product attributes. Additionally, consumers exhibit a progressively higher willingness to pay for mobile phones with superior eco-score levels, indicating potential financial benefits for manufacturers investing in higher environmental performance. This study makes an important contribution by addressing the under-researched area of multi-level eco-labelling in consumer electronics and demonstrating the practical relevance of multi-level labels in influencing market dynamics and driving sustainable consumer behavior.

1 | Introduction

The production and consumption of goods and services can have significant negative socio-ecological impacts (European Environment Agency 2023). While consumers are increasingly considering these effects in their purchasing decisions (Bangsa and Schlegelmilch 2020), research indicates that they still struggle to make well-informed, sustainable choices (Thøgersen 2021). To address this challenge, sustainability labeling schemes, such as ecolabels, are seen as key tools for promoting more sustainable consumer behavior (Majer et al. 2022). However, many existing sustainability labels face criticism for their complex, similar, or ambiguous content (Torma and Thøgersen 2021). Single-issue, stand-alone labels often fail to reflect the full range of a product's sustainability attributes (Lanaras-Mamounis et al. 2022), and the impact of many sustainability attributes on consumer behavior remains under-researched (Marcon et al. 2022). In response to these challenges, multi-level eco-labeling approaches have gained traction. These approaches aim to consolidate multiple sustainability dimensions into a single, comprehensive label (Torma and Thøgersen 2021, 2024). By reducing the number of labels and providing a more holistic view, multi-level eco-labeling aims to help consumers make more informed and sustainable choices (Dendler 2014; Torma and Thøgersen 2021).

[Correction added on 9 October 2025, after first online publication: Affiliation 2 was corrected from 'Research Unit Circular Transitions, Research Devision Circular Economy, Wuppertal Institute, Wuppertal, Germany' to 'Research Division Circular Economy, Wuppertal Institute for Climate, Environment and Energy, Wuppertal, Germany' in this version.]

Today, both practitioners and researchers are actively working on developing multi-level ecolabels (Weinrich and Spiller 2016). Notable examples include the eco-score, Eco Impact, and Planet Score for food products (Ikonen et al. 2020; De Bauw, Matthys, et al. 2021; De Bauw, De La Revilla, et al. 2022; Jürkenbeck 2023; Kolber and Meixner 2023). In particular, a graded, traffic light-colored eco-score has been shown to positively influence consumer food preferences (De Bauw, Matthys, et al. 2021; De Bauw, De La Revilla, et al. 2022; Marette 2021; Weber 2021) and to be more effective than traditional labeling approaches (Thøgersen et al. 2024). While recent studies suggest that higher levels of environmental sustainability increase consumers' willingness to pay (WTP) for sustainable food products and sports fashion (e.g., Jürkenbeck 2023; Kolber and Meixner 2023; Spindler et al. 2023), research on consumers' WTP for multi-level eco-labels within the consumer electronics sector is limited. For example, a literature review by Bangsa and Schlegelmilch (2020) indicates that the product category of electrical appliances represents only a small portion (7.5%) of all studies on sustainable consumption. Given the strong negative sustainability impact of product categories such as mobile phones (e.g., Sanfelix et al. 2020; Ercan et al. 2016; Suckling and Lee 2015), research on how to promote more sustainable production and consumption practices within the consumer electronics sector is needed. Additionally, consumer responses to an eco-score for consumer electronics may differ from sectors such as food or fashion products, as consumer electronics such as mobile phones carry far higher price tags and may involve more complex attribute trade-offs.

Existing studies investigating multi-level label approaches for consumer electronics have mostly focused on consumers' WTP for specific environmental attributes such as circularity for mobile phones and vacuum cleaners (Hunka et al. 2021; Boyer et al. 2021), energy efficiency classes for washing machines (Sammer and Wüstenhagen 2006) and televisions (Heinzle and Wüstenhagen 2012), durability levels for washing machines (Jacobs and Hörisch 2021), and a repairability index for smartphones (Reischl 2021). Using an eco-rating, a recent study has explored consumers' WTP for eco-friendly mobile phone plan bundles that included both service and handset (Mazurek and Prey 2025). Additionally, a prior study identified consumers' utility for an eco-score as well as consumer segments for mobile phones with an eco-score (Jacobs et al. 2025). However, whether and how strongly a multi-level eco-score influences consumers' WTP and share of preference (SOP) for smartphone hardware with varying levels of environmental sustainability represents a critical research gap.

Against this backdrop, this study investigates the impact of a holistic, hypothetical, multi-level eco-score on consumers' SOP and WTP for sustainable mobile phones. By utilizing adaptive choice-based conjoint analysis (ACBC) data that has been conducted for a prior study (Jacobs et al. 2025), we employ market simulations and analyze how varying eco-score levels influence consumers' SOP and WTP for sustainable mobile phones in different market scenarios. The research questions are as follows:

1. How does a hypothetical eco-score drive the SOP for sustainable mobile phones in different market scenarios, and does this influence vary depending on the eco-score level?
2. How much are consumers willing to pay more for mobile phones with successively higher eco-score levels?

The article is structured as follows: Section 2 provides an overview of the current research landscape on eco-labelling and outlines the study's theoretical framework. Section 3 details the research design and methods. Section 4 presents the results, while Section 5 discusses the implications of these results, the study's limitations, and avenues for future research. Finally, Section 6 concludes with the key results and their implications for businesses, marketers, and policymakers.

2 | Literature Review

2.1 | Multi-Level Sustainability Labelling

Scholars emphasize that consumer-friendly sustainability labeling schemes offer a promising solution to address the information asymmetry between producers and consumers, who often lack detailed knowledge about a product's sustainability performance (e.g., Chang et al. 2021; Nikolaou and Kazantzidis 2016). However, Fuso Nerini et al. (2019) argue that existing sustainability labelling schemes often focus on single aspects of sustainability. As a result, in practice, multiple single-issue labels are frequently presented alongside each other, which can lead to information overload, consumer confusion, and misunderstandings (e.g., Monier-Dilhan 2018). In response, research has begun exploring multi-level sustainability labeling approaches that combine various environmental dimensions to facilitate more informed consumer choices. Torma and Thøgersen (2021) propose defining multi-level sustainability labels as multi-dimensional, incorporating various sustainability standards and going beyond the categorical (yes or no) fulfilment of minimum sustainability criteria.

In the domain of sustainable food consumption, the effectiveness of multi-level eco-labeling schemes has gained traction. A notable example is the multi-level eco-score, which consolidates various ecological product criteria. Studies have demonstrated its effectiveness in guiding consumers towards sustainable food choices and encouraging increased sustainable consumption (De Bauw, De La Revilla, et al. 2022; Marette 2021). Furthermore, Weber (2021) found that a simple eco-ranking system helps mitigate information overload. Research by Jürkenbeck (2023) and Kolber and Meixner (2023) indicates that higher levels of a color-coded eco-score not only boost consumer preference for sustainable food products but also increase consumers' WTP. These effects are consistent regardless of consumers' prior knowledge of eco-scores or ecolabels. While many studies suggest that consumers and other stakeholders in the food sector appear to be ready for a holistic sustainability label and perceive it as a desirable tool (Futtrup et al. 2021), challenges such as a lack of data remain (Torma and Thøgersen 2024).

Research on multi-level labeling approaches in other sectors remains limited. For example, Spindler et al. (2023) explored how labels communicating various levels of environmental and social sustainability affect consumer preferences and WTP for sports apparel. Their results indicate that higher levels of ecological sustainability increase consumers' willingness to purchase and pay more for sustainable sports clothing in Germany. In a prior study, Jacobs et al. (2025) examined consumer preferences for a hypothetical eco-score and identified four consumer segments based on these preferences for various attributes. Their findings show that a multi-level eco-score positively impacts purchase behavior and highlights untapped market potential in two segments with stronger preferences for an eco-score.

Overall, research on the effectiveness of multi-level sustainability labeling schemes remains in its early stages and lacks a robust empirical foundation (Torma and Thøgersen 2021). While initial studies offer insights into how multi-level sustainability labels like the eco-score influence consumer choices, further research is needed to assess consumers' WTP for multi-level labels in less-explored sectors, such as consumer electronics.

2.2 | WTP for Sustainable Consumer Electronics

Multi-level eco-labels often utilize traffic light-colored scales ranging from green to red, with red indicating negative ratings. Research indicates that these graded labels are more effective than solely categorical positive or negative label approaches (Thøgersen et al. 2024). For example, coding lower ratings with a red color can serve as a warning sign and significantly influence consumers' purchase decisions and WTP (e.g., Deliza et al. 2020). A well-known example of a graded eco-label with a long track record for its effectiveness is the mandatory EU energy label for household appliances. This label uses a traffic light-colored scale to indicate seven energy classes, from dark green (labeled "A", most efficient) to red (labeled "G", least efficient) for products such as washing machines and televisions. According to a recent study on the annual sales of cold appliances for eight EU countries over the period of 11 years, the EU's energy labeling policies have positively impacted the market share of eco-friendly household appliances with high-energy classes (Schleich et al. 2021). The study suggests that EU energy labeling increased the market share of energy-efficient appliances by around 15 to 38 percentage points between 2010 and 2017. Additionally, over the last years, choice experiments have consistently revealed higher WTP for appliances with a high energy efficiency rating across various countries such as Switzerland, China, or India (Jain et al. 2021; Sammer and Wüstenhagen 2006; Zha et al. 2020). However, Heinzle and Wüstenhagen (2012) show for German consumers that the effectiveness of the energy label can decrease when it is adjusted or revised (e.g., introducing new categories beyond the highest-level A). They conclude that, to reduce uncertainty and information asymmetry between brands, marketers, and consumers, graded labels such as the EU energy label must present consumers with a meaningful reduction of complexity.

Sustainability labels often result in consumers considering a smartphone at a higher price. For example, Grankvist et al. (2019) found that students in Sweden, Norway, and Germany are willing to pay a 12%–18% premium for sustainability certified smartphones with an environmental or social sustainability label. Similarly, a choice-based conjoint (CBC) study by Bask et al. (2013) found that some consumers are willing to pay a premium of 10% for a mobile phone with sustainability features. Additionally, a recent ACBC study by Mazurek and Pray (2025) with German consumers found that green-minded consumers would pay roughly €11 more per month for a phone plan that included an eco-friendly phone, i.e., with a higher eco rating. While the study indicates a modest but tangible WTP premium for more sustainable phone plans among environmentally conscious consumers, the adapted eco-rating used in the study only consisted of three levels (low rating (35/100), medium rating (60/100), and high rating (85/100)) which were pre-associated with a monthly price change within the study design (0€, 2€, and 4€ respectively).

Other studies examining consumers' WTP for consumer electronics with a multi-level product label cover specific aspects of environmental sustainability such as circularity, durability, and repairability. On the topic of circularity, research by Boyer et al. (2021) indicates that UK customers are consistently willing to pay more for products with low or moderate levels of circularity. However, their results suggest that the WTP for circular products declines or disappears as the proportion of circularity increases. Regarding the durability of mobile phones, Wilhelm (2012) indicates the potential for durability labeling. In a study among U.S. college students, she found that a more durable phone (5 + years) is twice as preferred as an identical phone with a designed life of 3–4 years and 16 times as preferred as an identical phone with a designed life of 1–2 years. However, only 12% of respondents indicated that they would be willing to pay more for a very durable phone. On the topic of repairability, Reischl (2021) has shown that a Repairability Index influences the purchase behavior of Portuguese consumers by positively affecting WTP and the perceived quality of mobile phones. However, the study found no effect of a Repairability Index on the overall purchase intention.

In sum, while some studies have found that consumers are willing to pay a premium for consumer electronics with higher levels of specific environmental attributes, other studies found no effect on consumers' purchase intention or suggest that consumers' WTP can decrease as the performance of specific environmental attributes increases. As a result, consumers' WTP for different levels of a multi-level eco-score integrating the overall environmental performance of mobile phones remains unclear.

3 | Methods

Our research methodology consisted of two stages: an adaptive choice-based conjoint (ACBC) study (Section 3.1) and market simulations (Section 3.2).

3.1 | ACBC

CBC methods provide a way to elicit stated consumer preferences for hypothetical product attributes and sustainability information that have not yet been introduced or tested (Hunka et al. 2021). These methods can be used to estimate respondents' SOP and WTP for sustainable product attributes (Boyer et al. 2021; Hinnen et al. 2017). CBC experiments involve presenting consumers with a series of choice tasks, asking them to make trade-offs between product profiles with varying attribute levels. Choice data is collected by asking participants to choose a product profile within several consecutive choice tasks. Compared to standard CBC designs, adaptive designs have been shown to yield more accurate preference estimates by better accounting for preference heterogeneity (Huber and Zwerina 1996). Specifically, the two-stage decision-making process within ACBC experiments, including a build-your-own section and screening tasks, accounts for heuristics consumers apply in complex choice tasks (Hauser, Ding, et al. 2009). Within ACBC, subsequent choice tasks are tailored and refined based on respondents' individual preferences. As a result, ACBC has been shown to deliver better predictive validity compared to standard CBC methods and provide more realistic purchase situations that keep respondents focused and engaged (Johnson and Orme 2007). Additionally, ACBC can counteract the tendency to overestimate WTP (Miller et al. 2011; Sichtmann et al. 2011) by including a "none" option within a calibration task section (Brand and Rausch 2021; Sablotny-Wackershauser et al. 2024). Detailed descriptions of the method can be found in Jervis et al. (2012) and Chapman et al. (2009).

In ACBC analysis, the utility of a specific product profile combination comprises the sum of the marginal utilities (also called part-worths) for the respective attribute levels and an unexplained choice part (a random degree of stochastic error) for each respondent. Given the utility of all product profiles tested, the probability of choosing a specific product profile is estimated using a standard multinomial logit model for each respondent (Hauser, Eggers, et al. 2019). In addition to the average utilities, the individual marginal utilities for all attribute levels for each respondent are estimated using Hierarchical Bayes (HB) modelling to improve the estimation and to account for variability within the observed data (Hauser, Eggers, et al. 2019).

3.1.1 | Design

The hypothetical eco-score used in this study was designed as a multi-colored five-level label with a scale from "A" (dark green) to "E" (red), similar to designs that have been used in previous studies in the food sector (Jürkenbeck 2023; Kolber and Meixner 2023). We presented participants with the meaning of the eco-score, which was accessible throughout the experiment. To design the ACBC study, we used Sawtooth Software's Lighthouse Studio software (version 9.14.0), a standard application for conjoint analysis in marketing research. Along with the eco-score, we included mobile phone characteristics that were found to be important in previous studies, such as brand (Karjaluoto et al. 2005; Kim et al. 2020) and price (Potoglou et al. 2020; Boyer et al. 2021). Additionally, we screened mobile phone offers on popular German online marketplaces and conducted a qualitative pretest using thinking-aloud protocols to generate market-specific attributes and levels. Table 1 shows the mobile phone attributes and levels used in the survey. The brand attribute comprised the two sustainable mobile phone brands and the 14 most popular conventional brands in Germany (Statista 2022).

We applied four interrelated and sequential survey phases within the ACBC study (Sawtooth Software 2014) and provided a brief overview of the ACBC design and its phases in the survey introduction (Appendix A). In the Build-Your-Own (BYO) phase, respondents created an ideal product profile from 16 brands and three performance levels, followed by a screening phase where they selected acceptable profiles and identified "must-have" and "unacceptable" attributes to refine choice tasks. Implausible combinations were excluded, and each respondent was shown a maximum of four brands. In the final phases, respondents made choices among grouped product concepts and rated their likelihood of purchasing different profiles, including the winning concept. For a detailed overview of the phases, see Jacobs et al. (2025).

3.1.2 | Sample and Data Collection

The survey, conducted in May 2022 by the market research institute Innofact, utilized a large ISO-certified online access panel. It targeted German participants who reported shopping online several times a year on platforms such as Amazon, eBay, or Zalando. Additionally, participants regularly used search engines like Google, Bing, Ecosia, or DuckDuckGo. To qualify, participants needed to indicate an intention to purchase a mobile phone within the next 2 years, for instance, due to the expiration of their current contract. Quota sampling was employed to ensure representation across sociodemographic factors including gender, age, educational attainment, and monthly household net income. The final sample consisted of 534 individuals after excluding those who completed the survey too quickly and those providing nonsensical responses to open-text questions. Appendix B details the sociodemographic composition of the sample. The sociodemographic composition aligns with the German adult population. However, people with lower educational qualifications are slightly overrepresented, while people with higher educational qualifications are slightly underrepresented, making the sample nearly representative of the population.

3.2 | Market Simulation

Market simulation software can simulate respondents' preferences for competing products using individual part-worth utilities from HB estimation based on ACBC data (Sawtooth Software 2021). These market simulations can be employed to analyze the SOP for product alternatives with sustainability attributes in market scenarios (Hinnen et al. 2017; Hunka et al. 2021) and thus allow translating individual-level preferences from conjoint analysis into expected market outcomes. In addition, simulated market scenarios based on ACBC utility data allow an examination of how changes in sustainable product attributes affect the preference shares (Boyer et al. 2021) and WTP for specific product combinations (Spindler et al. 2023). Recent studies have used market simulations to investigate the effectiveness of eco-labelling schemes, e.g., consumer choices for the color-coded, multi-level EU energy label (Heinzle and Wüstenhagen 2012) and consumer demand for products with a hypothetical Circular Economy Score (Hunka et al. 2021). In this study, we employed the choice simulator by Sawtooth Software to estimate respondents' SOP for competing

TABLE 1 | Attributes and attribute levels of mobile phones in the ACBC analysis (Jacobs et al. 2025).

Attribute	Attribute level	Visual representation	Additional description for respondents
Price	€99		
	€199		
	€349		
	€499		
	€649		
	€799		
	€999		
Brand	Samsung		
	Apple		
	Huawei		
	Xiaomi/Mi		
	Google		
	LG		
	Nokia		
	Sony		
	Honor		
	HTC		
	Motorola		
	OnePlus		
	OPPO		
	ZTE		
	Fairphone		
	Shiftphone		
Performance	Basic		Everyday device with compromises in camera and technology, standard display, sufficient performance, and good photos in daylight.
	Middle class		Averagely equipped device with good camera technology, good display, good processor, good performance and price-performance.
	Upper class		Powerful smartphone with up-to-date technology, high-end processor, excellent display and top camera equipment, and strong performance.
Shipping costs	Free shipping		
	Shipping starting at €4.9		
Shipping time	Same working day		
	1–2 working days		
	3–5 working days		

(Continues)

TABLE 1 | (Continued)

Attribute	Attribute level	Visual representation	Additional description for respondents
Customer reviews	5 stars	★★★★★	Customer reviews stem from consumers who have already handled a product. Customer reviews serve as a decision-making aid before a purchase and indicate whether other buyers' expectations have been met.
	4 stars	★★★★☆	
	3 stars	★★★☆☆	
Condition	New		
	B-stock		Returned item/display item with signs of use.
	Refurbished		Returned item that has been checked for faults, malfunctions and visual defects and repaired if necessary. Items of this type are also referred to as 'refurbished' and are resold with a warranty.
CO_2 compensation	Yes		Products cause greenhouse gases and CO_2 emissions. A green tree indicates whether part of the sales price is invested in tree planting projects and thus in climate protection. The costs are included in the purchase.
	No		
Product longevity	'durable'	Langlebig	Products marked with the criterion 'durable' are characterised by robust materials and their durability.
	No information		
Fair production and trade	'fair and social'	Fair & Sozial	Products marked with the 'Fair & Social' criterion are characterised by socially responsible production conditions and fair trade.
	No information		
Eco-score	A		The eco-score allows comparison of the sustainability of products within a product group. Environmental criteria are added and assigned to the scale from A (dark green) to C (yellow) to E (red). A product with a dark green A is the more environmentally friendly choice compared to a product with a yellow C.
	B		
	C		
	D		
	E		

mobile phones and respondents' WTP for various eco-score levels in different market scenarios.

3.2.1 | SOP

SOP can be understood as the percentage of respondents preferring one product over other products in a pre-defined market scenario. The choice simulator software converts the raw utility data from the conjoint study into SOP for different product profiles in simulated market scenarios (Williams and Peitz 2021). The simulated SOP for a given product is the proportion of respondents who choose that option as their first (maximum utility) choice in a market scenario (Orme 2019). We used the randomized first choice method to estimate respondents' SOP. This method rests on the assumption that respondents would choose the option with the highest composite utility. The randomized first choice method accounts for some degree of error in respondents' choices and allows a simulation of how changes in product attributes affect the SOP for products in a market scenario (Orme and Baker 2000). Hence, we put multiple products into the market simulation tool and placed them in competition, using attribute levels measured in the conjoint study to define each product. This way, we could use the market simulator to assess product switching and market effects (Braun et al. 2016).

3.2.2 | WTP

WTP can be understood as the amount consumers are willing to pay for a product or service, or its respective attributes. Numerous methodologies have been described to use CBC data for the estimation of how much consumers are willing to pay for one product or service feature in comparison to another (e.g., Hunka et al. 2021). However, approaches such as scaling utilities with a simple algebraic formula to calculate the monetary equivalent of a utility point or calculating the median value of respondents' WTP do not account for competition in realistic market scenarios and often result in inflated monetary values and overstated WTP (Orme 2019). We employed a market simulation approach that is based on shares of preferences and allows us to consider relevant competition and potential reactions of competitors in a market scenario and thus yields more realistic results compared to basic CBC approaches (Orme 2021; Spindler et al. 2023). To estimate the WTP values, we used Sawtooth Software's choice simulator and ran simulations for both a simple two-product market scenario which allows us to compare the WTP for two otherwise identical products (e.g., Boyer et al. 2021) and a realistic market scenario via the sampling of scenarios (SOS) approach which considers competition. Using the first-choice rule in a simple two-product scenario, WTP simulation leads to identical results compared to an algebraic approach (Orme 2021). The SOS approach repeatedly samples among random competitive positionings in a market scenario accounting for random variations in a reference product for which the WTP is estimated (Orme 2021). First, the SOP for the reference product is simulated using the SOPs. Second, a product feature is enhanced, which results in a change in the product's simulated SOP. Finally, the price difference needed to drive the SOP for the reference product back to its original share before the enhancement represents the WTP for the enhanced product feature (Orme 2021). The simulation was repeated in multiple iterations using bootstrap sampling to account for uncertainty in real-world market environments and the robustness of the WTP estimates. Confidence intervals were estimated for WTP values converging towards a single value after 1000 simulations.

4 | Results

This section reports on the results of the study. First, we report on the relative importance of the eco-score attribute, followed by participants' SOP for (sustainable) mobile phones in competitive market scenarios and their WTP for successively higher eco-score levels.

TABLE 2 | Relative importances of attributes of the adaptive choice-based conjoint analysis. Attributes are sorted in order of decreasing importance.

Attribute	Average relative importance[a] in % ($n = 534$)	SD
Price	32.80	15.51
Brand	26.64	8.09
Equipment version	11.17	4.96
Condition	9.90	6.51
Eco-score	**6.37**	**3.88**
Customer reviews	3.24	2.19
Shipping time	2.27	1.39
Fair production and trade	2.14	1.67
Product longevity	2.00	1.56
CO_2 compensation	1.94	1.58
Shipping costs	1.54	1.32
Totals	100.00	

Abbreviations: *n* stands for the number of respondents; SD stands for Standard Deviation.
[a]Averaged across all respondents; with standard deviations.

4.1 | Relative Importance of Product Attributes

The relative importance of each product attribute reflects its effect on product choice. Each attribute's importance score is calculated as a percentage of the total utility range across all attributes (summing to 100%). A higher importance score means that changes in this attribute have a greater impact on preference, whereas lower scores indicate attributes to which respondents are less sensitive (for the average utility values of the individual attribute levels based on hierarchical Bayes estimation, see Jacobs et al. 2025). It is essential to note that relative importance does not specify which level of an attribute respondents prefer; rather, it indicates the extent to which the entire attribute contributes to the overall utility of the product. Importance scores are presented in Table 2. The eco-score is highlighted for emphasis.

All attributes tested have a significant impact on consumer decisions (see Jacobs et al. 2025). The eco-score is not the most important attribute for mobile phones; nevertheless, it is a relevant attribute. While price, brand, performance, and condition rank as the four most important attributes, the eco-score is positioned at the top of a set of second-tier attributes. It ranks higher than attributes such as customer reviews, shipping time, and shipping costs, as well as other specific sustainability-related attributes that were communicated in the form of categorical product badges (fair production and trade, product longevity, and CO_2 compensation). The level of importance is noteworthy given that the eco-score is a hypothetical attribute that has not yet been implemented for consumer electronics.

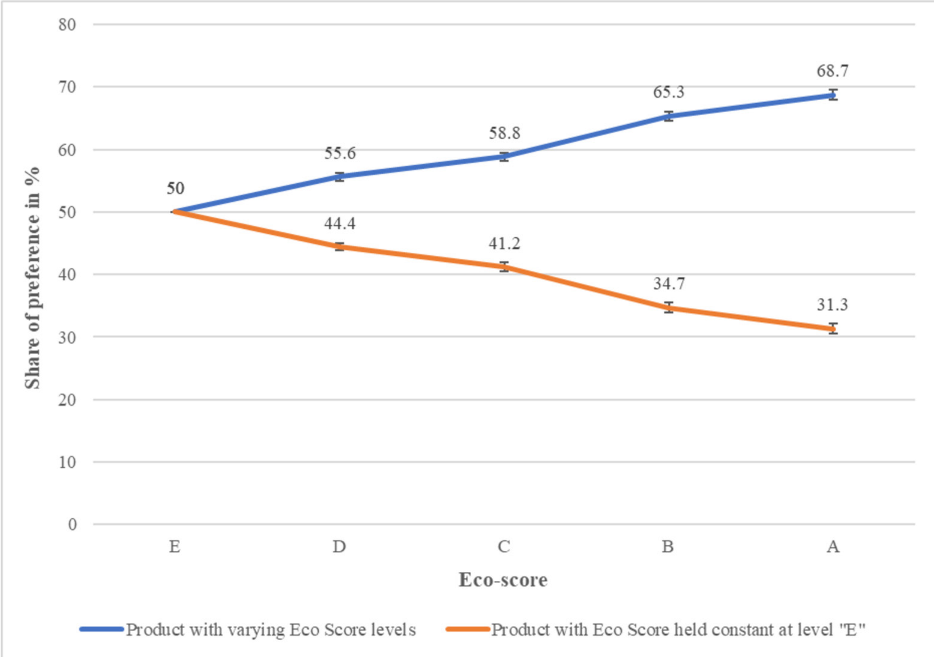

FIGURE 1 | Share of preference at each eco-score level for mobile phones competing in a two-product market scenario with otherwise identical product attributes (* statistically significant ($p<0.05$), error bars represent the standard errors, statistical significance is reported as determined by *t*-tests).

4.2 | Shares of Preference

Individual marginal utilities can be employed to simulate respondents' SOP for competing products in market scenarios (Hauser, Ding, et al. 2009). This analysis can be conducted through Sawtooth Software to evaluate whether eco-score level changes can influence the SOP for more sustainable smartphones.

4.2.1 | Two-Product Scenario

To evaluate how a product with a successively higher eco-score level is preferred compared to an otherwise identical product, we created a market scenario with two products (see Appendix C). The market simulation is changing one eco-score level at a time for one of the two otherwise identical products (see also Boyer et al. 2021). Other attributes were held constant at their most preferred levels, i.e., the levels with the highest utility values. To account for the prohibitions set in the survey design, we held all sustainability attributes, other than the eco-score, constant at their lowest level (no information). For example, a new Samsung phone with varying eco-score levels competes with an otherwise identical product for which the eco-score was kept constant at the reference level "E". We employed the randomized first-choice method to calculate the SOP (Huber et al. 2007). Figure 1 compares relative preferences for the two-product scenario at each eco-score level.

The results show that mobile phones with higher eco-score levels dominate the SOP in a two-product market scenario when all other attributes are identical. The most preferred option is the one with the highest eco-score level "A". Mobile phones with successively higher eco-score levels are consistently preferred over otherwise identical products ($p<0.05$)—the higher the eco-score, the higher the SOP for that product.

4.2.2 | Market Scenario

In the second step, we created a competitive market scenario that reflects the mobile phones available on the German market in 2022. We selected mobile phone alternatives, including retail prices and other product attributes, based on Google Shopping listings for smartphones. We compared the features of each phone listed and aligned them with attribute levels tested in the ACBC study. We eliminated listings that were too similar in their attribute combinations (Huber et al. 2007). In the final market scenario, we included two Shiftphone and Fairphone models, which can be considered best-practice sustainable mobile phones. This approach allowed us to examine sustainable brands within a competitive market scenario covering a wide range of product offerings with varying product features. The market scenario included a total of 47 phones from 16 brands, including refurbished offers (see Appendix D).

To examine the impact of the eco-score, we conducted and compared two simulations—one with a limited influence of the eco-score as a base scenario and a second scenario with all eco-score levels present. We used the randomized first-choice method and accounted for the prohibitions set in the ACBC experiment to determine the SOP in both simulated market scenarios (Huber et al. 2007). For the base scenario (scenario 1), we maintained a constant eco-score level "A" for all mobile phones to limit its effect on consumer preferences. For a market scenario with all eco-score levels present (scenario 2), we evaluated the sustainability performance of each of the 47 mobile phones. We

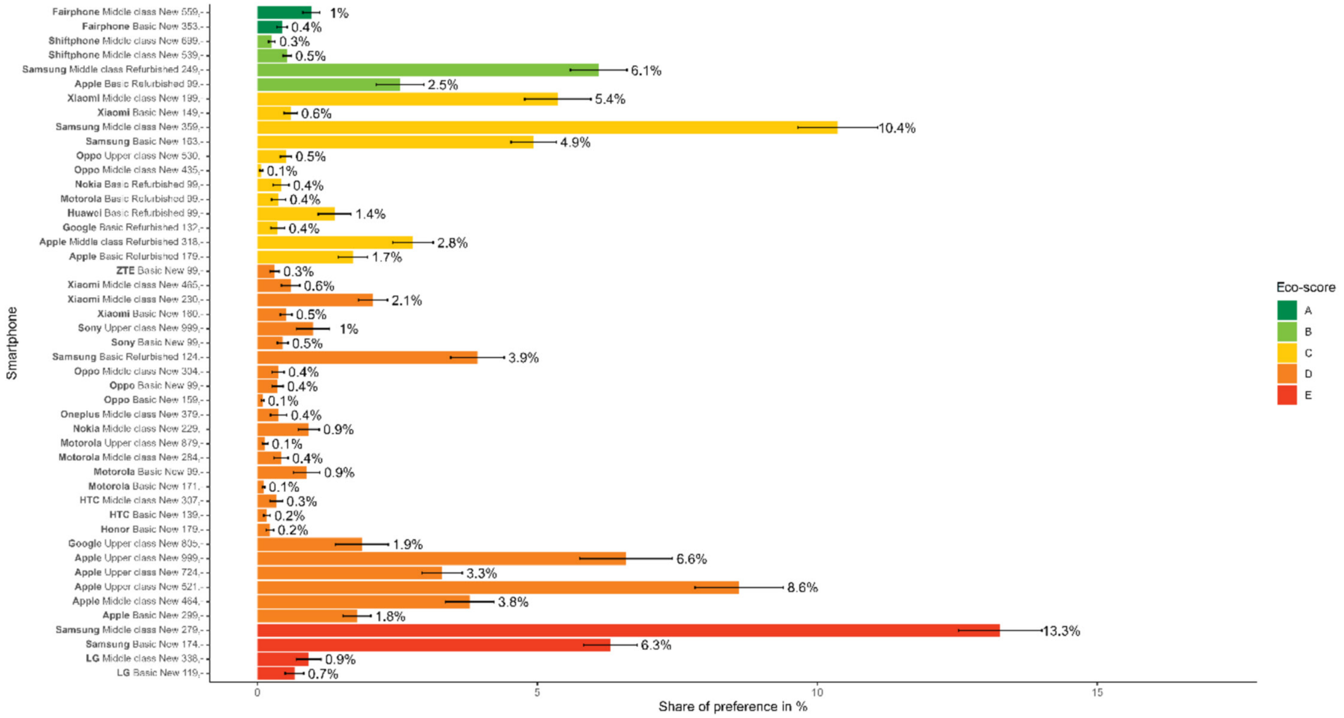

FIGURE 2 | Share of preference and 95% confidence interval for mobile phones in the base scenario (1) and their associated eco-score levels.

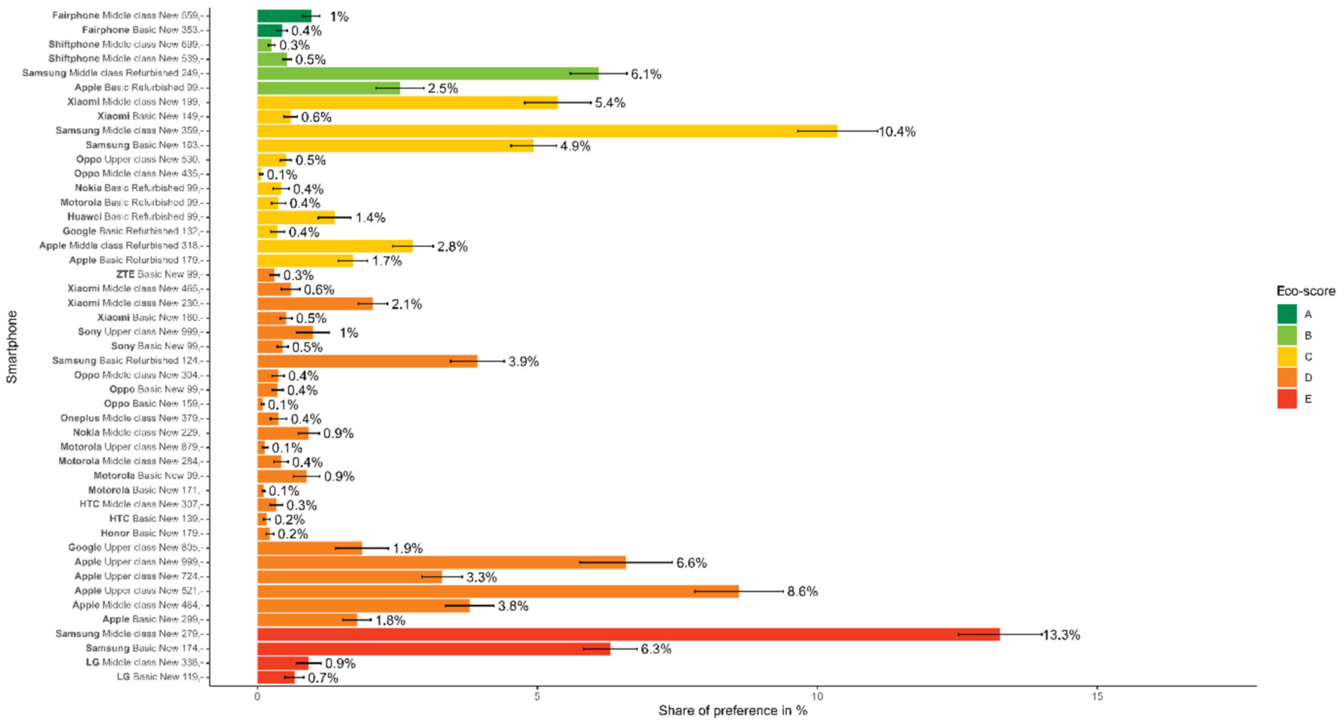

FIGURE 3 | Share of preference and 95% confidence interval for mobile phones in the market scenario 2 and their pre-defined eco-score levels.

assigned an individual eco-score level utilizing available market data on the environmental performance of mobile phones. The sustainability evaluation was based on publicly available sources on the sustainability performance of mobile phones, such as sustainability label product databases including the product finders of TCO Certified (TCO Certified 2025), the Blue Angel label (Blue Angel 2023), or the Fairtrade certification; as well as circularity metrics such as the French repairability index (European Environment Agency 2025) and the ethical consumer score (Owens 2022) (see Appendix E). Figures 2 and 3 depict the results for the market simulations of scenarios 1 and 2, respectively.

In the market simulation in which the eco-score is held constant and its influence is therefore limited (scenario 1), 10.9% of respondents prefer sustainable mobile phones (associated

TABLE 3 | Change in share of preference on the brand level from market scenario 1 to 2.

Brand	SOP in market scenario 1	SOP in market scenario 2	SOP change
Samsung	44.92%	44.19%	−0.73%
Apple	31.09%	29.43%	−1.66%
Xiaomi	9.10%	9.03%	−0.07%
Google	2.24%	1.89%	−0.35%
Motorola	1.94%	1.95%	0.01%
LG	1.57%	1.34%	−0.23%
Sony	1.45%	1.21%	−0.24%
Fairphone	1.40%	4.08%	2.68%
Huawei	1.38%	1.30%	−0.09%
Oppo	1.37%	1.30%	−0.08%
Nokia	1.34%	1.39%	0.04%
Shiftphone	0.78%	1.75%	0.97%
HTC	0.51%	0.42%	−0.09%
OnePlus	0.38%	0.29%	−0.09%
ZTE	030%	0.29%	−0.01%
Honor	0.22%	0.16%	−0.06%
	100%	100%	0%

with the eco-score "A" or "B"), and 6.1% and 2.5% of respondents opt for refurbished and low-priced models by Samsung and Apple, respectively, which score high on repair indexes and are associated with the eco-score "B". Only a small percentage of respondents prefer sustainable brands, such as Shiftphone (0.8%, associated with the eco-score "B") or Fairphone (1.4%, associated with the eco-score "A") (for detailed results see Appendix F).

When the market simulation is altered to include all pre-defined eco-score levels for each of the individual phones (scenario 2), the SOP for sustainable mobile phones (associated with eco-score "A" or "B") increases. Their SOP almost doubles to 19.1%, with a notable increase in SOP for Fairphone (1.1% and 3.0%, eco-score "A") and Shiftphone (1.2% and 0.6%, eco-score "B") models. Additionally, the SOP for the two refurbished and low-priced Apple and Samsung models with a good eco-score ("B") increases from 2.6% to 3.4% (Apple) and 6.1% to 9.8% (Samsung).

Table 3 presents the change in SOP on the brand level from the results of market scenario 1 to 2. Samsung and Apple phones remain the most popular phones in market scenario 2, dominating the share of preference. However, these brands show the largest decline in preference share. At the same time, the two sustainable brands (Fairphone and Shiftphone, carrying the eco-score levels "A" and "B" respectively), showed a positive change in SOP. Fairphone ranks fourth out of 16 brands, increasing its overall SOP from 1.4% to 4.08% when all eco-score levels are in place. Similarly, the Shiftphone brand more than doubles its initial SOP from 0.78% to 1.75%.

TABLE 4 | Change in number of respondents opting for mobile phones associated with different eco-score levels from market scenario 1 to 2.

Eco-score	Scenario 1, number of respondents	Scenario 2, number of respondents	*p*-value
	$n = 534$	$n = 534$	
A	5	17	0.009733**
B	45	82	0.000469***
C	159	184	0.101346
D	210	181	0.065468
E	115	70	0.000274***

Note: The chi-square test is used to compare frequencies of phone preferences associated with the eco-score levels in the two market scenarios. *p*-values below 5% are considered significant, with indicating significant results.
*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

4.2.2.1 | Changes of Individual Shares of Preference.

To further analyze changes in SOP when competing eco-score levels are introduced, we used the individual results of the SOP simulations and contingency tables for each scenario. We applied the 'maximum utility rule', assuming that respondents choose the option with the highest individual SOP, i.e., the highest composite utility, within each scenario. Table 4 aggregates the respondents with the highest SOP alongside the associated eco-score for each scenario. The analysis shows that the eco-score levels significantly impact the SOP for mobile phones in a competitive market scenario. When mobile phones with individual eco-score levels compete against each other, the number of respondents preferring offers associated with high eco-score levels ("A" and "B") increases, while the number decreases for the lowest eco-score level ("E").

For example, the number of respondents who prefer a mobile phone associated with the highest eco-score level "A" increases by 240%, equating to 12 more respondents, compared to a market where the eco-score is held constant for all products. Similarly, 37 more respondents prefer phones with an eco-score "B" which means an 82.2% increase for phones with this eco-score level compared to a market where the eco-score is held constant. At the same time, the share of respondents preferring mobile phones associated with the lowest eco-score level "E" decreases by 39% from market scenario 1 to 2. To investigate the individual shift in SOP for all respondents, we created a Sankey diagram based on the contingency tables for market scenarios 1 and 2 using the networkd3 package in R (version 4.3.3) (see Figure 4).

Figure 4 shows whether respondents choose a mobile phone with the same eco-score level or whether their preference for the eco-score changes from scenario 1 to scenario 2. The Sankey diagram offers detailed insights into the substantial increase in respondents preferring mobile phones with a high eco-score compared to a base scenario where the eco-score is

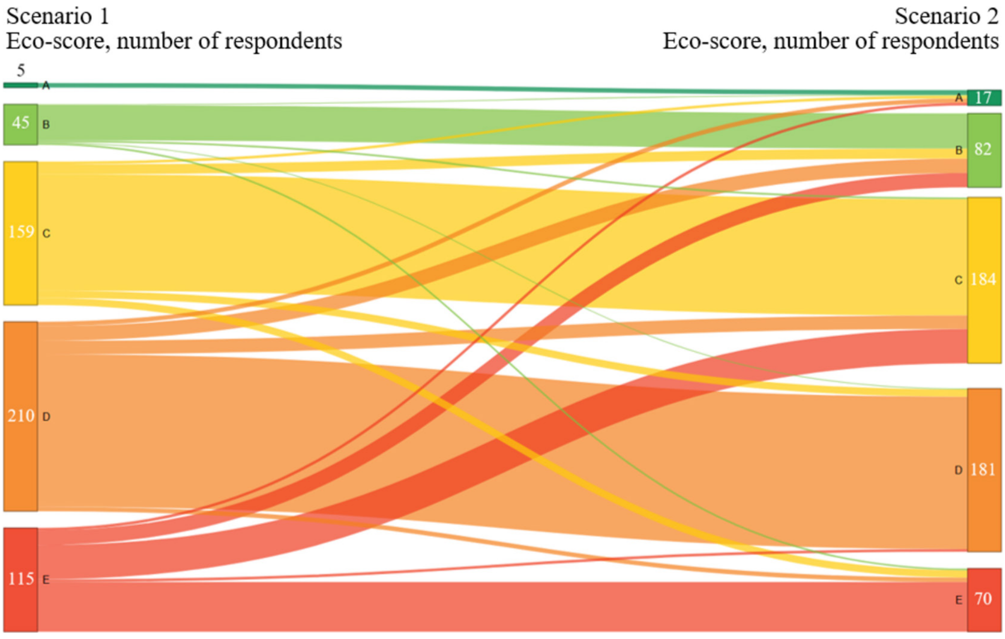

FIGURE 4 | Sankey diagram visualizing the number of respondents who prefer a mobile phone associated with a certain eco-score level in market scenarios 1 and 2 (color of nodes indicate the eco-score level (green "A" to red "E"), size of the nodes corresponds to the number of respondents, flows between the nodes illustrate whether there is a shift or consistency in preference, color of the flows indicates initial preferences in scenario 1, size of the flows corresponds to the number of respondents).

held constant. At the same time, the figure shows that most respondents maintain consistent mobile phone preferences, i.e., the introduction of an eco-score as a varying mobile phone attribute does not influence their preferences (see also Table 5, which depicts the number of respondents with consistent or changing preferences).

4.2.2.2 | Sensitivity. Finally, we examined how changes in various attributes affect the SOP for a reference product in a competitive market. We used sensitivity analysis to predict those changes through market simulation by varying one attribute at a time and holding all other attributes constant. The reference product was the most preferred mobile phone in scenario 2—a new, middle-class Samsung phone with an eco-score "C" costing €359. The attributes for this product are varied sequentially for all their levels. Figure 5 shows changes in the SOP for the reference product and which attributes most affect these changes. The line chart's red dots indicate the reference product's original SOP before the attribute level change in a competitive market.

The results suggest that changes in specific attribute levels such as an industry-leading brand (e.g., Samsung and Apple), a favorable price (€199), and condition (new), and a middle-class performance have the biggest impact on SOP for the reference product in a competitive market scenario. At the same time, changes in sustainable product attributes, especially the eco-score, also strongly affect the SOP for mobile phones. For example, improving the eco-score from level "C" to "B" or "A" results in a greater increase in the SOP than an enhancement in performance from middle to upper-class features. In addition, upgrades in product longevity, fair trade and production, and CO_2 compensation also increase the SOP for the reference product in a competitive market setting.

4.3 | WTP

WTP simulation enables the calculation of a relative WTP value, which indicates how much more (or less) a person is willing to pay for an attribute level X over an attribute level Y for a reference product (Orme 2021). We employed the WTP simulation approach described in Section 3.2.2 to investigate how much customers are willing to pay for a change in the eco-score level. In a similar approach to the SOP evaluation, we created market scenarios with two otherwise identical products and a competitive market scenario for the WTP simulation. We used the first-choice model with the two-product scenario and the SOS approach for the competitive market scenario. The WTP value is equivalent to the price delta associated with a product improvement relative to a reference attribute level. This price delta is required to drive respondents' SOP back to the original share for the product with the reference level, i.e., without improvement. By default, the least preferred levels of each attribute are set as the reference levels, meaning that the monetary WTP values must be interpreted in relation to these.

Apart from the sustainability attributes, the attribute levels with the highest utility values were chosen for both products in the two-product scenario. Again, due to the prohibition set in the ACBC survey, all sustainability attributes other than the eco-score were held constant at their least preferred level (no information) (see Appendix C).

4.3.1 | Two-Product Scenario

A two-product market simulation approach allows simulating respondents choosing between two versions of the same product: one with and one without an enhanced feature (e.g., Boyer et al. 2021). Hence, as a first step, a new, middle-class Samsung

TABLE 5 | Number of respondents changing or maintaining their mobile phone choice in relation to the eco-score.

Scenario 1, associated eco-score	Scenario 2, associated eco-score	Number of respondents
		$n = 534$
A	**A**	**5**
B	A	1
C	A	3
D	A	5
E	A	3
B	**B**	**39**
C	B	11
D	B	16
E	B	16
B	C	2
C	**C**	**129**
D	C	15
E	C	38
B	D	1
C	D	8
D	**D**	**169**
E	D	3
B	E	2
C	E	8
D	E	5
E	**E**	**55**

Note: The number of respondents maintaining their mobile phone choice are marked in bold.

phone with varying eco-score levels at a reference price level of €199 competes with an otherwise identical product for which the eco-score was kept constant at level "E". Figure 6 shows respondents' WTP increases for each improvement in the eco-score level. Table 6 shows the detailed results of the WTP simulation.

Our results show that the average German consumer is willing to pay higher prices for a mobile phone with progressively higher eco-score levels when compared to an otherwise identical product. For example, upgrading the eco-score from level "E" to "D" results in a potential price increase of 17.2% compared to the reference price level due to the additional WTP (=€34.2/€199*100). Similarly, upgrading the eco-score from "E" to "C" leads to a potential price increase of 23.2%, while upgrading to eco-score "B" leads to a potential increase of 78.7% in price compared to the reference level. Changing the eco-score from level "E" to "A" leads to an additional WTP that can more than double the price (110.9%) compared to the reference price level. Interestingly, eco-score level "D" falls within eco-score "C"'s 95% confidence interval, indicating that the WTP for both levels might be statistically indistinguishable (see Table 5). In addition, the confidence intervals for both eco-score levels "D" and "C" reveal that some respondents are unwilling to pay more for mobile phones with these levels. The confidence intervals for the eco-score levels "A" and "B" indicate that the average German consumer is always willing to pay more for the highest and second-highest eco-score levels.

4.3.2 | Market Scenario

In the next step, we used the SOS approach to assess how much respondents are willing to pay for changes in eco-score levels of a reference product in a realistic market scenario. We put all 16 brands in competition, with one product selected as the reference product. The reference product in this case study was a new, middle-class Samsung phone at a price of €199 that competed with similar models from all brands. In the simulation scenario, we adhered to the prohibitions set out in the ACBC experiment, with all middle-class phones ranging from €199 to €799 and eco-score levels for Fairphone and Shiftphone not falling below "B". To specify these attribute level ranges for the sampled scenarios in the choice simulator, we used the "Range()" function (Orme 2021). Apart from the sustainability attributes, all other attributes were held constant within the simulation at their most preferred levels. Following the SOS approach, we used bootstrap sampling to compute confidence intervals for the SOP simulation runs. For each simulation run, 1000 bootstrap samples were conducted.

Figure 7 shows that respondents' WTP for the Samsung reference phone increases with each improvement in the eco-score level in relation to the reference level. Again, Table 7 depicts the detailed market simulator results. The results reveal that consumers are consistently willing to pay more for a mobile phone with successively higher eco-score levels in a realistic market setting. The confidence intervals for both eco-score levels "D" and "C" reveal that some consumers may be unwilling to pay more for mobile phones with these levels in a realistic market.

To determine the WTP for all sustainability attributes evaluated while adhering to the prohibitions set within the ACBC study, we conducted a second SOS simulation using a new, middle-class Fairphone at a price level of €199 as the reference product. Consequently, sustainability attributes (product longevity, fair trade, and production) were only sampled for Fairphone and Shiftphone models and mobile phones with eco-score levels higher than "C". The CO_2 compensation attribute was introduced for all competitors. Table 8 presents the results of the SOS simulation with 15 competitors and the Fairphone as the reference product. The results indicate that consumers are generally willing to pay more for the highest eco-score levels "A" and "B" and for information regarding product upgrades in product longevity, fair trade, and production, and CO_2 compensation.

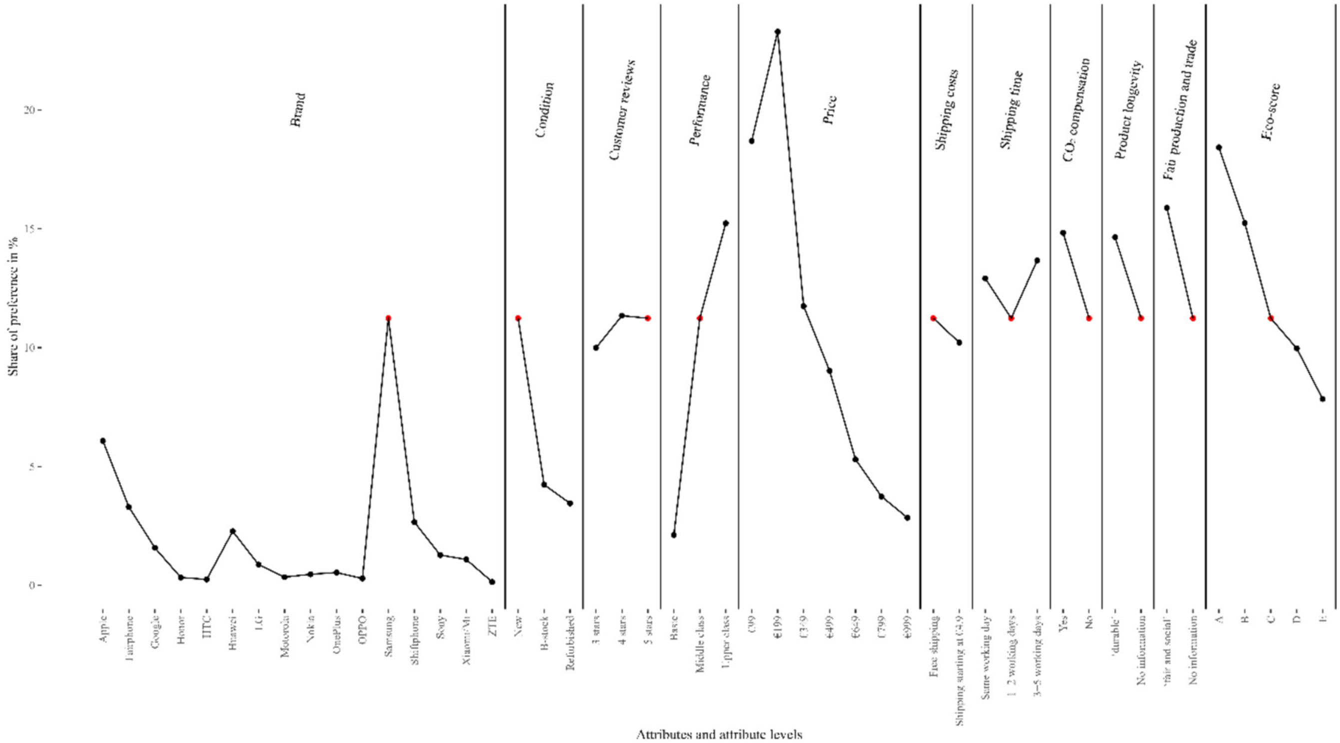

FIGURE 5 | Changes in share of preference for the reference product in market scenario 2 (lines show changes in share of preference for the reference product, red dots show the initial shares of preference for the reference product).

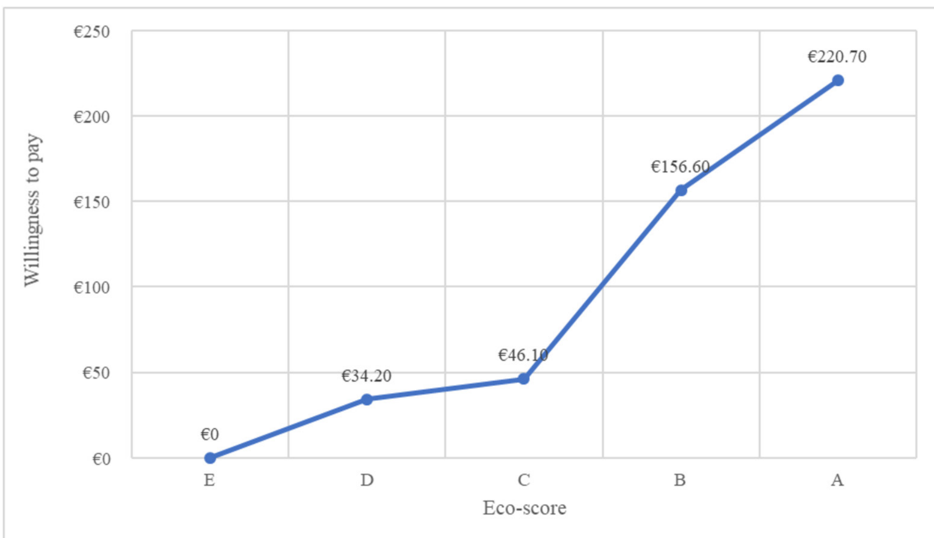

FIGURE 6 | Willingness to pay in a two-product market scenario.

TABLE 6 | Detailed willingness to pay simulation results for a new, middle-class Samsung phone at a price of €199 with varying eco-score levels in a two-product market scenario.

Eco-score	Willingness to pay	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
E	N/A (reference level)			
A	€220.7	€50.4	€121.3	€320.1
B	€156.6	€33.6	€90.2	€223.0
C	€46.1	€79.3	−€110.3	€202.5
D	€34.2	€64.9	−€93.8	€162.3

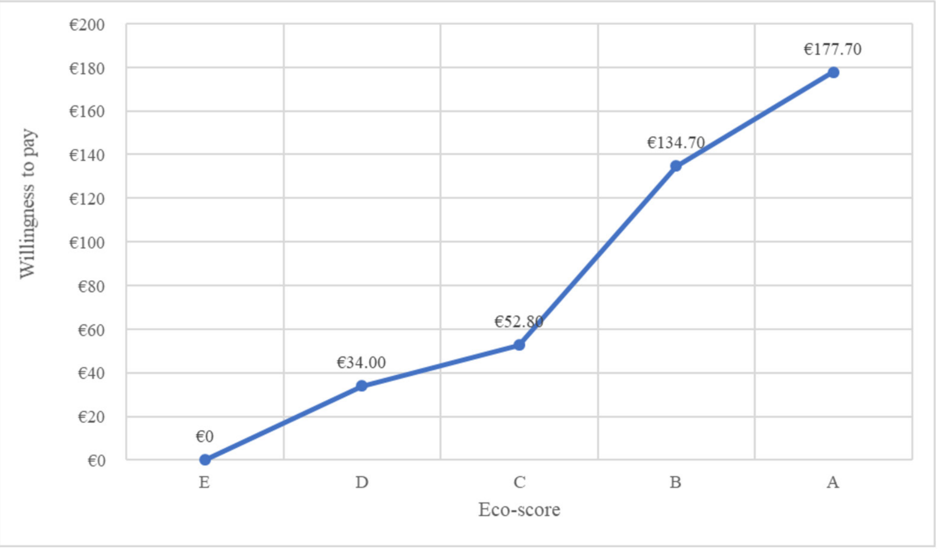

FIGURE 7 | Willingness to pay in a competitive market scenario.

TABLE 7 | Detailed willingness to pay simulation results for a new, middle-class Samsung phone at a price of €199 with varying eco-score levels in a realistic market scenario.

Eco-score	Willingness to pay	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
E	N/A (reference level)			
A	€177.7	€55.5	€68.2	€287.3
B	€134.7	€58.7	€19.0	€250.5
C	€52.8	€44.5	−€35.1	€140.7
D	€34.0	€46.4	−€57.6	€125.5

TABLE 8 | Willingness to pay simulation results for specific eco-score levels and other sustainability attribute levels of a new, middle-class Fairphone phone at a price of €199 in a realistic market scenario.

Eco-score	Willingness to pay	Standard error	Lower 95% confidence interval	Upper 95% confidence interval
E	N/A (reference level)			
A	€163.5	€94.9	−€23.7	€350.6
B	€98.5	€76.3	−€52.1	€249.0
C	N/A	N/A	N/A	N/A
D	N/A	N/A	N/A	N/A
Product longevity				
No information	N/A (reference level)			
“durable”	€40.3	€41.3	−€41.0	€121.7
Fair trade and production				
No information	N/A (reference level)			
“fair and social”	€61.4	€37.2	−€12.0	€134.8
CO_2 compensation				
No	N/A (reference level)			
Yes	€30.6	€42.5	−€53.3	€114.5

5 | Discussion

5.1 | Summary and Discussion of Results

This study analyzes the influence of a hypothetical, multi-level eco-score on SOP and WTP for mobile phones. Four key insights emerge from the study.

First, although price, brand, performance, and product condition together account for most of the total utility, the eco-score accounts for more than 6% of average relative importance and emerged as an influential second-tier attribute within a set of market-like product characteristics. The eco-score outranks shipping cost, shipping time, customer reviews, and the other sustainability cues in the form of categorical product badges (fair trade and production, durability, and CO_2 compensation). This is noteworthy because the eco-score is a hypothetical label for the consumer electronics sector—respondents had never encountered it on actual smartphones.

Second, in response to research question 1, the study reveals a clear upward trend in consumer preferences for mobile phones with higher eco-score levels. In a two-product scenario, we find that mobile phones with progressively higher eco-scores are consistently preferred over otherwise identical products—while holding all other attributes constant. The stepwise pattern ("A" > "B" > "C", etc.) confirms that consumers treat the label as an ordinal cue: each incremental improvement translates into a notable SOP gain. In a competitive 47-phone market scenario, introducing differentiated eco-score levels increased (almost doubled) the SOP for more sustainable phones (those considered best-practice models associated with eco-scores "A" or "B"), compared to the same market where the influence of the eco-score was limited. Importantly, this shift was mainly observed among respondents who initially preferred less sustainable phones in terms of their associated eco-score. This shift came at the expense of mobile phones with low and average environmental sustainability; the largest losses in SOP could be observed for industry-leading brands such as Apple and Samsung, whose models were associated with middle or low scores. Hence, the results suggest that implementing multi-level eco-score labeling in a competitive market can positively influence consumer choices towards more sustainable products and expand the market share of best-in-class sustainable mobile phone brands (such as Fairphone and Shiftphone) and refurbished models. Overall, these results align with previous research suggesting that multi-level sustainability labeling approaches can drive consumer demand for more sustainable products (e.g., Torma and Thøgersen 2024; Jürkenbeck 2023; Spindler et al. 2023; Mazurek and Prey 2025) and that graded, color-coded label approaches are effective in shifting consumer choices towards more sustainable alternatives (Thøgersen et al. 2024).

Third, sensitivity analysis revealed product improvements towards the highest eco-score levels A and B lead to stronger increases in SOP than upgrades in other desirable product attributes. For example, improving the eco-score level from "C" to "B" or "C" to "A" for a Samsung reference product results in a stronger increase in SOP than *upgrading* the device from mid-range to upper-range performance. However, a significant price drop or a desirable brand provides an even stronger change in SOP, reiterating that the eco-score is an influential yet not dominant attribute for consumers when making choices in a competitive market scenario. These results align with previous research on the effects of ecological scores for sports apparel and multi-level color-coded eco-scores for food products (e.g., Marette 2021; Jürkenbeck 2023; Spindler et al. 2023). The results indicate that higher levels of environmental sustainability can somewhat compensate for more preferred mobile phone attributes, such as a desirable brand or performance, and thus could support brand-switching behavior (Garga et al. 2019). At the same time, a favorable price of €199 serves as a push factor for more sustainable and refurbished models (Hazen et al. 2017). Concurrently, a high eco-score seems to compensate to some extent for the usually higher prices of sustainable mobile phones such as Fairphone.

Fourth, in response to our second research question, the study demonstrates how different levels of environmental product performance influence WTP. A key result is that consumers are consistently willing to pay more for mobile phones with successively higher eco-score levels in both a two-product and competitive 47-phone market. WTP increases continually with each upgrade in the eco-score level, compared to the baseline level "E". These results align with literature that reports a higher WTP for sustainable and eco-labeled products in other sectors (e.g., Brand and Rausch 2021; Jacobs and Hörisch 2021). Additionally, the results are consistent with studies showing higher WTP for higher levels of environmental sustainability, such as products with higher eco-score levels in the food sector (Jürkenbeck 2023) and products with better environmental performance in sports apparel (Spindler et al. 2023). At the same time, our results contradict the results of Boyer et al. (2021). While they found a goldilocks effect in consumers' WTP for a specific multi-level environmental attribute such as a circularity score—the WTP diminishes and, in some cases, declines as the proportion of recirculated content increases—higher levels of overall environmental sustainability result in successively higher WTP. However, our study shows that respondents' WTP does not change linearly with better environmental performance. The results suggest a threshold at which the eco-score begins to signal genuine sustainability (B and above). Once that threshold is passed, the WTP escalates rapidly. These results mirror a "winner-take-most" effect: products with mid-tier eco-score levels yield small incremental value in a competitive market, whereas the top eco-score levels unlock substantial monetary benefits. Consequently, there is a strong incentive for manufacturers to outperform average environmental sustainability performance if a multi-level environmental labeling scheme such as the eco-score is implemented.

5.2 | Limitations and Further Research Opportunities

This study has some limitations and offers opportunities for further research. While our study utilized a nearly representative sample, it focused on a single product (mobile phones) and is concentrated on a limited market (Germany). Research indicates that the impact of multi-level sustainability labelling can vary across markets (Torma and Thøgersen 2024). Potoglou et al. (2020) found that consumer WTP for mobile phones differs in Germany, India, Japan, Sweden, the United Kingdom, and the United States. However, in all regions, cost and functionality were often prioritized over ethical and environmental considerations. Thus, despite possible variations in WTP in different regions, our findings have broader implications for similar market dynamics. Future research should examine how cultural and economic factors influence WTP for eco-scores and explore comparative studies, especially in non-Western and emerging markets, to validate our results.

While single-issue, stand-alone eco-labels have been present in the German market for some time, the eco-score used in this study was hypothetical. Thus, we employed stated preference data to examine consumer reactions to label formats that were unfamiliar to participants (Hunka et al. 2021). Although hypothetical choice scenarios may introduce some bias, this method is generally considered less prone to bias than traditional survey response scales (Auger and Devinney 2007). To compensate for the lack of familiarity with the eco-score, we used a design familiar to participants from other contexts (e.g., the Nutri-Score label), including pictures of the label and its meaning throughout the ACBC study. This approach aimed to create situational familiarity with the hypothetical eco-score. Moreover, the eco-score has been shown to work remarkably well even when no additional information is provided (Jürkenbeck 2023) and independently of subjective ecolabel knowledge (Kolber and Meixner 2023).

Additionally, the prohibitions set in the ACBC only presented participants with limited mobile phone brand options, which may have resulted in a focus on the included brands. Nonetheless, we carefully selected the attributes to match a realistic choice situation. The pre-defined market scenarios and market simulations, especially the hands-on sustainability evaluation, are subject to some limitations. Due to a lack of publicly available information on each product's supply chain, the predefined eco-score levels within the market simulations were not based on life cycle assessments. Future studies could explore which specific criteria and indicators should be considered when assessing the environmental performance of consumer electronics. For example, developing product-specific life cycle assessments and dependable scoring and weighting criteria of sustainability attributes within the consumer electronics sector. Additionally, future studies should examine the credibility and amount of information consumers need to trust eco-labeling schemes such as the eco-score within the consumer electronics sector. Moreover, research is needed to explore the potential for designing and implementing a multi-level eco-labeling scheme. This includes investigating consumer acceptance, as well as the regulatory frameworks required to support its standardization and adoption in the market. Furthermore, future research should examine the interaction between the eco-score and other mandatory labels, such as the EU energy label, and their combined effect on consumer decision-making. Field experiments would be particularly valuable for validating our findings and assessing the practical influence of sustainability labels in actual purchase contexts.

6 | Conclusion

This study provides the first empirical evidence on consumers' WTP for a *multi-level eco-score* on mobile phone handsets, filling a significant gap in sustainable consumer electronics research. While previous research has yielded mixed results for the effectiveness of multi-level eco-labelling for specific environmental attributes, our results suggest that a more *holistic eco-score* can positively influence consumer choice.

To enable sustainable consumption decisions, clear information about a product's environmental performance is essential at the point of purchase. Multi-level eco-labeling such as the eco-score could provide this information in a comprehensible way. This study shows that successively higher eco-score levels increase the SOP for mobile phones compared to otherwise identical products in competitive market scenarios in Germany. Additionally, our findings indicate an increasing WTP for successively higher levels of environmental sustainability in competitive market scenarios. In conclusion, our study highlights the importance of multi-level eco-labeling such as the eco-score in driving consumer preferences and WTP for sustainable consumer electronics and contributes to the growing body of literature on possible strategies supporting a transition towards more sustainable production and consumption.

The results have several implications for businesses, marketers, and policymakers. Manufacturers are generally advised to invest in making their product portfolios more sustainable, as they can benefit financially from such improvements meeting consumer demand for more sustainable products. Incorporating the eco-score into marketing strategies can provide a competitive advantage in the growing market for sustainable consumer electronics. Additionally, policymakers can promote sustainable consumption practices by developing a standardized eco-score labeling scheme and incentivizing businesses to improve the sustainability of their products. From June 2025 onwards, new eco-design requirements apply for smartphones and tablets in EU markets (European Commission 2025). Products are now required to display information on their energy efficiency, battery longevity, protection from dust, water, and resistance to accidental drops, as well as a repairability score. Our findings can further inform the development of regulations and policies to promote sustainability in the consumer electronics industry. The introduction of the eco-score in the food sector in France and its voluntary adoption in other markets further highlight the potential of this tool. However, developing separate eco-score indices could cause consumer confusion. We advocate for the development of a harmonized eco-score framework across product categories to ensure clarity, facilitate compliance, and help consumers to compare the environmental performance of products effectively.

Acknowledgments

This research was funded by the German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, grant number 67KI2022A. Open Access funding enabled and organized by Projekt DEAL.

Conflicts of Interest

The authors declare no conflicts interests.

References

Auger, P., and T. M. Devinney. 2007. "Do What Consumers Say Matter? The Misalignment of Preferences With Unconstrained Ethical Intentions." *Journal of Business Ethics* 76, no. 3: 361–383. https://doi.org/10.1007/s10551-006-9278-3.

Bangsa, A. B., and B. B. Schlegelmilch. 2020. "Linking Sustainable Product Attributes and Consumer Decision-Making: Insights From a Systematic Review." *Journal of Cleaner Production* 245: 118902. https://doi.org/10.1016/j.jclepro.2019.118902.

Bask, A., M. Halme, M. Kallio, and M. Kuula. 2013. "Consumer Preferences for Sustainability and Their Impact on Supply Chain Management: The Case of Mobile Phones." *International Journal of Physical Distribution and Logistics Management* 43, no. 5/6: 380–406. https://doi.org/10.1108/IJPDLM-03-2012-0081.

Blue Angel. 2023. "Blue Angel Products and Services". https://www.blauer-engel.de/de/produkte.

Boyer, R. H. W., A. D. Hunka, M. Linder, K. A. Whalen, and S. Habibi. 2021. "Product Labels for the Circular Economy: Are Customers Willing to Pay for Circular?" *Sustainable Production and Consumption* 27: 61–71. https://doi.org/10.1016/j.spc.2020.10.010.

Brand, B. M., and T. M. Rausch. 2021. "Examining Sustainability Surcharges for Outdoor Apparel Using Adaptive Choice-Based Conjoint Analysis." *Journal of Cleaner Production* 289: 125654. https://doi.org/10.1016/j.jclepro.2020.125654.

Braun, A., H. Schmeiser, and F. Schreiber. 2016. "On Consumer Preferences and the Willingness to Pay for Term Life Insurance." *European Journal of Operational Research* 253, no. 3: 761–776. https://doi.org/10.1016/j.ejor.2016.02.023.

Chang, T.-W., Y.-S. Chen, Y.-L. Yeh, and H.-X. Li. 2021. "Sustainable Consumption Models for Customers: Investigating the Significant Antecedents of Green Purchase Behavior From the Perspective of Information Asymmetry." *Journal of Environmental Planning and Management* 64, no. 9: 1668–1688. https://doi.org/10.1080/09640568.2020.1837087.

Chapman, C., J. Alford, C. Johnson, R. Weidemann, and M. Lahav. 2009. "CBC vs. ACBC: Comparing Results With Real Product Selection." In *Sawtooth Software Conference Proceedings*. Sawtooth Software, Inc.

De Bauw, M., L. S. De La Revilla, V. Poppe, C. Matthys, and L. Vranken. 2022. "Digital Nudges to Stimulate Healthy and Pro-Environmental Food Choices in E-Groceries." *Appetite* 172: 105971. https://doi.org/10.1016/j.appet.2022.105971.

De Bauw, M., C. Matthys, V. Poppe, S. Franssens, and L. Vranken. 2021. "A Combined Nutri-Score and 'Eco-Score' Approach for More Nutritious and More Environmentally Friendly Food Choices? Evidence From a Consumer Experiment in Belgium." *Food Quality and Preference* 93: 104276. https://doi.org/10.1016/j.foodqual.2021.104276.

Deliza, R., M. de Alcantara, R. Pereira, and G. Ares. 2020. "How Do Different Warning Signs Compare With the Guideline Daily Amount and Traffic-Light System?" *Food Quality and Preference* 80: 103821. https://doi.org/10.1016/j.foodqual.2019.103821.

Dendler, L. 2014. "Sustainability Meta Labelling: An Effective Measure to Facilitate More Sustainable Consumption and Production?" *Journal of Cleaner Production* 63: 74–83. https://doi.org/10.1016/j.jclepro.2013.04.037.

Ercan, M., J. Malmodin, P. Bergmark, E. Kimfalk, and E. Nilsson. 2016. "Life Cycle Assessment of a Smartphone." Proceedings of ICT for Sustainability 2016. https://doi.org/10.2991/ict4s-16.2016.15.

European Commission 2025. "Energy, Climate Change, Environment. Energy Efficient Products. Smartphones and Tablets". https://energy-efficient-products.ec.europa.eu/product-list/smartphones-and-tablets_en.

European Environment Agency. 2023. *Conditions and Pathways for Sustainable and Circular Consumption in Europe*. Publications Office. https://doi.org/10.2800/137584.

European Environment Agency 2025. "Data on Products Evaluated Against the French Repairability Index. Circularity Metrics Lab". https://www.eea.europa.eu/en/circularity/thematic-metrics/business/data-on-products-evaluated-against-the-french-repairability-index-1.

Fuso Nerini, F., B. Sovacool, N. Hughes, et al. 2019. "Connecting Climate Action With Other Sustainable Development Goals." *Nature Sustainability* 2: 674–680. https://doi.org/10.1038/s41893-019-0334-y.

Futtrup, R., G. Tsalis, S. Pedersen, M. Dean, T. Benson, and J. Aschemann-Witzel. 2021. "Is the Whole More Than the Sum of Its Parts? Challenges and Opportunities for a Holistic Consumer-Friendly Sustainability Label on Food." *Sustainable Production and Consumption* 28: 1411–1421. https://doi.org/10.1016/j.spc.2021.08.014.

Garga, E., A. A. Maiyaki, and M. S. Sagagi. 2019. "Factors Influencing Brand Switching Behavior of Mobile Phone Users and the Mediating Effect of Customer Satisfaction: A Literature Review." *Journal of Education, Society and Behavioural Science* 29, no. 1: 1–11. https://doi.org/10.9734/jesbs/2019/v29i130097.

Grankvist, G., S. Å. K. Johnsen, and D. Hanss. 2019. "Values and Willingness-To-Pay for Sustainability-Certified Mobile Phones." *International Journal of Sustainable Development and World Ecology* 26, no. 7: 657–664. https://doi.org/10.1080/13504509.2019.1652212.

Hauser, J. R., M. Ding, and S. Gaskin. 2009. "Non-Compensatory (and Compensatory) Models of Consideration Set Decisions." In *Sawtooth Software Conference Proceedings*, 207–232. Sawtooth Software, Inc. https://mitsloan.mit.edu/shared/ods/documents?DocumentID=4054.

Hauser, J. R., F. Eggers, and M. Selove. 2019. "The Strategic Implications of Scale in Choice-Based Conjoint Analysis." *Marketing Science* 38, no. 6: 1059–1081. https://doi.org/10.1287/mksc.2019.1178.

Hazen, B. T., D. A. Mollenkopf, and Y. Wang. 2017. "Remanufacturing for the Circular Economy: An Examination of Consumer Switching Behavior." *Business Strategy and the Environment* 26, no. 4: 451–464. https://doi.org/10.1002/bse.1929.

Heinzle, S. L., and R. Wüstenhagen. 2012. "Dynamic Adjustment of Eco-Labeling Schemes and Consumer Choice: The Revision of the EU Energy Label as a Missed Opportunity?" *Business Strategy and the Environment* 21, no. 1: 60–70. https://doi.org/10.1002/bse.722.

Hinnen, G., S. L. Hille, and A. Wittmer. 2017. "Willingness to Pay for Green Products in Air Travel: Ready for Take-Off?" *Business Strategy and the Environment* 26, no. 2: 197–208. https://doi.org/10.1002/bse.1909.

Huber, J., B. Orme, and R. Miller. 2007. "Dealing With Product Similarity in Conjoint Simulations." In *Conjoint Measurement*, edited by A. Gustafsson, A. Herrmann, and F. Huber, 347–362. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-71404-0_17.

Huber, J., and K. Zwerina. 1996. "The Importance of Utility Balance in Efficient Choice Designs." *Journal of Marketing Research* 33, no. 3: 307. https://doi.org/10.2307/3152127.

Hunka, A. D., M. Linder, and S. Habibi. 2021. "Determinants of Consumer Demand for Circular Economy Products: A Case for Reuse and Remanufacturing for Sustainable Development." *Business Strategy and the Environment* 30, no. 1: 535–550. https://doi.org/10.1002/bse.2636.

Ikonen, I., F. Sotgiu, A. Aydinli, and P. W. J. Verlegh. 2020. "Consumer Effects of Front-of-Package Nutrition Labeling: An Interdisciplinary Meta-Analysis." *Journal of the Academy of Marketing Science* 48, no. 3: 360–383. https://doi.org/10.1007/s11747-019-00663-9.

Jacobs, K., J. Bergener, and M. Gossen. 2025. "The Influence of a Hypothetical Eco-Score on Purchase Decisions: Empirical Evidence on

Consumer Preferences and Consumer Segments for Mobile Phones." *Cleaner and Responsible Consumption* 18: 100289. https://doi.org/10.1016/j.clrc.2025.100289.

Jacobs, K., and J. Hörisch. 2021. "The Importance of Product Lifetime Labelling for Purchase Decisions: Strategic Implications for Corporate Sustainability Based on A Conjoint Analysis in Germany." *Business Strategy and the Environment* 31: 1275–1291. https://doi.org/10.1002/bse.2954.

Jain, M., A. B. Rao, and A. Patwardhan. 2021. "Energy Cost Information and Consumer Decisions: Results From a Choice Experiment on Refrigerator Purchases in India." *Energy Journal* 42, no. 2: 252–272. https://doi.org/10.5547/01956574.42.2.mjai.

Jervis, S. M., J. M. Ennis, and M. A. Drake. 2012. "A Comparison of Adaptive Choice-Based Conjoint and Choice-Based Conjoint to Determine Key Choice Attributes of Sour Cream With Limited Sample Size: CBC Versus ACBC Analysis of Sour Cream Drivers." *Journal of Sensory Studies* 27, no. 6: 451–462. https://doi.org/10.1111/joss.12009.

Johnson, R. M., and B. K. Orme. 2007. *A New Approach to Adaptive CBC (Research Paper Series)*. Sawtooth Software. https://sawtoothsoftware.com/resources/technical-papers/a-new-approach-to-adaptive-cbc.

Jürkenbeck, K. 2023. "The Effect of Information Among Established and New Sustainability Labelling on Consumers' Preference and Willingness to Pay." *Cleaner and Responsible Consumption* 10: 100131. https://doi.org/10.1016/j.clrc.2023.100131.

Karjaluoto, H., J. Karvonen, M. Kesti, et al. 2005. "Factors Affecting Consumer Choice of Mobile Phones: Two Studies From Finland." *Journal of Euromarketing* 14, no. 3: 59–82. https://doi.org/10.1300/j037v14n03_04.

Kim, J., H. Lee, and J. Lee. 2020. "Smartphone Preferences and Brand Loyalty: A Discrete Choice Model Reflecting the Reference Point and Peer Effect." *Journal of Retailing and Consumer Services* 52: 101907. https://doi.org/10.1016/j.jretconser.2019.101907.

Kolber, A., and O. Meixner. 2023. "Effects of Multi-Level Eco-Labels on the Product Evaluation of Meat and Meat Alternatives—A Discrete Choice Experiment." *Food* 12, no. 15: 2941. https://doi.org/10.3390/foods12152941.

Lanaras-Mamounis, G., T. A. Tsalis, K. Anagnostopoulou, K. I. Vatalis, and I. E. Nikolaou. 2022. "The Development of an Index for Assessing the Circularity Level of Eco-Labels." *Sustainable Production and Consumption* 33: 586–596. https://doi.org/10.1016/j.spc.2022.07.019.

Majer, J. M., H. A. Henscher, P. Reuber, D. Fischer-Kreer, and D. Fischer. 2022. "The Effects of Visual Sustainability Labels on Consumer Perception and Behavior: A Systematic Review of the Empirical Literature." *Sustainable Production and Consumption* 33: 1–14. https://doi.org/10.1016/j.spc.2022.06.012.

Marcon, A., J. L. D. Ribeiro, R. M. Dangelico, J. F. de Meiros, and É. Marcon. 2022. "Exploring Green Product Attributes and Their Effect on Consumer Behaviour: A Systematic Review." *Sustainable Production and Consumption* 32: 76–91. https://doi.org/10.1016/j.spc.2022.04.012.

Marette, S. 2021. "Ecological and/or Nutritional Scores for Food Traffic-Lights: Results of an Online Survey Conducted on Pizza in France." *Sustainability* 14, no. 1: 247. https://doi.org/10.3390/su14010247.

Mazurek, J., and R. Prey. 2025. "Greening the Telecommunications Industry – Consumer Preferences and Surcharges for Environmental Attributes of Mobile Phone Plans." *Telecommunications Policy* 49, no. 5: 102956. https://doi.org/10.1016/j.telpol.2025.102956.

Miller, K. M., R. Hofstetter, H. Krohmer, and Z. J. Zhang. 2011. "How Should Consumers' Willingness to Pay Be Measured? An Empirical Comparison of State-Of-The-Art Approaches." *Journal of Marketing Research* 48, no. 1: 172–184. https://doi.org/10.1509/jmkr.48.1.172.

Monier-Dilhan, S. 2018. "Food Labels: Consumer's Information or Consumer's Confusion?" *OCL* 25, no. 2: D202. https://doi.org/10.1051/ocl/2018037.

Nikolaou, I. E., and L. Kazantzidis. 2016. "A Sustainable Consumption Index/Label to Reduce Information Asymmetry Among Consumers and Producers." *Sustainable Production and Consumption* 6: 51–61. https://doi.org/10.1016/j.spc.2016.01.001.

Orme, B. 2019. "Introduction to Market Simulators for Conjoint Analysis." In *Getting Started With Conjoint Analysis: Strategies for Product Design and Pricing Research*, 4th ed., 89–105. Research Publishers LLC. https://sawtoothsoftware.com/resources/technical-papers/introduction-to-market-simulators-for-conjoint-analysis.

Orme, B. 2021. *Estimating Willingness to Pay Given (WTP) Competition in Conjoint Analysis. Research Paper Series*. Sawtooth Software, Inc. https://sawtoothsoftware.com/resources/technical-papers/estimating-willingness-to-pay-in-conjoint-analysis.

Orme, B., and G. Baker 2000. Comparing Hierarchical Bayes Draws and Randomized First Choice for Conjoint Simulations.

Owens, J. 2022. *Ethical Mobile Phones. Ethical & Environmental Rankings of 20 Mobile Phones, Best Buys and What to Avoid! Sustainable or Eco-Friendly Phones, Conflict Minerals, Repairability, 2nd Hand Options*. Ethical Consumer. https://www.ethicalconsumer.org/technology/shopping-guide/ethical-mobile-phones.

Potoglou, D., L. Whitmarsh, C. Whittle, I. Tsouros, P. Haggar, and T. Persson. 2020. "To What Extent Do People Value Sustainable-Resourced Materials? A Choice Experiment With Cars and Mobile Phones Across Six Countries." *Journal of Cleaner Production* 246: 118957. https://doi.org/10.1016/j.jclepro.2019.118957.

Reischl, R. M. 2021. "Implementation of the Repairability Index in the Smartphone Industry: An Analysis on Willingness to Pay, Perceived Quality and Purchase Intention". https://repositorio.ucp.pt/bitstream/10400.14/35760/1/202751597.pdf.

Sablotny-Wackershauser, V., M. Lichters, D. Guhl, P. Bengart, and B. Vogt. 2024. "Crossing Incentive Alignment and Adaptive Designs in Choice-Based Conjoint: A Fruitful Endeavor." *Journal of the Academy of Marketing Science* 52, no. 3: 610–633. https://doi.org/10.1007/s11747-023-00997-5.

Sammer, K., and R. Wüstenhagen. 2006. "The Influence of Eco-Labelling on Consumer Behaviour—Results of a Discrete Choice Analysis for Washing Machines." *Business Strategy and the Environment* 15, no. 3: 185–199. https://doi.org/10.1002/bse.522.

Sanfelix, J., M. Cordella, and F. Alfieri. 2020. "Guidance for the Assessment of Material Efficiency: Application to Smartphones." Publications Office. https://data.europa.eu/doi/10.2760/037522.

Sawtooth Software. 2014. "The Adaptive Choice-Based Conjoint (ACBC) Technical Paper [Technical Paper Series]." Sawtooth Software, Inc. https://content.sawtoothsoftware.com/assets/486b830d-5d61-4f37-92d2-d02b52a38659.

Sawtooth Software. 2021. *Improving and Optimizing Your Offerings With Conjoint Analysis Market Simulators*. Sawtooth Software. https://sawtoothsoftware.com/resources/videos/optimizing-offerings-conjoint-analysis-market-simulator.

Schleich, J., A. Durand, and H. Brugger. 2021. "How Effective Are EU Minimum Energy Performance Standards and Energy Labels for Cold Appliances?" *Energy Policy* 149: 112069. https://doi.org/10.1016/j.enpol.2020.112069.

Sichtmann, C., R. Wilken, and A. Diamantopoulos. 2011. "Estimating Willingness-To-Pay With Choice-Based Conjoint Analysis—Can Consumer Characteristics Explain Variations in Accuracy?" *British Journal of Management* 22, no. 4: 628–645. https://doi.org/10.1111/j.1467-8551.2010.00696.x.

Spindler, V., H. Schunk, and T. Könecke. 2023. "Sustainable Consumption in Sports Fashion—German Runners' Preference and Willingness to Pay for More Sustainable Sports Apparel." *Sustainable Production and Consumption* 42: 411–422. https://doi.org/10.1016/j.spc.2023.05.003.

Statista. 2022). "Smartphone-Marken in Deutschland 2022". Statista. https://de.statista.com/prognosen/999729/deutschland-beliebteste-smartphone-marken.

Suckling, J., and J. Lee. 2015. "Redefining Scope: The True Environmental Impact of Smartphones?" *International Journal of Life Cycle Assessment* 20, no. 8: 1181–1196. https://doi.org/10.1007/s11367-015-0909-4.

TCO Certified. 2025. "TCO Certified Product Finder". TCO Certified. https://tcocertified.com/product-finder/.

Thøgersen, J. 2021. "Consumer Behavior and Climate Change: Consumers Need Considerable Assistance." *Current Opinion in Behavioral Sciences* 42: 9–14. https://doi.org/10.1016/j.cobeha.2021.02.008.

Thøgersen, J., F. J. Dessart, G. Marandola, and S. L. Hille. 2024. "Positive, Negative or Graded Sustainability Labelling? Which is Most Effective at Promoting a Shift Towards More Sustainable Product Choices?" *Business Strategy and the Environment* 33: 6795–6813. https://doi.org/10.1002/bse.3838.

Torma, G., and J. Thøgersen. 2021. "A Systematic Literature Review on Meta Sustainability Labeling— What Do We (Not) Know?" *Journal of Cleaner Production* 293: 126194. https://doi.org/10.1016/j.jclepro.2021.126194.

Torma, G., and J. Thøgersen. 2024. "Can a Meta Sustainability Label Facilitate More Sustainable Consumer Choices?" *Business Strategy and the Environment* 33, no. 2: 283–306. https://doi.org/10.1002/bse.3488.

Weber, A. 2021. "Mobile Apps as a Sustainable Shopping Guide: The Effect of Eco-Score Rankings on Sustainable Food Choice." *Appetite* 167: 105616. https://doi.org/10.1016/j.appet.2021.105616.

Weinrich, R., and A. Spiller. 2016. "Developing Food Labelling Strategies: Multi-Level Labelling." *Journal of Cleaner Production* 137: 1138–1148. https://doi.org/10.1016/j.jclepro.2016.07.156.

Wilhelm, W. B. 2012. "Encouraging Sustainable Consumption Through Product Lifetime Extension: The Case of Mobile Phones." *International Journal of Business and Social Science* 3, no. 3: 16.

Williams, W. and M. Peitz 2021. "An Introduction to Market Simulations in the Choice Simulator". https://sawtoothsoftware.com/resources/events/webinars/an-introduction-to-market-simulations-in-the-choice-simulator.

Zha, D., G. Yang, W. Wang, Q. Wang, and D. Zhou. 2020. "Appliance Energy Labels and Consumer Heterogeneity: A Latent Class Approach Based on a Discrete Choice Experiment in China." *Energy Economics* 90: 104839. https://doi.org/10.1016/j.eneco.2020.104839.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Supporting information.