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From Awareness to Action: Consumer Behaviour, Attitudes and Business Strategy in Sustainable and Circular Electronic Devices

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ABSTRACT

Technological change and the increasing use of electronic devices have made electronic waste one of the fastest-growing waste streams worldwide, posing significant environmental and social challenges. Thus, understanding consumer behaviour regarding the purchase, use and disposal of electronic products is key to developing effective circular economy strategies. This study aims to investigate the determinants of purchasing decisions, replacement habits and end-of-life management of electronic devices by Italian consumers, with a focus on generational and gender differences. An online questionnaire with 407 respondents was administered, and the data were analysed using statistical tests, principal component analysis and K-means clustering. The results highlighted a good level of environmental awareness, not always accompanied by consistent behaviour. Only a minority of consumers knew where to dispose of end-of-life devices (29.48%), resulting in domestic accumulation (53.04%). However, growing attention to product repairability emerged, alongside greater confidence in the refurbished market compared to the second-hand market. From a generational perspective, young people showed interest in design and innovation, but less responsibility in disposal, while older age groups were more aware and informed. Finally, economic incentives emerged as the most effective measure for guiding sustainable behaviour (30.71%). Distinct behavioural patterns and motivations were found across consumer groups, requiring differentiated strategies: educational initiatives for younger individuals, economic incentives for those with limited resources and premium programmes for eco-conscious consumers. The results suggest that effective policies to reduce electronic waste should integrate incentives, targeted information campaigns and enhanced collection infrastructures, fostering responsible consumption and greater citizen engagement in circular economy practices.

1 | Introduction

Waste electrical and electronic equipment (WEEE or e-waste) has rapidly transformed into one of the world's fastest-growing waste streams (Cao et al. 2024; Liu et al. 2023). The valorisation of WEEE is strategic not only for mitigating its environmental impact but, crucially, for securing the supply of resources, including critical raw materials (CRM) necessary for modern technology and the energy transition. The strategic nature of e-waste valorisation is recognised at the European level by Regulation (EU) 2024/1252, which seeks to encourage sustainable WEEE management in European countries. Furthermore, proper e-waste management is crucial for achieving the United Nations 2030 Agenda Sustainable Development Goals (SDGs), particularly SDG 12 on Responsible Consumption and Production (Gaur et al. 2023) and SDG 13 on Climate Action.

Despite its potential to drive economic growth and generate 'green jobs,' the e-waste sector continues to face substantial challenges, beginning at the collection phase (Newaz and Appolloni 2024; Testa et al. 2024). For example, especially in informal systems that are typical of developing countries, e-waste pickers and collectors, despite their essential contribution to recycling and resource recovery, frequently face precarious working conditions and substandard wages (Chitaka et al. 2025). However, challenges also remain in formal systems, especially due to low return rates.

In addition to improved recycling, WEEE management effectiveness requires economic incentives and behavioural interventions to translate intention into active participation (Parajuly et al. 2020). The recycling of electronic boards represents a strategic solution for the circular economy and resource security, with the price of gold playing a decisive role in the economic sustainability of the process (D'Adamo et al. 2026). Previous research has explored WEEE management through various lenses, often focusing on contextual barriers and the modelling of behaviour based on cognitive factors (Islam, Sabbir, et al. 2025; Sharma et al. 2024; Wang et al. 2019). Related to contextual barriers, studies have shown that the spatial accessibility and convenience of collection points are major determinants of WEEE collection behaviour, contributing to the persistently low formal collection rates observed in many contexts (Puzzo and Prati 2025).

In terms of cognitive and behavioural determinants, personality-related moderation effects indicate that awareness of e-waste consequences interacts with traits such as extraversion and emotional stability in shaping attitudes, suggesting targeted engagement strategies to encourage disposal (Nauman et al. 2025). Behaviour change may also depend on personal priorities; for example, individuals who prioritise economic gain or social status over environmental concerns are less likely to engage in proper waste management practices (Iskander et al. 2025).

From a circular supply-chain perspective, reuse orientation and remanufacturing capability have been found to be dominant criteria for the evaluation of sustainable options (Hasan et al. 2025). Research has further shown that circular positioning enhances the success of e-waste crowdfunding initiatives by increasing funding and backer involvement (Lu et al. 2026). At a business-model level, circular configurations outperform linear systems both environmentally and economically, with product-as-a-service models offering stronger life cycle alignment than repair-based extensions (Rittershaus et al. 2026). Complementary research has identified enabling domains, including regulation, design, awareness, infrastructure and financial incentives, recommending instruments such as harmonised EPR schemes, right-to-repair policies and deposit-refund mechanisms (Abdelmeguid and Corsini 2026). Finally, prolonged device use and higher recycling rates have been shown to contribute positively to ecological structure and environmental quality (Baykut et al. 2026).

Weak incentives, low consumer awareness and inadequate policy support are key obstacles to the circular management of e-waste (Jaiswal and Mukti 2024), compounded by gaps in policymaking, socio-economic and cultural barriers, technological constraints and insufficient treatment infrastructure (Gollakota et al. 2020). In this context, consumer awareness of the circular economy may play a fundamental role in supporting and enhancing recycling initiatives (Jaiswal and Mukti 2025).

Building on these cognitive and socio-economic determinants, consumer willingness to pay (WTP) for efficient disposal services or for refurbished and circular products may represent a key indicator of their support for circular WEEE policies, though the interplay between behavioural drivers and economic incentives remains underexplored (Azizi et al. 2023; Kerber et al. 2024; Yang et al. 2024). Existing research has not sufficiently investigated: (i) the multidimensionality of factors influencing consumer WTP for WEEE management (Michael et al. 2024) and (ii) how demographic differences (age and gender) and awareness can be used to effectively segment consumers/customers (Md H Islam, Islam, et al. 2025). This gap has prevented policymakers from designing precise and targeted financial incentive schemes (e.g., rewards and reimbursements), which are fundamental for achieving high recycling rates. Although previous studies have extensively investigated sustainable consumption, WTP for circular products and environmental awareness, they have typically examined these dimensions in isolation. As a result, the literature rarely integrates behavioural awareness, infrastructure knowledge and economic incentives within a unified empirical framework capable of generating actionable consumer segments. This limitation is particularly relevant for circular economy business models, which require firms to understand not only whether consumers are sustainable, but also how different psychological and contextual drivers combine to shape distinct behavioural profiles. To address this gap, the present study adopted a segmentation-oriented approach linking behavioural drivers to operational implications for firms in regulated circular markets. Therefore, the study aimed to answer the following research question: How do environmental awareness, logistical knowledge and economic incentives differentially influence consumers' actual WEEE disposal behaviour? The remainder of the paper is structured as follows: Section 2 presents the literature review to further build hypotheses for the survey; Section 3 details the survey methodology and statistical analyses; Section 4 presents the results; Section 5 provides a discussion; and Section 6 concludes the study.

2 | Literature Review

The topics of WEEE, consumer WTP and customer involvement in WEEE disposal are attracting growing scholarly attention. The present systematic literature review (SLR) was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al. 2021). The procedure was adapted by integrating the traditional SLR framework with bibliometric analysis, as suggested by Avenali et al. (2023). The literature search was performed in the Scopus database on 15 October 2025. The initial query, applied to all searchable fields, was formulated as follows:

'WEEE' OR 'e-waste' AND 'sustainable development' OR 'sustainability' AND 'awareness' AND 'price' OR 'willingness to pay' AND 'customer.'

This initial search identified a total of 654 documents. After applying the following two exclusion criteria:

- E1: The publication is not an article or review
- E2: The publication is not written in English

The number of articles was reduced to 567. Given the high volume, a preliminary bibliometric analysis, called a 'thematic map' (Cobo et al. 2011), was conducted to obtain an overview of the main research directions and conceptual clusters in the field, following the approach proposed by Avenali et al. (2023). Figure S1 illustrates the thematic map of the 567 articles retrieved from this initial query.

Based on this initial mapping, the search strategy was refined to focus on the core research objective. The query was restricted to the article title, abstract and keywords fields for the keywords 'WEEE,' 'e-waste,' and 'sustainable development.' The refined query returned 23 documents. One of these was a book chapter and, according to the predefined eligibility criteria (E1), was excluded from further consideration. After a manual screening of the content of the 22 documents retrieved, 18 final articles were selected and reviewed in depth. Figure S2 reports the final PRISMA scheme of the entire review process. The following section provides a detailed examination of the 18 selected articles.

In general, it has been concluded that knowledge of the environmental consequences of e-waste and awareness of recovery practices are key factors in promoting proactive attitudes and increasing the intention to recycle (Abdul Waheed et al. 2023; Koshta et al. 2022). However, theoretical awareness does not necessarily guarantee consistent behaviour: in various contexts, a significant proportion of consumers, while recognising the dangers of e-waste, do not participate in public collection programmes (Siddiqua et al. 2022). This disconnect can also be explained by psychological and individual variables, as traits such as extraversion and emotional stability influence the translation of knowledge into attitude and behaviour (Nauman et al. 2025). Environmental education and specific training programmes therefore represent essential tools for consolidating awareness and directing it towards concrete practices (Abdul Waheed et al. 2023; May and Steuer 2025).

Behaviourally, perception of the sustainable value of electronic devices is influenced by factors related to brand recognition, service quality, period of use and perceived price, which determine purchase motivation, brand loyalty and recycling intention (Tu et al. 2018). Demographic variables such as gender, income and education also help shape these perceptions, with women and lower-middle income groups showing greater sensitivity to sustainable value (Siddiqua et al. 2022; Tu et al. 2018). Consumer preferences for eco-friendly products (e.g., laptops and smartphones) also confirm that price, energy efficiency and recyclable materials remain key determinants, suggesting lines of development for sustainable design (Liao and Chuang 2022). After end of use, recycling intentions depend on attitude, social norms, perceived control and responsibility, with cross-country differences: in some markets, social norms and control dominate; while in others, duty and personal responsibility prevail (Kumar 2019). Use of performance evaluation models with sustainability indicators allows for more systematic monitoring of the effects of production, consumption and disposal choices along the supply chain (Jain et al. 2022).

WTP is positively influenced by perceived control, awareness of consequences and intention to recycle, and indirectly affected by attitudes and subjective norms (Koshta et al. 2022). High self-efficacy and environmental responsibility increase WTP for recycling, but the weak perception of a 'circular premium,' especially among youth, reveals a gap between values and WTP (Chiappetta Jabbour et al. 2023a). Economic incentives, buy-back programmes and subsidies that are coordinated across online and offline channels are key to improving collection and recycling efficiency (Chen et al. 2024; Guo and Zhong 2023). Competition and consumer bargaining power may also have a positive impact on collection prices and reverse chain profits, contributing to the overall sustainability of the system (Li et al. 2022). Particularly for smartphones (within the scope of the present study), responsible behaviour towards the environment is reflected in consumer willingness to recycle (Cheng et al. 2022).

Regarding policy and industrial operations, the adoption of extended producer responsibility approaches promotes integration between design for recyclability, end-of-life management and process innovations, with positive effects on sustainability throughout the supply chain (Cai and Choi 2021). At the same time, the adoption of advanced collection systems and well-organised recovery infrastructures may generate significant economic, employment and environmental benefits (Guo and Zhong 2021). Scenario analyses show that parameters such as replacement rates, production costs and sales prices directly affect profitability and recycling rates, providing important management insights (Khakbaz and Tirkolaee 2022). Digital technologies (e.g., IoT systems applied to WEEE collection and traceability) improve environmental sustainability, reduce emissions and heavy metal contamination, and increase health and social benefits (Guo and Zhong 2023). Moreover, a reasonable carbon tax should be considered (Lyu et al. 2022). Effective e-waste management requires a systemic approach combining awareness, behaviour and economic tools to turn awareness into sustainable action.

Based on the literature, this study adopted a conceptual framework that considered environmental awareness, perceived accessibility of disposal infrastructure and economic incentives as interacting behavioural drivers shaping circular participation. Rather than assuming linear causality, the model assumed configuration effects leading to different consumer profiles, which were empirically identified through clustering techniques. The systematic review highlighted three recurring determinants of circular consumption behaviour: awareness-behaviour misalignment, perceived accessibility of disposal infrastructure and economic incentives. The following hypotheses translated these consolidated findings into testable behavioural relationships within a segmentation framework:

H1. *Awareness–behaviour gap in WEEE disposal.*

There is a positive but nonlinear relationship between environmental awareness and WEEE disposal behaviour, confirming the existence of an 'awareness-behaviour gap' where high awareness does not automatically translate into correct disposal actions.

H2. *Role of infrastructure knowledge in recycling behaviour.*

Knowledge of collection point locations and logistic accessibility has a direct positive effect on proper disposal behaviour, significantly reducing the propensity for domestic hoarding of obsolete devices.

H3. *Economic incentives as key drivers of action.*

Economic incentives (i.e., monetary rewards) exercise a stronger positive influence on consumer disposal behaviour compared to purely informational or soft-policy campaigns.

3 | Methodology

Questionnaires represent a quick and effective way to collect consumer opinions (Ananno et al. 2021; Dhir, Koshta, et al. 2021; Koshta et al. 2022), and the literature highlights the particular advantages of web-based questionnaires for economic evaluations (Menegaki et al. 2016). This method is especially appropriate when investigating perception-based constructs. Moreover, surveys have been widely used in research examining behaviour towards e-waste management, demonstrating their applicability in the context of WEEE studies (Alblooshi et al. 2022; Maphosa 2021). Figure 1 presents a step-by-step methodological flowchart illustrating the sequence from the literature review and questionnaire design to the data collection, sampling, statistical analysis (i.e., tests, PCA and clustering) and interpretation.

3.1 | Survey

Surveys represent one of the most widely used methods for collecting primary data in studies published in *Business Strategy and the Environment* (Kumar et al. 2021), and they are particularly common in investigations of sustainability-related issues among consumers (Cascavilla et al. 2025; Rehman et al. 2025).

In the present study, the questionnaire was based partly on a previous survey tool (Chiappetta Jabbour et al. 2023a, 2023b), which was used as a reference and subsequently adapted to the research context. Before distribution, a preliminary version was submitted to a group of experts in the field of e-waste management, who provided useful comments to improve its clarity, relevance and completeness. The final questionnaire is provided in the supplementary material. The purpose of the study was explained to all respondents, and anonymity was guaranteed. Data were collected from April to July 2025 via the Google Forms platform.

A nonprobabilistic purposive sampling approach was adopted, targeting consumers involved in electronic product ownership and disposal decisions (Campbell et al. 2020; Palinkas et al. 2015). The sample size was determined following

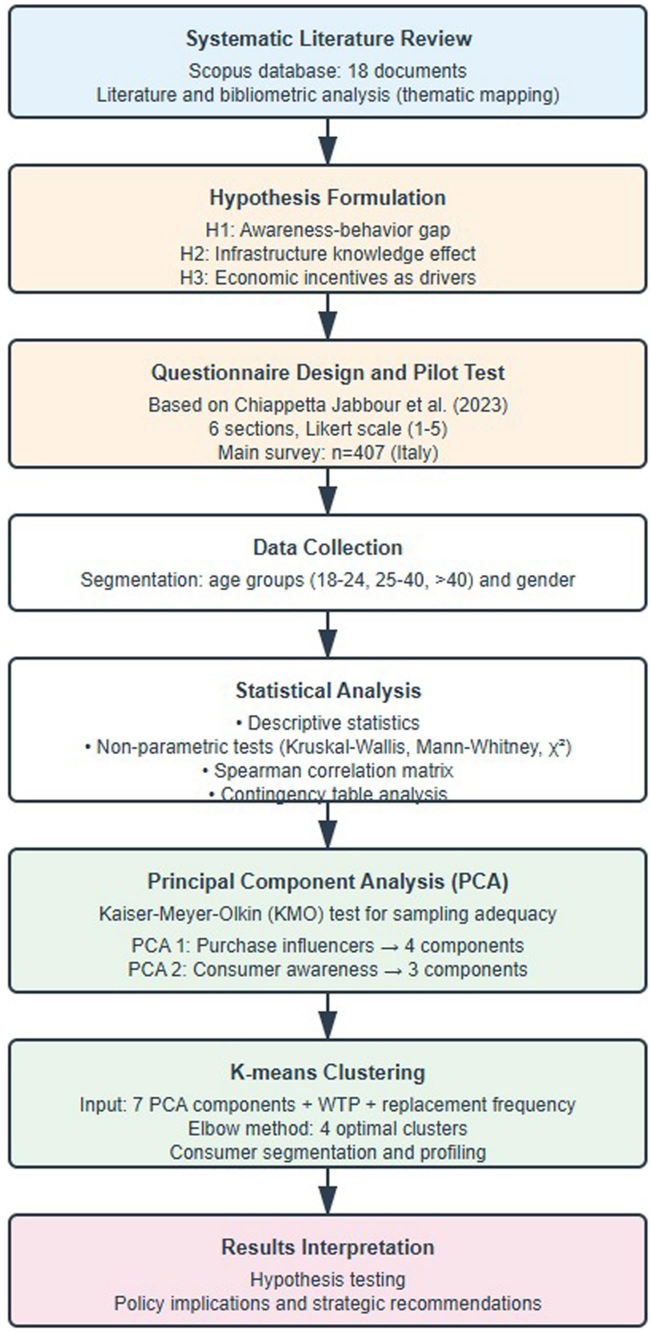

FIGURE 1 | Methodological flowchart.

recommendations for multivariate exploratory analysis, which suggest a minimum of five to ten observations per variable and at least 300 observations for stable clustering solutions (Siddiqui 2013). The final sample of 407 respondents satisfied these criteria, ensuring the robustness of the segmentation procedure rather than population representativeness. The higher representation of younger and lower-income respondents reflects the demographic groups most actively engaged in frequent device replacement cycles and online purchasing channels, which are central to circular electronic flows (Oraee et al. 2024). Therefore, the composition of the sample aligns with the behavioural processes under investigation, rather than constituting a distortion of the analytical objective (Robinson 2014).

The questionnaire was divided into six sections. In the first section, respondents were asked to provide socio-demographic information. In the second section, the focus shifted to the factors influencing consumer choice when purchasing electronic devices. The third section investigated habits regarding the use and replacement of electronic devices, in order to understand how often consumers change their devices and the reasons behind these choices. In the fourth section, the focus shifted to the issues of the circular economy and disposal. After clarifying the concepts of new, used and refurbished products, information was collected on the frequency of purchase of used or refurbished devices, WTP for new devices compared to used or refurbished ones, and the disposal methods adopted by users and their knowledge of local WEEE centres. The fifth section analysed individual behaviour and level of environmental awareness. Respondents were asked to express their level of agreement with a series of statements related to personal commitment to sustainability, knowledge of environmental issues and intention to adopt responsible behaviours in the future. In the sixth and final section, an attempt was made to identify the most effective strategies for encouraging the collection and proper disposal of WEEE. After a brief explanation of the meaning and importance of separate collection, respondents were asked to select the interventions they considered most useful.

In addition to examining the aggregate responses of the entire sample in detail, we also divided the sample on the basis of age group and gender, in order to assess whether (and to what extent) opinions, habits and environmental awareness varied between young adults, working-age adults and mature adults, as well as between men and women.

The survey applied a Likert scale ranging from 1 to 5, which was the main tool used to collect responses to various questions. For the statistical analysis of the questionnaire data, an inferential approach based mainly on nonparametric tests was adopted, given the ordinal nature of the response scales and the frequent violation of the assumptions of normality and homoscedasticity, as verified by the Shapiro–Wilk and Levene tests. In particular, the Kruskal–Wallis test was used to compare the assessments expressed by the different age groups, followed, in cases of significance, by Dunn's post hoc test with Holm correction, in order to identify specific differences between pairs of groups. For the comparison between two independent groups, as in the case of gender analysis, the Mann–Whitney–Wilcoxon test was used, which is the nonparametric equivalent of the *t*-test for independent samples. In cases where two conditions measured on the same individuals were compared (e.g., willingness to purchase used or refurbished products, smartphones or computers), the Wilcoxon test for paired samples was applied. Finally, for the analysis of categorical variables (e.g., WEEE disposal methods), the chi-square test of independence was used, with the possible use of Fisher's exact test or the chi-square test with simulated *p* in cases of low expected frequencies. Significance level was set at 0.05.

3.2 | Analytical Framework to Identify Consumer Types

To move beyond traditional socio-demographic analysis, a multi-stage psychographic and behavioural segmentation framework was implemented. This approach was designed to uncover latent consumer value systems and behavioural intentions. The analytical framework employed to identify distinct consumer types was a sequential application of principal component analysis (PCA) followed by K-means clustering. PCA is widely used for dimensionality reduction and to identify latent structures in correlated data (Daraio et al. 2024). By transforming a set of correlated variables into a smaller number of continuous, orthogonal components that preserve most of the original variance, PCA mitigates multicollinearity and improves the stability, precision and interpretability of subsequent analyses (Ding and He 2004) (Lynn and McCulloch 2000). Following the PCA, K-means clustering was applied to partition the sample into distinct, nonoverlapping segments based on respondents' attitudinal profiles and the principal components estimated. In the context of environmental behaviour research, K-means clustering has proven effective for identifying distinct groups of individuals who share similar attitudinal and behavioural profiles (Assef et al. 2022; Zhong et al. 2022). Such segmentation was crucial, as previous studies have highlighted the influence of awareness, control and policy on e-waste participation. Furthermore, K-means is a nonhierarchical, partitional clustering algorithm that iteratively assigns each observation to one of *k* clusters according to the similarity of their features (MacQueen 1967).

Before performing PCA, the suitability of the dataset for factor analysis was assessed using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy. The KMO index evaluates the proportion of variance among variables that might be common variance, with values closer to 1.0 indicating greater suitability. Generally, KMO values above 0.8 are considered good, while values below 0.5 suggest unsuitability for PCA (Kaiser and Rice 1974).

4 | Results

The questionnaire was completed by a total of 407 respondents in Italy with an average age of 30.6 years (Figure S3). Three age groups were identified: 18–24 years (47.4%), 25–40 years (32.7%) and over 40 (19.9%). The sample was predominantly female (57.8% vs. 41.5% male) (Figure S4). In terms of income, the majority of the sample earned less than 20,000 € (59.7%), followed by 20,001–40,000 € (27.8%), 40,001–60,000 € (7.1%) and > 60,000 € (5.4%).

The sample was not intended to be statistically representative of the Italian population. Rather, it reflected the segment of consumers actively interacting with digital purchase and disposal channels, which is particularly relevant in the context of circular electronic markets. Therefore, the results should be interpreted as depicting behavioural patterns within a technologically engaged consumer base, rather than Italy as a nation.

The sample was generally suitable when compared with those of other studies conducted on Italian consumers. In fact, in the literature, the average number of respondents may be lower (Abbate et al. 2025; Testa et al. 2019) or slightly higher (Carranza et al. 2023; Varese et al. 2025) than that considered here. Overall, the number of respondents in the present study appears consistent with that reported by other authors (Becchi et al. 2026; Di

Pillo et al. 2025), who highlight how the issue of sustainability cuts across different consumer sectors.

With regard to the digital dimension, there was substantial convergence in both the number of responses and the greater presence of women in the sample, in line with what has been documented in previous studies (Becchi et al. 2026; Varese et al. 2025). It should also be noted that the sample had a lower average age than the Italian population; however, this characteristic does not appear atypical, as some research in this area has intentionally focused on younger age groups (Chiappetta Jabbour et al. 2023b; Di Pillo et al. 2025).

4.1 | Factors Influencing the Purchase of Electronic Devices

The second section of the questionnaire investigated the main criteria taken into consideration by consumers when purchasing electronic devices (Figure 2). The most relevant factors that emerged were quality and reliability of the device (both 4.15 on a scale of 1–5) and technical performance (4.10). This was followed by price (3.63), while characteristics such as the possibility of repairing the device (3.50), design (3.35) and brand (3.30) tended to receive intermediate ratings. Finally, the criteria with the lowest ratings were low-emission production (2.70) and fashion or current trends (2.40). These results suggest that consumers are moving towards solid, efficient and reliable devices, while still paying attention to price. While environmental sustainability and fashion trends were marginal in the decision-making process, they may become more important in the future through information, education and incentive policies.

Analysis of the factors influencing electronic device choice revealed notable generational differences (Figure S5). Statistical analyses were performed using R. The Kruskal–Wallis test was applied to eight factors, revealing significant differences between age groups for design ($p = 0.019$), fashion and current trends ($p = 0.020$) and low-emission production ($p = 0.007$) (Table S1a). Dunn's post hoc tests with Holm correction identified the specific differences: For design, respondents aged 18–24 valued aesthetics more than those over 40; for fashion and trends, those aged 18–24 were more trend-sensitive than those over 40; and for low-emission production, respondents aged 18–24 valued sustainability less than both those aged 25–40 and those over 40 (Table S1b). These results suggest that young consumers prioritise appearance and image, while older adults give more weight to environmental sustainability. This highlights the need for marketing strategies tailored to generational preferences and for broader promotion of environmental awareness. Repairability was consistently valued across all age groups, reflecting the importance of durability and extended device life.

Comparisons between men and women showed that both groups valued technical performance and quality/reliability most highly (Figure S6). Men scored higher for technical performance (4.25 vs. 4.00), quality/reliability (4.30 vs. 4.05) and price (3.76 vs. 3.53), reflecting a greater focus on function and cost. Women, however, gave slightly more importance to repairability and low-emission production (2.86 vs. 2.48) and less to fashion and trends (2.50 vs. 2.25), suggesting a more balanced approach with attention to sustainability. Mann–Whitney tests revealed significant gender differences for price ($p = 0.036$), technical performance ($p = 0.006$), quality/reliability ($p = 0.017$) and low-emission production ($p = 0.003$).

4.2 | Use Habits and Replacement of Electronic Devices

The third section of the questionnaire revealed that smartphones were replaced more frequently than notebooks/PCs. In particular, respondents scored replacement frequency for smartphones

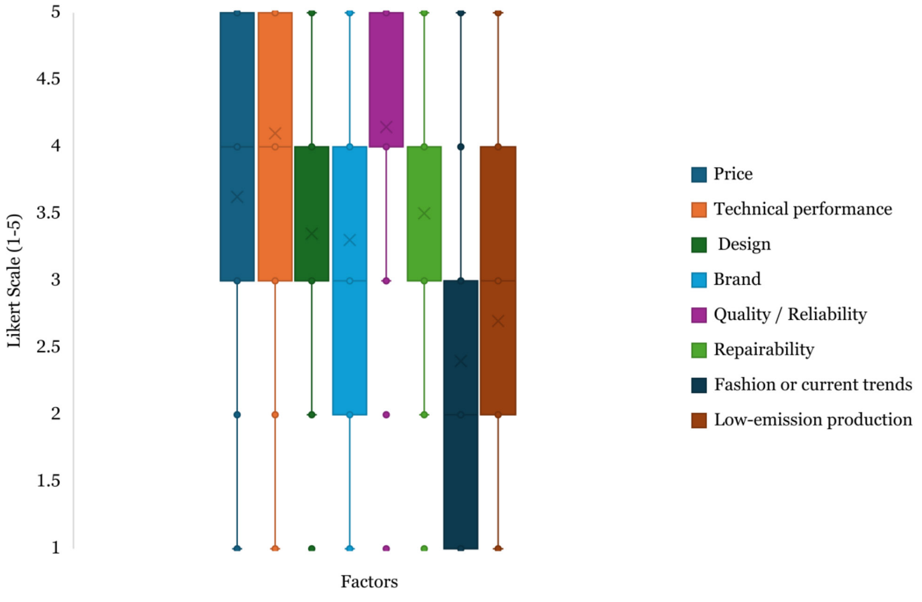

FIGURE 2 | Factors influencing the purchase of electronic devices.

at an average of 2.54 (SD = 1.12), and notebooks/PCs at an average of 1.89 (SD = 1.07).

The analysis by age group showed fairly consistent behaviour (Figure 3), as the Kruskal–Wallis test did not reveal significant differences between age groups, either for smartphones or for notebooks/PCs (Table S2). The same applied to gender when analysed using the Mann–Whitney–Wilcoxon test. More precisely, young adults and working-age adults reported very similar average values (2.57 and 2.59). In addition, for notebooks/PCs, values were stable (approximately 1.9) across all age groups, reflecting the perception of computers as durable goods that are less subject to rapid replacement dynamics. The breakdown by gender confirmed a substantially consistent picture, with women and men reporting almost identical smartphone replacement frequencies (2.54 vs. 2.53) and mildly divergent frequencies for notebooks/PCs (1.90 vs. 1.86).

The main reason for replacing devices was functional (Figure 4): 54.30% of respondents replaced a device because it had broken or stopped working, and 37.10% because it no longer performed well. Reasons related to market dynamics (e.g., release of a new model, possibility of trade-in and availability of discounts) had a marginal impact, each registering less than 4%. Overall, respondents tended to keep devices until they failed, suggesting the need for strategies to enhance durability and promote repair, in line with the circular economy. The Chi-square test showed no significant differences in terms of age (Table S3), yet significant differences in terms of gender ($\chi^2(4) = 17.8$; $p = 0.001$; Fisher $p = 0.0009$). For all age groups, breakage or malfunction was the main reason for replacement: 50.78% among 18–24 years old and 60.5% among those over 40. Declining performance was more frequent among younger respondents (39.90%), suggesting that younger consumers may perceive obsolescence earlier. By gender, women replaced more due to failure (62.55%) and men due to performance issues (47.93%). In both groups, market-related reasons remained minimal. Post hoc analysis showed that women more often reported the reason ‘It broke or stopped working,’ while men more often indicated ‘It no longer performs well enough.’ No other reasons showed significant gender differences.

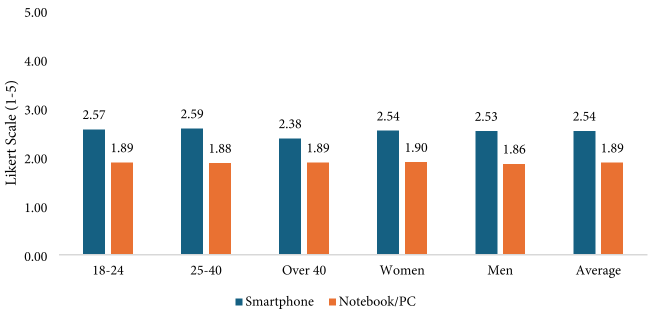

FIGURE 3 | Frequency of electronic device replacement.

4.3 | Circular Economy

The fourth section of the questionnaire investigated respondents' purchasing behaviour with regard to used and refurbished electronic devices—two key categories for promoting a circular economy in the technology sector. The results were not impressive: the average purchase of refurbished devices was 1.68, while that of used devices was 1.54 (Figure 5). Despite its benefits, the use of used or refurbished products was low, requiring greater consumer trust, awareness, and incentives.

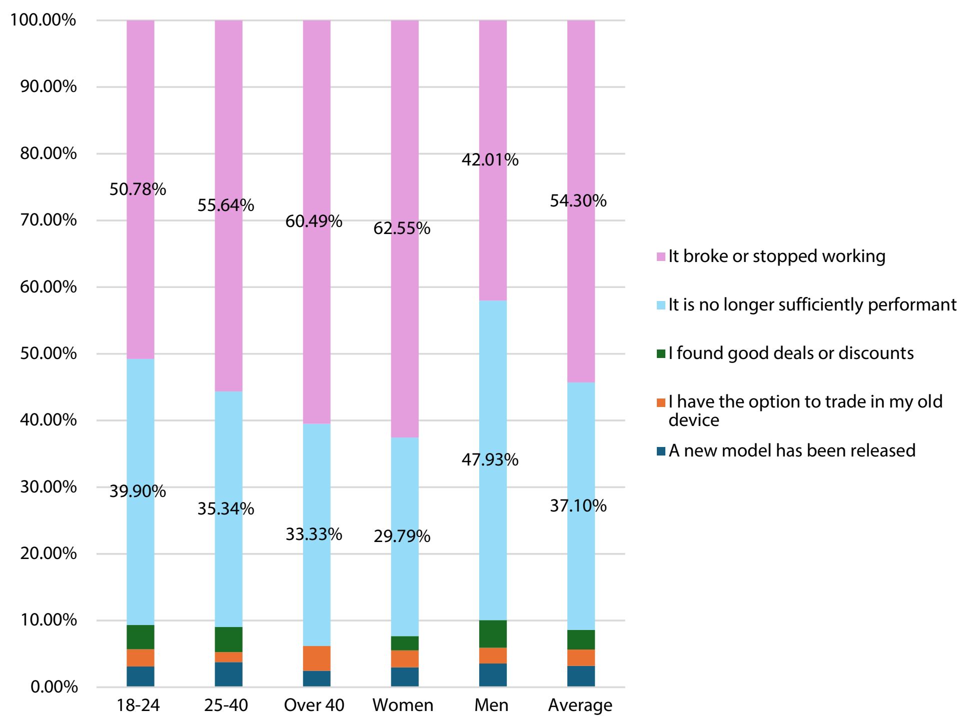

FIGURE 4 | Main reason for replacing an electronic device.

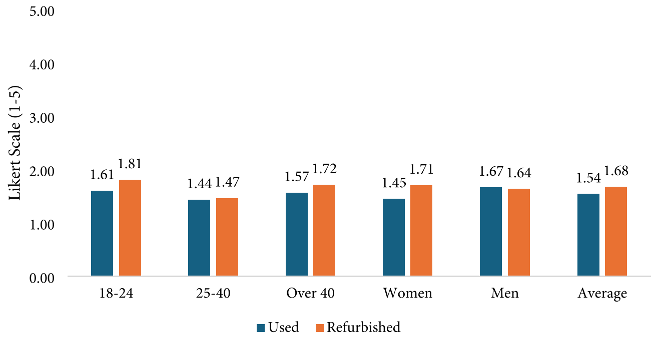

FIGURE 5 | Average frequency of purchasing used and refurbished devices.

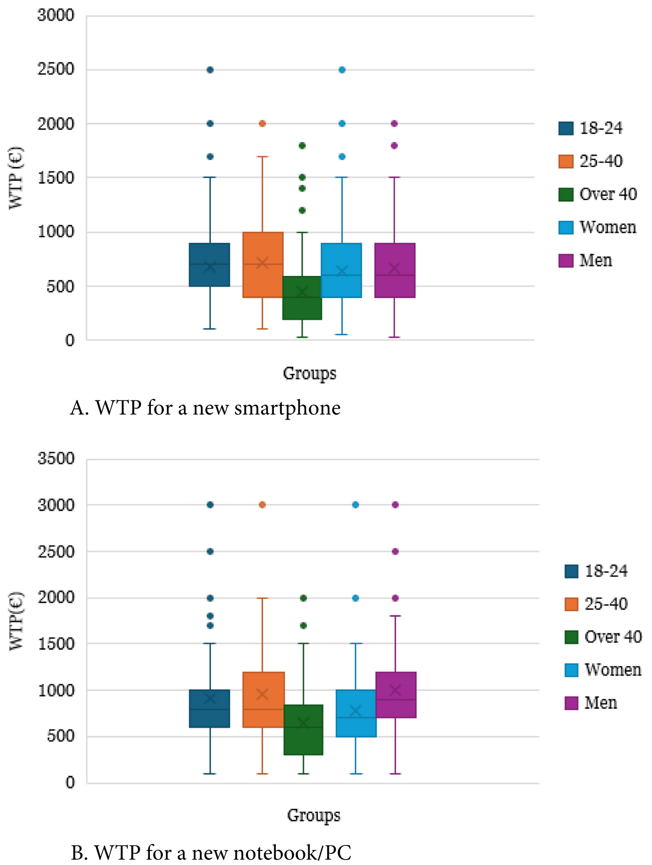

FIGURE 6 | (A) WTP for a new smartphone. (B) WTP for a new notebook/PC.

The Kruskal–Wallis test showed no significant differences between age groups for the purchase of used devices (Table S4), while for refurbished devices, a significant difference was found ($\chi^2 = 10.6$; $p = 0.0049$), suggesting that age influences the frequency of these purchases. Within age groups, respondents aged 18–24 purchased refurbished devices more often than used ones ($p = 0.007$). Dunn's post hoc test indicated that the global difference for refurbished devices was mainly due to the comparison between young adults (18–24) and adults aged 25–40 ($p = 0.003$), with the younger group reporting higher averages. This suggests that young people are more open to alternatives that are not new, likely for economic and convenience reasons. Overall, across all age groups, refurbished devices were purchased slightly more often than used ones.

Regarding gender, men reported a slightly higher average frequency for used devices (1.67 vs. 1.45), while for refurbished devices the values were very similar (1.64 vs. 1.71). Mann–Whitney–Wilcoxon tests revealed significant gender differences for used devices ($p = 0.0012$), while no differences emerged for refurbished devices. Paired-sample Wilcoxon tests showed that women purchased more refurbished than used devices on average ($p < 0.001$), whereas men showed no difference between these two product types. This suggests that these markets remain niche, far from offering real alternatives to new devices.

Neither age nor gender decisively influenced the purchase of used or refurbished devices, which were relatively uncommon. Still, the slight differences hint at possible communication levers: affordability for younger people and the perception of a guarantee for women.

4.4 | Economic Assessment

In the fourth section, respondents indicated the maximum amount they would pay for a new smartphone or notebook/PC, providing an estimate of WTP (Figure 6). Kruskal–Wallis tests showed significant age-group differences for smartphones ($\chi^2 = 38.4$; $p < 0.001$) and notebooks ($\chi^2 = 26.8$; $p < 0.001$). The average WTP for smartphones was 649 € (SD = 367 €), and for notebooks/PCs it was 874 € (SD = 511 €). Overall, these data reflect strong WTP for new technological products, as well as a strong heterogeneity in subjective value assessments, likely influenced by socio-economic variables or usage habits.

Dunn's post hoc tests showed significant generational differences ($p < 0.001$): the 25–40 age group showed the highest WTP (722 € for smartphones, 957 € for notebooks), followed by those aged 18–24, while those over 40 reported lower amounts (453 € and 641 €, respectively) (Figure S7). Gender differences were nonsignificant for smartphones but significant for notebooks/PCs (Mann–Whitney, $p < 0.001$). Women would have spent 640 € on a smartphone and 781 € on a notebook, compared to 668 € and 1008 € for men, indicating a greater male propensity to invest in higher-priced technology. Notebooks/PCs were consistently valued more than smartphones, especially by men.

By age, expected discounts for used devices ranged from 39.11% (18–24) to 42.71% (25–40), and for refurbished devices from 31.18% (18–24) to 36.11% (over 40). By gender, women expected slightly lower discounts for used devices (40.04% vs. 41.82%) and slightly higher discounts for refurbished products (33.94% vs. 32.88%). Kruskal–Wallis tests indicated no significant age differences for used devices but significant differences for refurbished devices ($\chi^2 = 8.29$; $p = 0.016$), mainly for those aged 18–24 years and over 40 (Table S6). Paired Wilcoxon tests showed that expected discounts were higher for used than refurbished devices across all age groups ($p < 0.01$).

Respondents attributed less value to nonnew devices, but considered refurbished devices more reliable than used ones, accepting higher prices in exchange for guarantees and checks.

This indicates a preference for professionally refurbished products, which is useful for circular economy strategies.

Mann–Whitney tests showed no gender differences, but paired Wilcoxon tests confirmed that both men and women valued refurbished devices more, accepting smaller discounts ($p < 0.001$). These results confirm that, regardless of gender, respondents attribute higher value and reliability to refurbished devices than to used ones, thus accepting lower discounts.

4.5 | Disposal

The fourth section of the questionnaire examined how electronic devices are disposed of when no longer used. Over half of respondents (53.07%) kept obsolete devices at home, limiting material recovery (Figure 7). Only 15.97% used WEEE collection centres, 15.72% sold or gave devices away, 11.79% used trade-ins, and 3.44% disposed of them in the rubbish, highlighting the need for awareness campaigns and simpler disposal options. Chi-square tests confirmed significant age effects on disposal ($\chi^2(8) = 34.22$; $p < 0.001$). Keeping devices at home was most common among 18–24 years old (62.7%), decreasing to 49.6% in the 25–40 age group and 35.8% in those over 40, reflecting younger people's tendency to accumulate devices, possibly for sentimental reasons or lack of awareness. Use of a WEEE centre rose with age (8.8% among those aged 18–24, 15.8% among those aged 25–40, 33.3% among those over 40), indicating greater environmental responsibility among older adults. Disposal in unsorted waste ranged from 3%–5%, showing ongoing environmental risk. Selling or giving away peaked in the 25–40 age group (21%), reflecting a willingness to reuse or monetise items. Overall, sustainable disposal practices increased with age, but high home retention among young people suggests a need for targeted awareness and incentives.

Gender differences were not statistically significant ($\chi^2(4) = 6.92$; $p = 0.14$), showing only a slight indication that women more often kept devices at home (56.6% vs. 47.9%), while men more frequently used structured channels (17.2% vs. 14.9%) or disposed incorrectly (5.9% vs. 1.7%). Women tended to keep unused devices, while men were more likely to dispose of them, both correctly and incorrectly.

Awareness of WEEE collection points was low: 70.52% of respondents did not know their location, while 29.48% were aware (Figure 8). This highlights a significant information gap regarding the location of WEEE centres, underlining the urgent need for awareness campaigns and better institutional communication to encourage virtuous behaviour. Chi-square tests confirmed significant differences by age ($\chi^2(2) = 28.42$; $p < 0.001$)

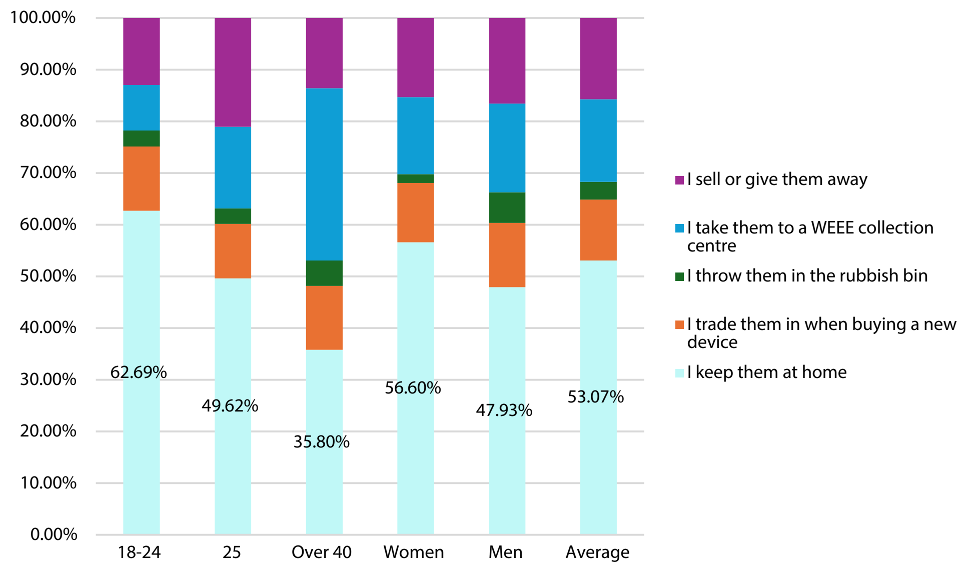

FIGURE 7 | Disposal practices for electronic devices that were no longer used.

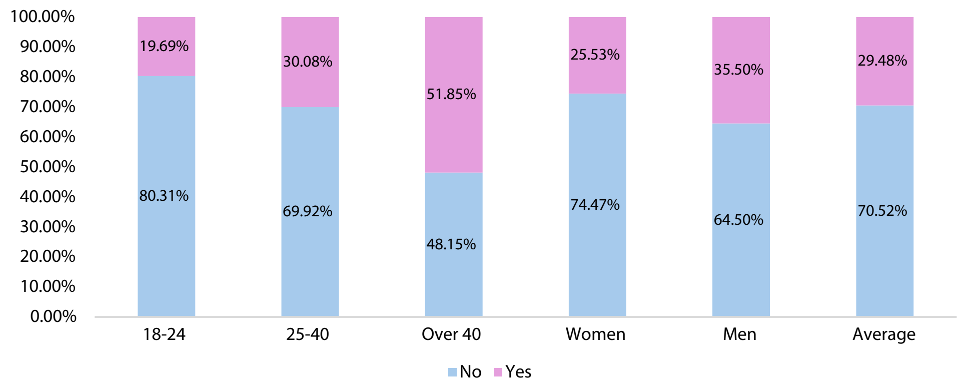

FIGURE 8 | Knowledge of local WEEE collection points.

and gender ($\chi^2(1)=4.22$; $p=0.040$), with awareness increasing with age (19.69% among those aged 18–24, 30.08% among those aged 25–40, 51.85% among those over 40). The generational gap was clear: young people kept devices and had little knowledge about collection centres, while adults were more aware and disposed of electronics properly. Women showed lower awareness than men (25.53% vs. 35.50%).

4.6 | Environmental Behaviour and Awareness

The fifth section of the questionnaire investigated respondents' environmental awareness and commitment to sustainable practices. The data showed good overall environmental awareness (Figure 9). Most respondents stated that they understood the negative consequences of improper disposal of electronic products (4.02) and believed that recycling electronic waste was useful and necessary (4.11). Similarly, the statement 'I care about the environment and try to act in an environmentally responsible manner' scored an average of 3.71, confirming a trend towards environmentally friendly behaviour. However, willingness to translate this awareness into concrete action was slightly lower. The statement 'I am willing to spend time disposing of my electronic devices properly' scored an average of 3.48, while willingness to bear the financial cost dropped to an average of 2.90. This indicates that, while recognising the importance of the issue, part of the sample was reluctant to actively commit time or resources. Finally, social influence was moderate: the statement 'People close to me think it is important to recycle electronic devices properly' scored an average of 3.15, suggesting that perceived social norms were not particularly influential. These results highlight the need for policies that not only raise awareness but also facilitate and provide practical incentives for proper disposal, in order to transform awareness into concrete and widespread behaviour.

The Kruskal–Wallis test and Dunn's post hoc test with Holm correction showed that the only item with statistically significant generational differences concerned the intention to recycle WEEE correctly when the opportunity arose (Figure S9). In particular, the 18–24 age group reported significantly lower average values than both the 25–40 age group ($p \approx 0.0016$) and those over 40 ($p \approx 0.0095$), while no differences emerged between the two adult groups. This highlights a lower propensity among younger people to translate environmental awareness into concrete recycling behaviour. In general, environmental awareness increased with age: those over 40 reported higher average values for almost all statements, particularly with regard to the intention to recycle WEEE (4.22) and the willingness to devote time to disposal practices (3.74). For the other items, differences in group means were not statistically significant (Table S7). The perceived social importance of recycling seemed to increase slightly with age, rising from an average of 3.08 among those aged 18–24 to 3.36 among those over 40. Conversely, younger age groups showed lower values, especially in relation to financial commitment: willingness to bear the cost of ensuring correct WEEE disposal remained below 3 in the 18–24 and 25–40 age groups, rising only slightly among those over 40 (3.10). Thus, while theoretical awareness was widespread, concrete behaviour was more evident among adults and less so among young people, indicating the need for targeted interventions to involve the latter more effectively.

Analysis of statements relating to attitudes and intentions regarding WEEE disposal showed similar average values between women and men, with minor differences (Figure S10). Analysis of gender differences in statements of environmental awareness and responsibility was conducted using the Mann–Whitney–Wilcoxon test, applied to the seven items in the questionnaire. The results showed no statistically significant differences between men and women (all p values adjusted using the Holm method were above the 0.05 threshold),

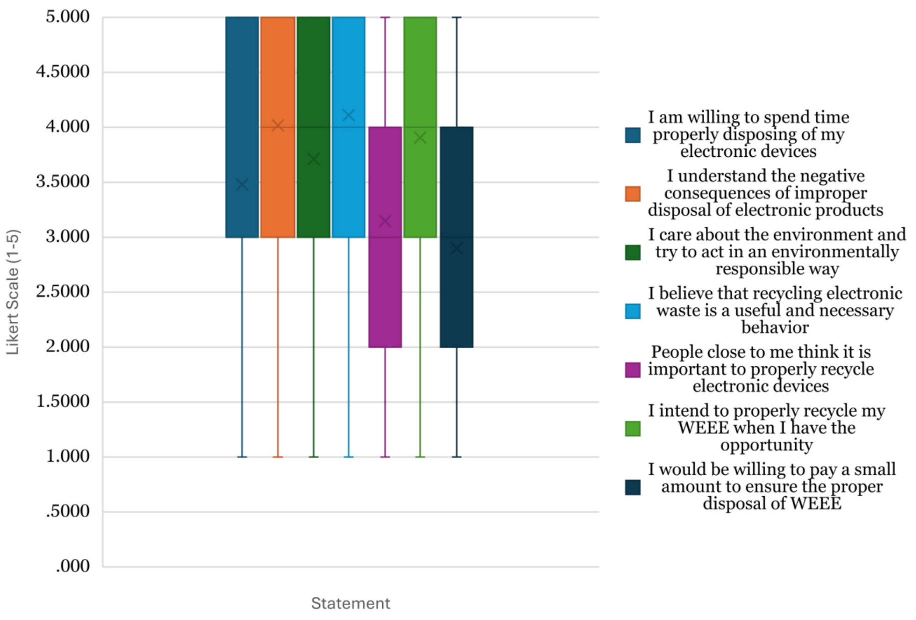

FIGURE 9 | Environmental behaviour and awareness.

indicating substantial homogeneity in the perceptions and attitudes surveyed.

4.7 | End-of-Life Strategies for WEEE

The sixth and final section of the questionnaire explored participants' opinions on the most effective strategies for promoting the proper disposal of e-waste (Figure 10). The most popular strategy was economic incentives (e.g., discounts on the return of WEEE), indicated by 30.71% of the sample, followed by the exchange of obsolete devices for new ones at a reduced price (21.87%), and home collection (19.16%)—a measure that greatly simplifies waste management. Information campaigns (15.23%) and the installation of more collection centres (13.02%) were less preferred, suggesting that communication alone or an increase in collection points may not be sufficient. These data highlight a clear trend: for WEEE collection to be truly effective, information and infrastructure policies must be accompanied by incentives that generate direct and tangible benefits.

The chi-square test ($\chi^2(8)=7.55$, $p=0.478$) showed no significant differences between age groups in terms of the strategies considered most effective in encouraging WEEE collection. Preferences for economic incentives were reported by all, but increased significantly with age, from 29.02% for those aged 18–24 to 30.08% for those aged 25–40 and 35.80% for those over 40. This suggests that older groups may respond slightly more to financial measures such as discounts and device returns. Young people (18–24) were more receptive to information campaigns (19.17%) than those aged 25–40 (12.03%) and over 40 (11.11%), showing sensitivity to awareness-raising tools. Adults aged 25–40 preferred home collection (23.31%), which was seen as practical, while device trade-ins remained stable, being slightly more preferred among over 40s (24.69%). Overall, economic strategies were most effective, but priorities differed slightly: Young people favoured awareness, adults favoured logistical solutions, and those aged over 40 favoured financial incentives and exchanges. A differentiated approach combining financial, informational, and organisational tools is therefore recommended.

A comparison of men and women regarding strategies to improve WEEE collection showed no significant differences ($\chi^2(6)=11.44$; $p=0.076$). Both genders prioritised economic incentives (35.50% of men, 27.23% of women), highlighting the impact of financial measures. Women, however, gave more importance to information campaigns (19.15% vs. 9.47% of men), showing greater sensitivity to awareness and education. Overall, men tended to favour economic incentives and practical solutions such as trade-ins and home collection, while women placed more emphasis on educational and informational tools. Although these differences were not statistically significant, they may nonetheless suggest differing approaches to raising awareness and promoting proper WEEE disposal between genders.

4.8 | Relationship Between Purchasing Choices and Environmental Awareness

To explore the relationship between factors driving purchasing choices and the extent of environmental awareness, a Spearman correlation matrix was created (Figure S11). Sustainability-oriented choice criteria were weakly associated with environmental awareness. Low-emission production showed the highest correlations (ρ between 0.27 and 0.36) with environmental concern, willingness to devote time to disposal, and intention to recycle WEEE correctly. Quality, reliability and repairability also showed positive links (ρ between 0.15 and 0.23). Price and design showed minimal correlations, while fashion and current trends had a negative coefficient ($\rho=-0.12$). Overall, while significant, the

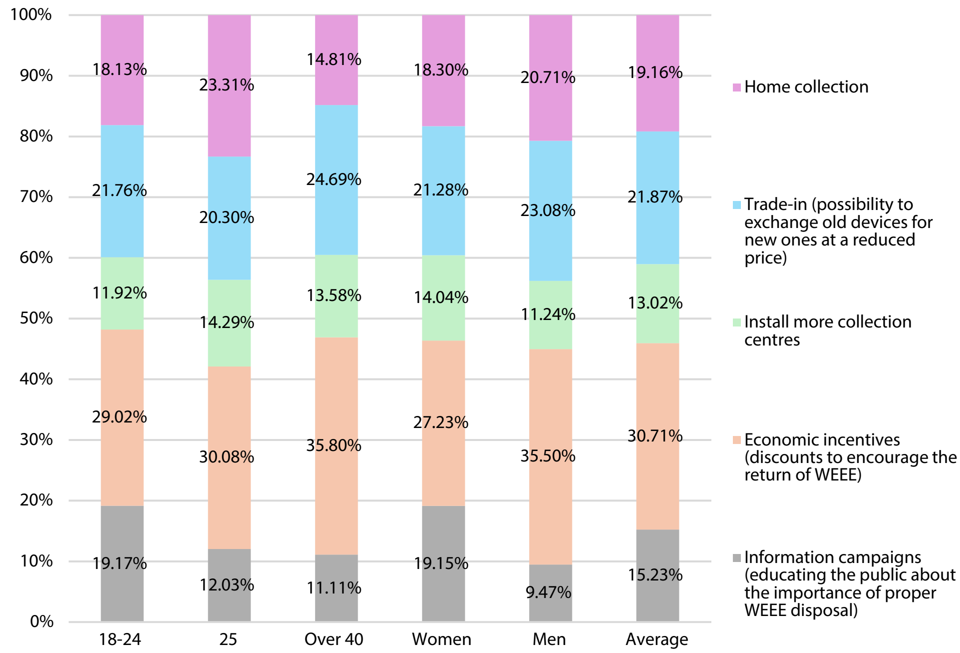

FIGURE 10 | End-of-life strategies for WEEE.

relationships suggest that environmental awareness is only moderately influenced by choice factors.

4.9 | Association Between Knowledge of WEEE Centres and Disposal Methods

To verify whether knowledge of local WEEE centres was associated with the actual disposal method declared, a contingency table was constructed, crossing two variables (Table S8): (i) knowledge of local WEEE centres (yes/no) and (ii) prevailing disposal method (e.g., keeping them at home, trading them in, throwing them in the rubbish, taking them to a WEEE collection centre, selling them or giving them away). The chi-square test of independence (χ^2) showed that the distribution of disposal methods indicated a highly significant association ($\chi^2(4) = 161.85$ with $p < 0.001$). The summary table in percentages further showed that, among those who were unaware of WEEE centres, a tendency to keep devices at home prevailed (65.50%); while among those who were aware of them, more than half reported that they took devices to a collection centre (50.83%). These results suggest that greater dissemination of information on the existence and accessibility of WEEE centres may lead to more appropriate disposal behaviour, with a positive impact on the sustainable management of electronic waste.

4.10 | PCA Results

In accordance with Section 3.2, the rest of the article proposes the results of the analytical framework for identifying consumer types. The first analysis was built upon two PCAs, to ensure that the variables used in the clustering analysis were orthogonal and uncorrelated. The first PCA, focused on product attribute importance, identified four principal components (see Table S9 for the PCA loadings). Although measured on Likert scales, the variables represented latent attitudinal constructs. While Likert scale data are technically ordinal, standard PCA is commonly applied as a dimensionality reduction technique prior to clustering in behavioural research, when the objective is to identify behavioural profiles rather than estimate structural causal parameters. This is because these ordinal variables are generally treated as approximations of underlying continuous constructs (Linting et al. 2007). Sampling adequacy was verified through the KMO test (0.819), confirming the suitability of component estimation. The four extracted components (product importance [PI]), explaining 82.5% of the variance (see Figure S12), were interpreted as follows:

- PI-PC1 (general quality): This dimension exhibited high negative loadings for quality/reliability (−0.419), design (−0.401), brand (−0.385) and technical performance (−0.391), representing a prioritisation of overall product quality and trusted attributes over price or trends.
- PI-PC2 (aesthetics vs. value): This dimension exhibited strong negative loadings on fashion/trends (−0.591) and brand (−0.402), contrasted with a moderate positive loading on price (0.386), suggesting a trade-off between aesthetic or symbolic preferences and economic considerations.
- PI-PC3 (sustainability orientation): This dimension captured respondents' environmental and sustainability concerns in purchasing decisions, showing primarily high positive loadings on low-emission production (0.748) and repairability (0.391).
- PI-PC4 (price sensitivity vs. durability): This dimension exhibited a high positive loading on price (0.707) and a negative loading on repairability (−0.418), indicating an orientation toward cost-consciousness at the expense of long-term product durability or reparability.

The second PCA focused on consumer awareness, attitudes, and behavioural intentions related to WEEE. The analysis extracted three principal components with a KMO value of 0.902, confirming the sampling adequacy (see Table S10 for the PCA loadings). The three main components extracted (consumer awareness, CA components), explaining 81.6% of the variance (Figure S13), were interpreted as follows:

- CA-PC1 (intrinsic responsibility): This dimension was characterised by high positive loadings on environmental concern (0.407), belief in recycling usefulness (0.405), and intent to recycle (0.415), representing an internalised sense of ecological responsibility and personal moral duty towards proper WEEE disposal.
- CA-PC2 (perceived social norm and fee rejection): This dimension exhibited strong negative loadings on social norms (−0.673) and fee payment willingness (−0.573), indicating a recognition of social expectations around recycling and a simultaneous opposition to paying disposal fees, reflecting tension between normative awareness and economic resistance.
- CA-PC3 (financial willingness to recycle): This dimension combined a positive loading on social norms (0.668) and a strong negative loading on fee payment willingness (−0.686), suggesting a distinct attitudinal pattern in which social influence and economic considerations jointly shaped readiness to engage in recycling behaviours.

4.11 | Cluster Results

Building on the seven PCA components from the previous section, K-means clustering was performed to identify distinct consumer types, including behavioural variables measuring WTP for notebooks and smartphones and self-reported frequencies of device replacement. The elbow method suggested four optimal clusters (Figure S14, see Tables S10 and S11 for more details).

Cluster 1 (29.46%), labelled 'Budget-Conscious Aesthetic Seekers,' showed low engagement across all dimensions. They had the lowest WTP (766 € for notebooks, 428 € for smartphones), low replacement frequency (1.54 for notebooks, 1.98 for smartphones), minimal sustainability interest (CA-PC1 = 1.314; PI-PC3 = 0.038) and high sensitivity to aesthetics (PC2 = 0.852). Economic constraints likely limited their participation in proper sustainability considerations such as recycling.

Cluster 2 (12.87%), 'Aesthetic, Trend, and Brand-Oriented Rejectors,' was strongly fashion and brand-driven. They reported high WTP (891 € for notebooks, 694 € for smartphones) and moderate replacement frequencies (1.81 and 2.54), but strongly negative pro-environmental attitudes (CA-PC1 = −2.381) and low intrinsic responsibility (CA-PC2 = −0.230). Their e-waste generation was primarily driven by status, rather than necessity or environmental concern, making them challenging for policy interventions.

Cluster 3 (28.71%), 'eco-conscious high spenders,' combined positive sustainability and repairability scores (PI-PC3 = 0.195; CA-PC1 = 1.662) with high WTP (918 €; 751 €) and the highest smartphone replacement frequency (2.92). They valued sustainable, high-quality products and were likely receptive to circular economy initiatives such as trade-in or premium take-back schemes.

Cluster 4 (28.96%), 'pragmatic mainstream buyers,' focused on durability and functional purchasing. They showed low interest in sustainability and aesthetics (PI-PC3 = −0.292; PI-PC2 = −0.311), the highest WTP (938 €; 762 €), and moderate replacement frequency (2.01 notebooks; 2.73 smartphones), reflecting pragmatic choices and openness to proper recycling channels.

5 | Discussion

The results of this analysis offer partial support for the proposed framework. Regarding H1, the findings confirmed that, while environmental awareness was high across the sample, it was not a sufficient predictor of correct behaviour, aligning with the 'awareness-action gap' in the literature. In support of H2, the data revealed that 'logistic knowledge' was a critical discriminator, as respondents who simply did not know where to go to dispose of their e-waste were responsible for the highest rates of hoarding. Finally, consistent with H3, the cluster analysis showed that pragmatic mainstream buyers responded significantly better to monetary incentives than to environmental appeals, suggesting that, for a large segment of consumers, economic utility may outweigh ethical concerns.

The literature has widely emphasised that the sustainability of WEEE is a priority that can no longer be postponed (Kumar and Dixit 2018a, 2018b) and that the active participation of users in collection and recycling programmes is an essential prerequisite for the success of circular models (Shahrasbi et al. 2021). However, numerous studies have highlighted the persistence of incorrect or insufficient practices: individuals often do not dispose of devices through official channels, preferring to accumulate them at home or dispose of them improperly (Corsini et al. 2020; Ongondo et al. 2011).

The results of this survey fit perfectly into this picture. Over half of the sample (53%) stated that they kept smartphones and notebooks that are no longer used at home, while only a minority (15.97%) took them to a WEEE collection centre. This behaviour, already widely documented in the literature, confirms the gap between declared environmental awareness and actual practice, whereby obsolete devices are retained for data security reasons or due to a lack of information on disposal channels (Borthakur and Govind 2019; Debnath et al. 2020).

These findings empirically confirm H1, demonstrating the persistence of a significant awareness-behaviour gap in WEEE disposal, despite high levels of declared environmental concern. This behavioural gap aligns with evidence that awareness interacts with personality traits (e.g., extraversion and emotional stability) in shaping attitudes towards e-waste, while economic or status-oriented values can reduce proper disposal engagement (Iskander et al. 2025; Nauman et al. 2025).

The survey also allowed for a deeper understanding of socio-demographic differences—an aspect already noted in previous studies (Michael et al. 2024; Puzzo and Prati 2025). Young adults (aged 18–24) were more inclined to keep their devices, while those over 40 were more likely to use WEEE collection centres. This suggests that age may play a decisive role, with greater maturity associated with a more developed sense of responsibility. In contrast, younger people, despite declaring themselves aware of the consequences of incorrect disposal, may find it more difficult to translate this awareness into concrete action.

Another relevant finding concerns knowledge of the available infrastructure. Only 29.48% of respondents reported that they knew where WEEE centres were located in their area. This lack of information was decisive: among those who did not know about local centres, almost two-thirds (65.50%) kept old devices at home, while among those who did know, more than half (50.83%) disposed of them correctly. This statistically significant result confirms what has already been highlighted in the literature on the importance of making collection points visible and accessible (Dhir, Malodia, et al. 2021; Dhir, Koshta, et al. 2021; Jangre et al. 2022). Accordingly, H2 was supported, as knowledge of WEEE collection infrastructure emerged as a decisive factor in promoting correct disposal behaviour and reducing device hoarding.

Alongside informational aspects, psychological factors emerged as influential in shaping intention to recycle. Previous research has identified value compatibility, environmental concerns, and perceived benefits as determinants of recycling intention (Dhir, Koshta, et al. 2021). The data collected partly confirmed these findings, as awareness of the consequences of improper disposal and the perceived usefulness of recycling scored highly (4.02 and 4.11 out of 5, respectively), while willingness to bear the economic costs remained low (2.90). Commitment in terms of time was also lower (3.48), highlighting a gap between stated attitudes and actual behaviour (Chiappetta Jabbour et al. 2023a).

The reuse and refurbishment market represented another critical dimension. Despite its potential to reduce WEEE flows, engagement with this market remained marginal in the present sample (Alonso-Almeida et al. 2020; Chiappetta Jabbour et al. 2023b). The majority had never purchased used or refurbished devices (1.54 and 1.68 out of 5, respectively). However, younger people were more open to purchasing refurbished devices, likely for economic reasons. This suggests that the refurbishment market may serve to introduce consumers to the logic of circularity, provided that perceived reliability of the products is strengthened. These findings align with circular supply-chain research highlighting reuse orientation and remanufacturing capability as key decision criteria (Hasan et al. 2025), showing that circular business models, especially product-as-a-service,

TABLE 1 | Discussion on cluster groups.

Consumer type	Budget-conscious aesthetic seekers	Aesthetic, trend, and brand-oriented rejectors	Eco-conscious high spenders	Pragmatic mainstream buyers
How to convince them to buy sustainable	Emphasise affordable sustainability: highlight low-cost refurbished or used options (Alonso-Almeida et al. 2020; Chiappetta Jabbour et al. 2023b), combining design appeal and savings. Communicate long-term economic benefits (Newaz and Appolloni 2024).	Use status-driven green marketing: link sustainability to premium image and brand exclusivity (Newaz and Appolloni 2024). Influencer or brand-led campaigns can connect trends with eco-premium positioning (Corsini et al. 2020).	Emphasise stress repairability, durability, and ethical production (Chiappetta Jabbour et al. 2023a, 2023b). Highlight transparent supply chains and certifications that reinforce responsible consumption	Emphasise functional sustainability: durable, energy-efficient, high-value-for-money products. Avoid moralising tones; appeal to rational benefits.
How to convince them to dispose properly	Use financial incentives (Azizi et al. 2023; Shevchenko et al. 2019) and home collection services (Dhir, Malodia, et al. 2021) to reduce effort and cost barriers. Provide simple trade-in schemes (Puzzo and Prati 2025). Combine price sensitivity with visible, low-effort disposal channels to activate behaviour (Borthakur and Govind 2019).	Introduce branded take-back programs and visible partnerships between brands and WEEE channels (Shahrasbi et al. 2021), reinforcing brand identity rather than ecological duty. Behaviour guided by status consumption rather than environmental concern (Michael et al. 2024).	Present drop-off points clearly (Dhir, Malodia, et al. 2021; Jangre et al. 2022): ensure information visibility and ease of access. Offer premium trade-in or green membership schemes (Azizi et al. 2023). They already act in line with sustainability but require logistical facilitation to close the behaviour gap.	Provide convenient collection points (Dhir, Malodia, et al. 2021; Jangre et al. 2022) and trade-in opportunities linked to product value (Shahrasbi et al. 2021). Make e-waste collection procedures simple and visible (Corsini et al. 2020).
Particularities	Economic constraints and high sensitivity to aesthetics limit engagement; likely difficult to motivate without strong financial incentives or very visible, low-effort options.	Highly brand-loyal and trend-sensitive; difficult to reach through environmental messaging, requiring image-based appeal.	Highly brand-loyal and trend-sensitive; difficult to reach through environmental messaging, require image-based appeal.	Focused on practicality and durability; respond best to functional, convenient, and rational approaches.

outperform linear systems both environmentally and economically (Rittershaus et al. 2026).

The issue of price also appeared central. As highlighted in the literature, awareness alone is not enough if it is not accompanied by tangible benefits (Newaz and Appolloni 2024). The data confirmed this, as respondents stated they expected substantial reductions for used and refurbished goods (40.70% and 33.49%, respectively). The fact that the expected discount for refurbished goods was lower indicates greater confidence in this type of product, which was perceived as safer than used goods. This supports research showing that regulatory and economic tools (e.g., eco-modulated EPR schemes, right-to-repair policies and deposit-refund mechanisms) promote circular participation, while increased recycling and longer product use improve environmental quality (Abdelmeguid and Corsini 2026; Baykut et al. 2026).

Finally, the research explored the strategies considered most effective for increasing WEEE collection. Respondents prioritised financial incentives (30.71%), followed by trade-ins (21.87%) and home collection (19.16%). Information campaigns and an increase in the number of collection centres obtained lower percentages, confirming that, in the absence of direct benefits, the propensity to dispose of e-waste remains limited. The absence of economic incentives was perceived as one of the main barriers (Shevchenko et al. 2019), thereby reiterating the need to combine information and regulatory tools with economic measures to increase perceptions of WEEE recycling as simple and convenient (Azizi et al. 2023; Dhir, Malodia, et al. 2021). These results confirmed H3, as economic incentives and low-effort solutions were deemed more effective in driving WEEE disposal behaviour than information-based interventions, alone.

Despite widespread environmental awareness, action on WEEE disposal remained limited because of effort, cost and poor infrastructural knowledge. Effective policies should therefore combine targeted information campaigns, especially for young people, with economic and logistical measures that make disposal easy. Only this integrated approach can convert awareness into concrete recycling behaviour and support circular economy goals. Table 1 provides some recommendations that emerged from our analysis based on the segmentation proposed in Sections 4.10 and 4.11, comparing them with what is proposed in the literature for the identified consumer categories. The segmentation results suggest that circular economy strategies should move beyond uniform sustainability communication. In more detail, firms should differentiate interventions by combining informational tools, economic incentives and infrastructure visibility according to the behavioural profile of each consumer cluster. The relationships among incentives, policy frameworks, and consumer attitudes towards circular solutions have been corroborated by previous research on e-waste (Gollakota et al. 2020; Jaiswal and Mukti 2025; Jaiswal and Mukti 2024).

The results of the segmentation analysis further align with findings showing that sustainability literacy shapes the ability to engage with circular tools such as digital product passports (Becchi et al. 2026), while circular positioning (seen, e.g., in crowdfunding) highlights the role of behavioural differentiation in mobilising stakeholder engagement (Lu et al. 2026). In addition, subsidies may boost demand for sustainable products, even among price-sensitive consumers, whereas carbon taxes are likely to have limited impact (Cascavilla et al. 2025).

6 | Conclusions

This study aimed to investigate how environmental awareness, knowledge of disposal infrastructure, and economic incentives interact in shaping consumer participation in circular electronic product systems. The research aimed to move beyond isolated behavioural explanations by examining how these factors combine to generate distinct patterns of action. The results identified four main consumer profiles, each associated with differentiated forms of circular engagement.

Theoretically, the paper contributes to the circular economy literature by validating a behavioural segmentation model integrating behavioural awareness, contextual constraints, and economic incentives within a unified empirical framework. The main novelty lies in its demonstration that 'lack of action' is not a monolith, but a phenomenon that arises from distinct drivers (lack of knowledge vs. lack of incentive), depending on the consumer cluster. Thus, the paper shifts the analytical focus from examining individual determinants to understanding how established behavioural drivers cluster into coherent participation profiles.

While the individual relationships observed are consistent with prior research, the contribution lies in their joint operationalisation within a segmentation framework linking behavioural psychology to operational circular strategies. By identifying actionable consumer configurations rather than isolated predictors, the findings support the design of differentiated operational and communication strategies for firms and policymakers in regulated circular markets. More broadly, the study bridges consumer behaviour research and circular business model design—an integration rarely operationalised in previous empirical works.

The study also provides an in-depth picture of Italian consumers' behaviour regarding the purchase, use and disposal of electronic devices, highlighting good theoretical awareness of sustainability but lack of translation into concrete behaviour. Although many recognise the importance of reducing environmental impact, quality, performance, and price remain the main purchasing criteria. Generational differences are also evident: Young people (aged 18–24) appear more attentive to design and technological trends but are less responsible in terms of disposal, while adults show greater attention to the product life cycle and better knowledge of WEEE collection centres. This indicates the need for policies aimed at younger people through educational programmes and targeted digital content.

A significant problem is lack of knowledge about WEEE collection points, leading to the accumulation of devices at home. Therefore, more effective institutional communication, better accessibility of centres and more convenient collection services are needed.

For companies, the results indicate a growing interest in repairability and durability. This suggests that investment in sustainable design, modular solutions and maintenance-oriented after-sales services may offer a competitive advantage. The refurbished market shows significant potential, especially when supported by quality certifications and transparent communication. Economic incentives appear to be the most effective lever for stimulating correct behaviour (e.g., device return).

These findings offer key insights for electronics manufacturers and retailers. Because purely environmental appeals (H3) are less effective for certain clusters, companies should implement 'deposit-refund' schemes or 'trade-in' discounts to motivate pragmatic mainstream buyers. To address H2, retailers should integrate disposal points directly into the new product purchase journey (e.g., 'one-click pick-up' of old devices when delivering new ones), removing the logistical friction that causes hoarding. Brands may target eco-conscious high spenders through certified refurbished lines, leveraging these consumers' high willingness to engage in circular loops without the need for aggressive monetary incentives.

The environmental value of WEEE recycling should be better communicated, as many consumers do not fully perceive the benefits in terms of emissions reductions and raw material recovery. Simple, visual and motivating campaigns may contribute to bridging this gap.

From a strategic perspective, the present findings support a transition from ownership-oriented product design to circulation-oriented design. Modular components, easy battery replacement, and certified refurbishment compatibility would increase the economic viability of secondary markets, allowing firms to design products for not only durability, but also predictable recovery. This would enable the development of refurbishment platforms, subscription models and secondary sales channels, with consumer behaviour integrated as a design parameter, rather than an ex-post market reaction.

Despite its contributions, the study had some limitations. First, the cross-sectional nature of the data prevented causal inferences. Second, use of a sample skewed towards younger demographics limited the generalisability of the findings to the broader Italian population, and particularly older consumers, who may exhibit different disposal habits. Third, the study was conducted within a mature regulatory environment, thereby restricting the international representativeness. Future research should therefore address these limitations by adopting longitudinal designs to test behavioural changes over time and by expanding the sample to include representative quotas of nondigital natives. Furthermore, comparative studies between Southern and Northern European countries—or between countries with different regulatory and infrastructural contexts—could contribute to further disentangling the relative influence of cultural versus infrastructural barriers.

Consumer behaviour is heterogeneous and requires differentiated strategies depending on motivations, budgets and replacement habits. Despite some methodological limitations, the present work shows that achieving SDG 12 requires an integrated approach, combining targeted policies, industrial innovation, and individual responsibility to develop a truly sustainable technological ecosystem.

Author Contributions

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Figure S1:** Thematic map. **Figure S2:** PRISMA scheme. **Figure S3:** Age distribution of the sample (years). **Figure S4:** Breakdown of the sample by age and gender . **Figure S5:** Factors influencing the purchase of electronic devices by age group. **Figure S6:** Factors influencing the purchase of electronic devices by gender. **Figure S7:** Average WTP for a new electronic product. **Figure S8:** Discount for a used and refurbished electronic device. **Figure S9:** Environmental behaviour and awareness by age group. **Figure S10:** Environmental behaviour and awareness by gender. **Figure S11:** Factors influencing purchase decision and environmental awareness. The following acronyms are used: A = I am willing to spend time properly disposing of my electronic devices; B = I understand the negative consequences of improper disposal of electronic products; C = I care about the environment and try to act in an environmentally responsible way; D = I believe that recycling electronic waste is a useful and necessary behaviour; E = People close to me think it is important to properly recycle electronic devices; F = I intend to properly recycle my WEEE when I have the opportunity; G = I would be willing to pay a small amount to ensure the proper disposal of WEEE. **Figure S12:** Percentage of explained variances of the principal component for the consumer attitudinal factors. **Figure S13:** Percentage of explained variances of the principal component for the awareness variables. **Figure S14:** Optimal number of clusters estimation (Elbow Method). **Table S1a:** Statistical analysis—Factors influencing the purchase of electronic devices by age groups. **Table S1b:** Statistical analysis—Factors influencing the purchase of electronic devices by age groups. **Table S1c:** Statistical analysis—Factors influencing the purchase of electronic devices by gender group. **Table S2:** Statistical analysis—Frequency of replacement of electronic devices. **Table S3:** Statistical analysis—Main reason for replacing an electronic device. **Table S4:** Statistical analysis—Average frequency of purchase of used and refurbished devices. **Table S5:** Statistical analysis—WTP for a new electronic product. **Table S6:** Statistical analysis—Discount for a used and refurbished electronic device. **Table S7:** Statistical analysis—Environmental behaviour and awareness. **Table S8:** Knowledge of WEEE centres and disposal methods. **Table S9:** PCA loadings—Product importance. **Table S10:** PCA loadings—WEEE awareness. **Table S11:** Centres of the clusters: Frequency and willingness to pay for high-tech products. **Table S12:** Centroid values per cluster—PCA components.