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RESEARCH ARTICLE

Mitigating Cosmetic Packaging Waste: Consumer Acceptance of Expanding the Deposit-Refund System for a Circular Economy in Hungary

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Abstract – Deposit-refund systems (DRSs) are widely used to increase recycling rates and support circular economy goals, but most schemes still only focus on beverage containers, and other packaging streams have received less attention. Cosmetic packaging is a relevant waste category because it is generated in every household and produced in massive quantities, while still suffering from low recovery rates. To evaluate consumer acceptance and openness toward expanding the DRS framework to this sector, this study utilizes empirical evidence from an online consumer survey in Hungary. Data were collected through an online consumer survey and analysed to identify socio-demographic, educational, and behavioural factors linked to acceptance. The analysis was particularly focused on environmental education and training of the participants, the role of gender, income, and the perceived responsibility for reducing non-recycled packaging waste. Across the examined demographic groups, surveyed respondents overwhelmingly support expanding the deposit-refund system, and this theoretical willingness remained consistently high regardless of the socio-demographic background. However, although respondents assign primary recycling responsibility to external actors, they surprisingly place themselves second. Contrary to the expectations based on previous literature, prior environmental education across formative life stages did not demonstrate a statistical association with acceptance within this sample. These findings provide valuable insights for policymakers, producers, and waste-management stakeholders who envision the future of waste management within the framework of a circular economy.

Keywords – Waste management, Deposit-Refund System, Recycling, Cosmetics.

JEL classification**:** Q53, Q58, Q57

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1. INTRODUCTION

Deposit-refund systems (DRSs) have become one of the most effective policy instruments for advancing circular economy objectives and improving packaging recovery rates. Across Europe, deposit-based systems have consistently achieved recovery rates exceeding those of conventional waste-management schemes, making them a key component of contemporary circular economy policy (Calabrese et al., 2021; Calvin Lakhan, 2024).

The growing importance of DRS is planted in the European Union's regulatory framework. Directive (EU) 2019/904 on single-use plastics established ambitious collection targets for beverage packaging, while the Packaging and Packaging Waste Regulation (PPWR) further strengthens circular economy requirements through enhanced recovery and recycling obligations (European Parliament and Council, 2019; European Parliament & of the European Union, 2025). These policies have encouraged member states to introduce increasingly effective collection systems capable of achieving high recovery rates.

While the effectiveness of DRS schemes for beverage packaging is well documented, considerably less attention has been paid to extending deposit-based collection mechanisms to other packaging categories, for example, cosmetic packaging.

Around 25.8 million tons of plastic waste is generated in Europe every year. Morganti highlights that the global cosmetics industry produces more than 120 billion packaging units annually (British Beauty Council, 2020; Morganti, Morganti, Gagliardini, et al., 2021). Moreover, 60% of these are made from plastic materials, many of which are not readily biodegradable or recyclable (Cubas et al., 2020). In the case of cosmetic packaging, reuse is rather rare, and chemical and mechanical recycling is not easily feasible. The packaging is often heavily contaminated with product residues, which are often difficult to remove by washing (Cinelli et al., 2019; Klein et al., 2025; Moscatelli et al., 2026). In addition to the basic problem that many units of plastic waste are produced in the cosmetics industry, there is also a problem that, due to inadequate collection or disposal, a lot of cosmetic plastic packaging ends up in landfills or in nature. If current consumption rates continue, it is estimated that 12 billion tons of plastic will end up in landfills by 2050, and the life cycle of petroleum-based plastics is very carbon-intensive. (Bom et al., 2019). At the same time, several cosmetic brands have introduced voluntary take-back programs, suggesting that consumers may be willing to participate in dedicated collection schemes when appropriate infrastructure is available (Beauty Kitchen UK Ltd., n.d.; Innisfree by Amorepacific Corporation, n.d.; Kiehl's Since 1851., n.d.; Lush Manufaktura d.o.o., n.d.; MAC Cosmetics, n.d.; Moscatelli et al. 2026).

Expanding the deposit system to the cosmetics sector addresses multiple environmental challenges simultaneously. First, it drives resource conservation by providing high-purity polymer streams (e.g., PET, HDPE, PP), which reduces the industry's reliance on virgin, fossil-based plastics and lowers the carbon footprint of packaging production (Thoden Van Velzen et al., n.d.). Second, a purpose-built cosmetics DRS establishes circular material flows by preventing downcycling: unlike commingled curbside recycling, a dedicated deposit system minimizes (or ideally eliminates) cross-contamination from food or hazardous waste, thereby keeping cosmetic-grade plastics within a closed-loop system and increasing the overall proportion of recycled materials (Benyathiar et al., 2022). Finally, this expansion achieves substantial waste reduction by shifting consumer behavioral incentives (Amirudin et al., 2023a; Prakash et al., 2024). Concurrently, the centralized collection facilitates industrial cleaning and wastewater treatment, reducing the uncontrolled release of cosmetic chemical residues into natural ecosystems.

Existing Hungarian research has primarily examined the implementation and acceptance of the current beverage-container system (Boros et al., 2021; Szűcs et al., 2024, 2025). To address the research gap regarding non-beverage polymer streams, this study establishes the social justification for expanding the DRS framework to cosmetic packaging, supported by existing literature and practical examples of its environmental necessity. The research presents primary consumer survey data as empirical evidence evaluating stated consumer openness toward this proposed environmental intervention within the surveyed cohort.

2. LITERATURE REVIEW

2.1 International Experiences and Efficiency of Deposit Return Systems

The international significance of the DRS is demonstrated through several examples from around the world. Ten states have adopted deposit laws in the USA, achieving a beverage container recycling rate of approximately 60%, which is only 24% in non-deposit states (Benyathiar et al., 2022). In the Netherlands PET bottles collected via DRS yield 99.3% targeted polymer purity, significantly outperforming both mechanically recovered and separately collected (street-bin or curbside) plastics (Thoden Van Velzen et al., n.d.). After introducing a mandatory DRS in 2011, Ecuador saw its PET recycling rate elevate from 39% to over 100% (even a surplus resulted from cross-border imports of bottles by individuals seeking the deposit) (Avis, 2025). In the absence of mandatory legislation, a voluntary DRS run by a local drinks company for refillable glass bottles achieves an impressive 90% recovery rate in Botswana, which strongly outperforms glass bottles outside the DRS, which frequently end up as litter or in landfills (Avis, 2025). Since Indonesia faces a national plastic collection rate of only 39%, studies propose DRS as a necessary solution presented that 85% of Indonesian respondents would accept and participate in a DRS (Amirudin et al., 2023b). International examples prove the significance of DRS by showing that it is globally recognized as one of the most effective structural mechanisms for capturing high-quality packaging waste (Calabrese et al., 2026; Calvin Lakhan, 2024; Konstantoglou et al., 2023; Zhou et al., 2023). If this practice would be implemented beyond beverage packaging, a huge increase could be achieved in waste collection and recycling, significantly improving the current recycling rate, which is now only around 9% of cosmetic packaging globally (British Beauty Council, 2020; OECD, 2022).

Deposit-refund systems have demonstrated remarkable effectiveness across Europe (Table 1). Countries such as Germany, Norway, Finland, Lithuania, and Denmark have achieved recovery rates exceeding 90% following the implementation of DRS. At the same time, more recent adopters, including Slovakia, Romania, and Ireland, have reported similarly promising results (Calvin Lakhan, 2024). These experiences demonstrate that well-designed DRS structures can substantially increase packaging collection rates while reducing environmental leakage and supporting circular economy objectives.

2.2 Socio-Demographic and Psychological Factors Driving DRS Acceptance

General Behavioral Drivers and Barriers

The effectiveness of any deposit-refund system ultimately depends on consumer behavior. Environmental actions are shaped by a combination of values, attitudes, social norms, perceived responsibility, and situational factors (Steg & Vlek, 2009). Ertz et al. (2023) identify macroenvironmental, situational, and individual-level determinants that jointly influence recycling participation (Ertz et al., 2023). Research consistently demonstrates that environmental concern positively affects recycling behavior (Antonetti & Maklan, 2014; Leary et al., 2014). However, positive attitudes alone do not guarantee participation: practical barriers, like inconvenience, uncertainty regarding recyclability, insufficient information, and poor infrastructure, often weaken the relationship between environmental concern and active cooperation (Fogt Jacobsen et al., 2022). Furthermore, perceptions of responsibility play a significant role. These findings suggest that support for expanding DRS schemes beyond beverage packaging is likely to depend on both environmental motivations and practical considerations.

Table 1 Comparative data of the increase in recycling rates before and after the introduction of DRS in 21 European countries (until 2024). Own compilation, based on the table of Lakhan (Calvin Lakhan, 2024 (Calvin Lakhan, 2024, supplemented with Hungary based on data from Eunomia (Eunomia, 2020). and MOHU (from the introduction to 31 Dec 2025) (MOHU MOL Hulladékgazdálkodási Zrt., 2026).

Country	DRS introduction	Deposit fee (€)	Reported Collection / Return Rate (%)
Germany	2003	0.25	98
Norway	1999	0.18-0.36	95–97
Lithuania	2016	0.10	91
Finland	1996	0.10–0.40	94
Denmark	2002	0.13-0.39	89
Estonia	2005	0.10–0.20	90+
Netherlands	2005, 2021	0.15	95
Sweden	1984	0,094-0,19	85
Slovakia	2022	0.15	93
Latvia	2022	0.10	83
Romania	2023	0.10	84
Ireland	2024	0.15	73
Hungary	2024	0.13	~ 90

Environmental Attitudes vs. Monetary Incentives

The European pattern demonstrates that the effectiveness of DRS extends beyond economic incentives alone. Studies from Greece, Portugal, Slovakia, and Northern Ireland indicate that environmental attitudes are often stronger drivers of participation than the monetary value of the deposit itself. These examples show that environmental attitudes are typically stronger drivers of participation than the monetary value of the deposit itself (Dempster et al., 2021; Konstantoglou et al., 2023; Martinho et al., 2024).

Socio-Demographic Influences: Income, Age, and Gender

While environmental behavior is based on education from early childhood, socio-demographic factors (eg. age, gender, place of residence or income) have a deeper influence on the perception of DRS and their support for their expansion (Mielinger & Weinrich, 2024). Although the results of international research are contradictory, understanding these factors is key to expanding DRS to cosmetic packaging. The example of Japan shows that while inactive, older or lower-income women are more physically active in in-store recycling, higher-income women may underperform in everyday recycling due to lack of time (Yu et al., 2025). In contrast, Greek and Canadian research indicates that households with higher income and social status are more environmentally sensitive and respond more intensely to even minor financial incentives or prohibitions (Konstantoglou et al., 2024; Rivers et al., 2017).

Perceived Responsibility

On a psychological level, consumers often attribute waste-management failures to governments, municipalities, retailers, or manufacturers rather than to themselves (Hansmann & Steimer, 2015). Through a survey of 147 participants, a self-serving attribution bias was identified

where people justify their own littering by blaming external factors, such as inadequate trash cans or poor infrastructure and even further, people tend to use "justifications" and "neutralization techniques" to resolve the contradiction between their environmentally conscious principles and their actual, environmentally neglective behavior (Hansmann & Steimer, 2015). As a result, successful collection systems typically emphasize convenience, accessibility, and shared responsibility rather than individual blame (Birau & Faure, 2018; Hansmann & Steimer, 2017; Mayer & Kohl, 2024). Meilinger and Weinrich examine the concept of perceived responsibility: the focus group interviews of the study highlight that consumers are frustrated by the burden placed on them and expect the redistribution of responsibility. Consumers also feel to be unfair that the responsibility for managing plastic waste is placed almost entirely on them, while producers benefit from the profits of plastic. Participants agreed that manufacturers should be obliged to bear greater responsibility, for example through the design of recyclable packaging, and manufacturers are also held responsible for overpackaging (Mielinger & Weinrich, 2024).

2.3 The deposit system in Hungary

Hungary introduced its nationwide deposit-refund system on 1 January 2024 through Government Decree No. 450/2023 (X.4.), with a transition period extending until 30 June 2024 ((Magyarország Kormánya, 2023; MOHU MOL Hulladékgazdálkodási Zrt, 2024). Consumers can reclaim deposits through store vouchers, direct bank transfers via a mobile application, or charitable donations (MOHU MOL Hulladékgazdálkodási Zrt, 2024; Szűcs et al., 2025; Vuk & Bauerné Gáthy, 2025). The introduction of the Hungarian DRS was intended to align the objectives of the SUP Directive and support the achievement of the EU's 90% collection target for plastic beverage bottles by 2029 (Bobek-Nagy et al., 2023; European Parliament and Council, 2019). Since its implementation, it has become a central component of the national waste-management infrastructure and has achieved recovery rates approaching European best-practice levels (MOHU MOL Hulladékgazdálkodási Zrt., 2026).

Previous studies provide valuable insight into public support toward the Hungarian DRS. Before implementation, consumers generally supported the concept of deposit-based collection for its perceived environmental benefits, although substantial concerns were expressed about inconvenience, storage requirements, and waiting times at collection points (Boros et al., 2021; Szűcs et al., 2024). When it was still a theoretical concept, support among the population was extremely high: according to one research, 71.8% of people said that they would collect packaging in their households if the state paid for the return. According to the measurement, the typical and most enthusiastic supporters of the system were highly educated, urban women (Boros et al., 2021). In a survey conducted in early 2024, right at the launch of the system, 66.8% of respondents expected minor or major inconvenience in their everyday lives, 58.3% of people did not expect anything positive from the system (Szűcs et al., 2024). The follow-up survey published in 2025 presents main changes in consumer attitudes compared to the preliminary measurements a year earlier: acceptance in principle increased and resistance decreased.

Ráti concludes that to maintain the commitment of Hungarian consumers, it is essential to strengthen emotional involvement and eliminate infrastructural frustrations (e.g., machine availability, cleanliness, queuing) beyond purely rational and material arguments; otherwise, the existing environmentally conscious attitude will not translate into actual action. The research found that gender, age, and income alone did not show significant differences in how often consumers use the system (Ráti & Maró, 2026). This contradicts the results of previous Hungarian research, which showed greater support for the system among women (Boros et al., 2021). However, very marked differences were found in the case of educational level: although consumers with secondary education used the system significantly more than those with primary education, graduates (university graduates) returned bottles significantly less often than those with secondary education (Ráti & Maró, 2026).

Despite these findings, existing Hungarian research has focused almost exclusively on beverage packaging. Whether consumers would support extending similar mechanisms to other product categories, such as cosmetic packaging, remains unexplored for now.

3. RESEARCH QUESTIONS AND HYPOTHESES

The study aims to validate the expansion of the deposit return system using survey feedback from Hungarian consumers. By integrating insights from circular economy research, recycling behavior literature, and DRS studies, the research contributes to a better understanding of consumer participation in emerging circular economy initiatives beyond beverage packaging. Based on the theoretical background and the current efficacy level of the Hungarian Deposit-Refund System (DRS), this study addresses four main Research Questions (RQ) and evaluates the following corresponding hypotheses:

RQ1: Would consumers be willing to use the deposit-refund system currently operating in Hungary for extended product groups, specifically empty cosmetics packaging?

- H1: The majority of consumers show a positive attitude and conceptual willingness to use the deposit-refund system for extended product categories beyond beverage packaging.

RQ2: How are environmental education and training associated with supportive attitudes toward the system's extension?

- H2: Considering the current environmental psychology consensus, education received during formative life stages exhibits a statistically significant positive association with

supportive conceptual attitudes toward the DRS extension, compared to training only received during adulthood or the complete absence of environmental education.

RQ3: Do socio-demographic background factors play a significant role in consumer attitudes and behavioral intentions regarding the extension of the deposit-refund system?

- H3: Gender matter in the issue of consumer attitude and women tend to be more enthusiastic and supportive towards regarding the expansion of DRS.

- H4: In alignment with international DRS literature, financial demographics (household income) do not act as a primary determinant of system support, as intrinsic environmental values consistently outweigh monetary or economic motivations.

RQ4: Which economic and structural actors do respondents perceive as primarily responsible for increasing the recycling rate of packaging waste?

- H5: Reflecting psychological attribution and self-serving biases, consumers attribute significantly higher systemic responsibility to external market and state actors (producers and regulators) than to individual consumer behavior.

4. MATERIALS AND METHODS

Data collection was conducted using an online survey-based approach via the LimeSurvey platform. The survey was developed exclusively in Hungarian, as it was tailored to the socio-cultural and legislative context of Hungary's waste management landscape. This approach ensured that all respondents were fully familiar with local terminology (e.g., the 'MOHU' operational structure or the 50 HUF/€0,13 deposit fee), thereby reducing the linguistic ambiguity or conceptual misunderstanding to a minimum. Participation was entirely voluntary and anonymous, as neither personal identification nor registration was required for completion. The questionnaire was distributed digitally between November 12, 2025, and May 31, 2026. The questionnaire was distributed digitally between November 12, 2025, and May 31, 2026 via institutional academic networks Hungarian University of Agriculture and Life Sciences – MATE, University of Pécs, Hungarian University of Sports Science, National University of Public Service, Károli Gáspár Reformed University, Greenology.hu (National Green Innovation and Sustainability Knowledge Center webpage), targeted sustainability, zero-waste public discussion communities, and groups interested in cosmetic products communities across social media platforms. To prevent multiple submissions from individual participants, the LimeSurvey platform employed browser cookie restrictions. Prior to completing the online questionnaire, all participants were presented with an informed consent statement detailing the research objectives and data handling practices; informed consent was implicitly obtained from all participants who voluntarily advanced to complete the survey.

Sample Characteristics and Limitations

In total, 917 responses were recorded. Data screening and participant flow followed a multi-stage protocol: First, to eliminate potential distortions in adult consumer behavior, respondents under 18 (n = 34) were excluded from the analysis, leaving an initial adult cohort of 883. Among these adult participants, n=8 records were identified as incomplete due to participant dropout prior to the core thematic blocks evaluating DRS extension willingness and structural responsibility. Following the data cleaning process, the responses of N = 875 adult respondents (who had answered every question in full) were analyzed.

The sampling method was online and voluntary (convenience sampling). The final sample shows a specific bias, with a higher density of female respondents, capital city residents, and individuals with higher educational degrees. The reliance on digital recruitment may have underrepresented segments of the population with limited internet access or lower digital literacy. These factors indicate that the findings cannot be interpreted as nationally representative estimates of public support. Post-stratification weighting or population-adjustment procedures were not applied, therefore, the reported proportions reflect the stated attitudes of respondents in this convenience sample rather than the general Hungarian adult population. External generalization requires caution, and future investigations are needed. Given the general absence of independent demographic effects beyond gender, this study favored a parsimonious bivariate approach; in this context, the trichotomous modeling of the "Uncertain" category (11.9%) confirms that ambivalence is distributed across demographic strata rather than being structured along socioeconomic divides. Future studies utilizing larger, quota-representative datasets should employ full structural equation modeling or multivariate multinomial models to isolate minor interaction effects between early environmental education and demographic determinants.

The research protocol and the questionnaire design were reviewed and approved by the institutional ethics committee of Hungarian University of Agriculture and Life Sciences. All procedures were conducted in accordance with the relevant ethical guidelines for human subjects research.

Questionnaire Design and Operationalization

Following an initial socio-demographic section, the survey contains 24 thematic questions organized into structural blocks. Consumer attitudes and behavioral intentions were captured using multiple-choice questions, open-ended inquiries for qualitative feedback, and standard five-point Likert scales (where 1 represented complete disagreement or the lowest level of awareness, and 5 represented complete agreement or the highest level of awareness).

Statistical Analysis

For quantitative processing, descriptive statistics were applied, using absolute frequencies and relative percentages

to summarize categorical responses. To determine the existence and strength of relationships between categorical variables, Pearson's Chi-square ($\chi 2$) tests of independence were systematically performed.

P-values were adjusted using the Holm-Bonferroni step-down procedure (with false discovery rates checked via the Benjamini–Hochberg method), to control the family-wise error rate across multiple demographic comparisons. The Chi-square statistic ($\chi 2$), degrees of freedom (df), valid sample size (nvalid), unadjusted and adjusted p-values (padj), and Cramér's V effect sizes with 95% confidence intervals are reported for each test. Distributional assumptions were verified for all contingency tables; all expected cell frequencies exceeded the standard threshold of 5 (minimum expected count >6.8). Furthermore, to evaluate the practical strength and relevance of the statistically significant associations, Cramér's V effect size coefficients were computed and interpreted according to standard psychometric thresholds (where $V \approx 0.1$ denotes a weak, $V \approx 0.3$ a moderate, and $V \approx 0.5$ a strong association). Statistical computations and data visualization were carried out using RStudio (version 2025.05.1 Build 513 "Mariposa Orchid", Posit Software, PBC, running on R version 4.x), utilizing the "tidyverse" and "haven" packages for data restructuring and graphical deployment.

When respondents could simultaneously select multiple entities, the individual choices were statistically dependent; to establish a robust non-parametric framework for comparing related binary proportions within the same sample, Cochran's Q test was conducted (RQ4, H5).

Table 2 Socio-demographic profile of the respondents

Socio-demographic variables	Category	Number of respondents (n)	**Percentage (%)**
Gender	Female	579	66.17
	Male	290	33.14
	Missing/undisclosed	6	0.69
Age	18–24 years	206	23.54
	25–34 years	195	22.29
	35–44 years	231	26.40
	45–54 years	163	18.63
	55–64 years	57	6.51
	Above 65	23	2.63
Residence	Capital (Budapest)	363	41.49
	County seat / Big city	225	25.71
	Other city	162	18.51
	Community / Village	120	13.71
	Missing / Undisclosed	5	0.58
Education	Higher education / Postgraduate	575	65.71
	High school / Secondary school	271	30.97
	Other (8th grade or less and Technical school)	24	2.74
	Missing / Undisclosed	5	0.58
Monthly Income (€)	Below 702.5	55	6,85
	702.5-1124	99	12,33
	1124-1686	150	18,68

	1686-2248	129	16,06
	2248-2810	146	18,18
	Above 2810	224	27,90

Source: Author's own primary dataset via LimeSurvey, N = 875; 2026

The empirical analysis is based on the finalized adult dataset (N = 875). While the questionnaire achieved high completion rates, certain demographic variables exhibit a minor degree of item non-response due to the optional nature of personal questions. The total sample count (n) fluctuates slightly across the analytical categories presented in Table 2. While the response rates for gender, education, and residence remained near-perfect (above 99%), the household income section showed a slight decline, yielding a 91.77% response rate (n = 803).

All relative percentages in this study are calculated using the actual number of valid responses for each variable. Although the original survey monitored broader consumer behavior (including brand loyalty and purchasing habits), the scope of the present paper is dedicated to evaluating consumer awareness, waste sorting routines, and the social readiness to expand the current DRS framework as a circular economy intervention.

5. RESULTS AND DISCUSSION

Evaluation of consumer willingness to extend the DRS framework (RQ1 & H1)

The descriptive results show that majority of the respondents, 74.4% (n = 651), expressed positive theoretical willingness to utilize the REpont infrastructure beyond beverage packaging (Figure 1). In the questionnaire, this item explicitly contextualized non-beverage packaging by presenting key household categories: “Would you be open to using the REpont system for packaging other than beverage bottles (e.g., food containers, shampoo and other bathroom cosmetic bottles, detergent bottles)?” Thus, participants evaluated this prospect with explicit reference to daily cosmetic and personal care containers. In contrast, only 13.7% (n = 120) of the adult sample actively opposed the structural expansion of the framework, while the remaining 11.9% (n = 104) reported being undecisive about the question. These empirical findings provide support for Hypothesis 1 (H1: The majority of consumers exhibit a positive attitude and conceptual willingness to use the deposit-refund system for extended product categories beyond beverage packaging), confirming that the conceptual demand for expanding the circular mechanism into the beauty and personal care sector enjoys a majority within the studied consumer segment.

To further evaluate the baseline support, a conservative integration of the response categories was performed. Even under a worst-case scenario framework, where all undecided or hesitant respondents ("Not sure", 11.9%) are bundled together with those who are actively opposing the innovation ("No", 13.7%) the consolidated opposition group reaches only 25.6%. Consequently, the proportion of consumers theoretically open to the DRS extension (74.4%) remains nearly three times larger than the combined negative and neutral groups.

Several underlying structural, socio-demographic, and psychological factors could explain this high receptivity within the sample: as mapped in the socio-demographic profile (Table 2), the sample is mainly composed of highly educated individuals (66.3% holding a university degree) and economically stable households (25.1% in the highest income bracket). Reflecting the social desirability bias established in environmental psychology literature, respondents frequently overestimate their willingness to participate in "green" initiatives to align with modern public norms and ecological expectations. However, since the beverage DRS has been operating in Hungary, the routine of storing and physically returning empty containers has already been normalized within everyday household management. Consumers do not perceive expansion as a completely unknown and dreadful burden, but rather as a logical, cross-industry extension of an existing infrastructural habit (Dempster et al., 2021; Konstantoglou et al., 2024; Martinho et al., 2024; Boros et al., 2021).

Complementary Descriptive Evaluation of Willingness

To further evaluate the authenticity of consumer openness, stated attitudes from the initial single-choice question it was compared with responses to a broader multi-option item presented later in the survey: “What would you personally be willing to do to reduce plastic packaging waste originating from cosmetics and beauty products?”. This checklist offered participants various actionable alternatives to reduce cosmetic plastic waste, including expanding the DRS alongside reuse and refill schemes.

The descriptive comparison showed that response patterns were consistent across the two questions (Figure 2). While 74.4% of respondents (n = 651) were theoretically open to the DRS extension when evaluated directly, 69.9% (n = 612) consistently selected the DRS extension when it appeared as one of various options on a waste reduction checklist. However, since the expansion of the DRS was added as a pre-defined option among the possible answers, and both questions were evaluated by the same participants within the same questionnaire, this result cannot be interpreted as independent confirmation, nor does it erase biases from social desirability, the question order, or common method variance. It provides supplementary

descriptive support for the finding that the participants in the sample consistently identify deposit-based collection as an option that encourages action.

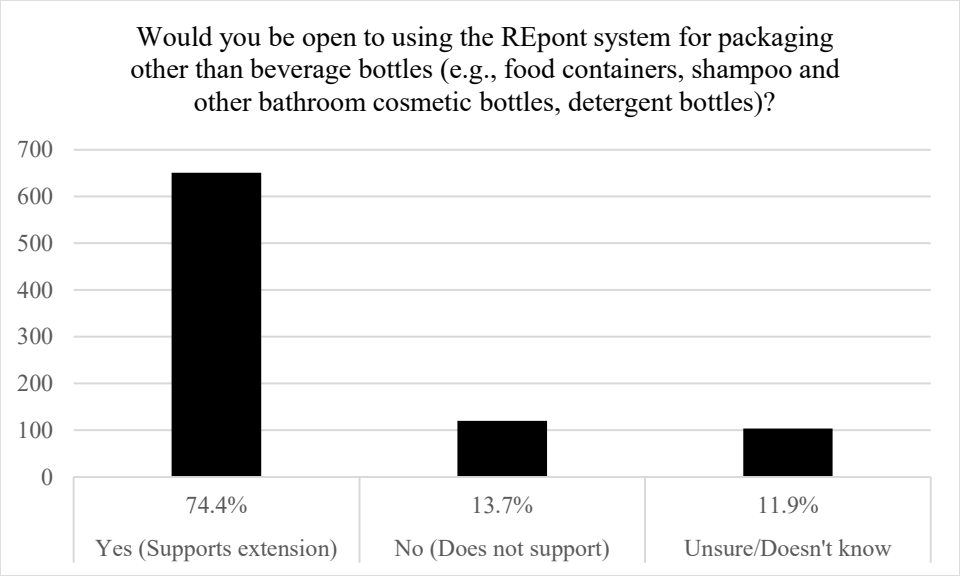


Figure 1 Consumer attitudes toward systemic DRS expansion. Response frequencies regarding the structural question: "Would you be open to using the REpont system for packaging other than beverage bottles (e.g., food containers, shampoo and other bathroom cosmetic bottles, detergent bottles)?" based on the finalized adult dataset
Source: Author's own primary dataset via LimeSurvey, N = 875; 2026

Furthermore, it should be noted that in-store refill stations were selected by a very high proportion of respondents (73.6%; n = 644) which numerically exceeds the selection rate for the deposit-return system (DRS) option (69.9%). This descriptive finding suggests that respondents do not view refill systems and deposit-return infrastructure as mutually exclusive; rather, they regard them as complementary solutions for the circular management of plastic packaging.

In summary, regarding the first research question (RQ1), the empirical results indicate a widespread and strong willingness among the sample; thus, the answer to RQ1 is positive. Based on the high level of acceptance observed for both aspects under examination, Hypothesis H1 is supported within this surveyed cohor

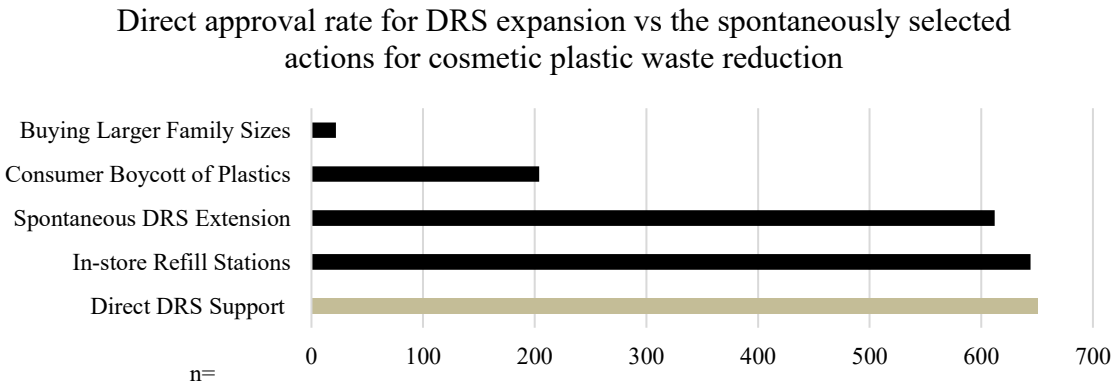


Figure 2 Complementary descriptive comparison of consumer attitudes toward DRS expansion: Comparison of stated willingness from the primary single-choice item (grey bar) with selections from the subsequent multi-option plastic reduction checklist (black bars), based on the finalized adult dataset. The checklist comparison provides complementary descriptive evidence and does not constitute an independent psychometric validation. *Source: Author's own primary dataset via LimeSurvey, N = 875; 2026.*

Based on the above results, RQ1 (Would consumers be willing to use the deposit-refund system currently operating in Hungary for extended product groups, specifically empty cosmetics packaging?) can be answered affirmatively for the surveyed cohort, with stated willingness reaching 74.4% among respondents.

Significance of formal and informal environmental education and training (RQ2 & H2)

To answer Research Question 2 (RQ2) and evaluate Hypothesis 2 (H2), Pearson's Chi-square tests of independence were performed to detect whether there was a relationship between environmental education across different stages of education and consumer willingness to support the expanded DRS framework specifically among respondents in this sample.

While the unadjusted bivariate test indicated a marginal association for secondary-school education (χ^2=6.87,df=2,p=0.0322) the effect size was negligible ("Cramér's " V=0.100). After adjusting for multiple testing across educational stages (using the Holm-Bonferroni correction), the association was no longer statistically significant (p_{adj} =0.0966). Environmental education during primary school, higher education, or adult workplace training similarly showed no statistically significant relationship with extension attitudes within this surveyed cohort (p>0.05).

Because these data rely on self-reports of past experiences from a non-probabilistic cross-sectional sample, potential recall bias prevents directional or causal developmental inferences. Given the lack of robust statistical significance and the minimal effect sizes, the empirical findings from this specific dataset do not support Hypothesis H2. Rather, stated willingness to adopt the DRS extension remained uniformly high across all educational backgrounds among the participants of this study, demonstrating that within this sample, openness toward system expansion exists independently of past formal environmental schooling. In light of the results, it seemed interesting to examine whether combined, cumulative configurations of educational milestones might reveal more pronounced patterns. Therefore, the respondents' profiles were categorized into educational trajectories (Figure 3). Descriptive analysis reveals observable differences between these groups (which were based on the respondents' self-reports), although the sample sizes vary significantly:

- Respondents reporting uninterrupted exposure across the whole spectrum: primary, secondary, higher education, and workplace exhibited the highest nominal support at 95.0% with zero active rejection; however, this group was very small within the sample (n = 40).

- Participants who received environmental education only in secondary school (also a small group of respondents: n =

35) showed 82.9% support, while those combining secondary with higher education (n = 115) demonstrated 82.6% support (with active opposition of 4.3%).

- In contrast, cohorts with training only in primary and secondary school (n = 104) or adulthood (higher education and workplace, n = 117) yielded support rates of 74.0% and 68.4%.

- Fragmented educational trajectories (e.g., primary school combined solely with adult workplace training, n = 57) showed the lowest support (66.7%) and higher active hesitation.

Overall, while the trends in this study suggest a somewhat higher level of stated openness among respondents who received broader environmental education, early environmental education did not prove to be a statistically significant predictor of system support after correcting for multiple comparisons. Consequently, the empirical data did not support Hypothesis H2 within this convenience sample.

Socio-demographic components of DRS extension willingness (RQ3 & H3, H4)

To test H3 (Gender matters in the issue of consumer attitude and women tend to be more enthusiastic and supportive regarding the expansion of DRS) and H4 (In alignment with international DRS literature, financial demographics (household income) do not act as a primary determinant of system support, as intrinsic environmental values consistently outweigh monetary or economic motivations) and answer RQ3 (Do socio-demographic background factors play a significant role in consumer attitudes and behavioral intentions regarding the extension of the deposit-refund system?), Pearson's chi-square (χ2) independence tests were conducted. The role of basic socio-demographic parameters was assessed to determine whether they influence consumers' attitudes towards the expansion of the deposit refund scheme. Based on the statistical outcomes, although the initial p-value indicated significance due to the large sample size, the negligible effect size (Cramér's V = 0.100) suggests that H3 is not robustly supported in practical terms. Instead, the results highlight that public support remains consistently high across all examined demographic groups.

Referring to the conclusions that were observed in the literature, this study result did not confirm what Yu described regarding the expansion of DRS: "The study found that support for and use of the system depended very strongly on age, gender, education and income" (Yu et al., 2025). In the present results, it was found that socio-demographic background factors do not play a primary or comprehensive role in shaping consumers' attitudes and intentions regarding the extension of the deposit system. However, Yu also described that "fully engaged consumers were typically older, more likely to be female, had lower incomes, were more likely to be inactive (e.g., retired or housewives), and more likely to live in single-family homes" (Yu et al., 2025). The observation was similar regarding gender in previous Hungarian surveys regarding socio-demographic correlations; according to the study, the

typical and most enthusiastic supporters of the system were highly educated, urban women (Boros et al., 2021).

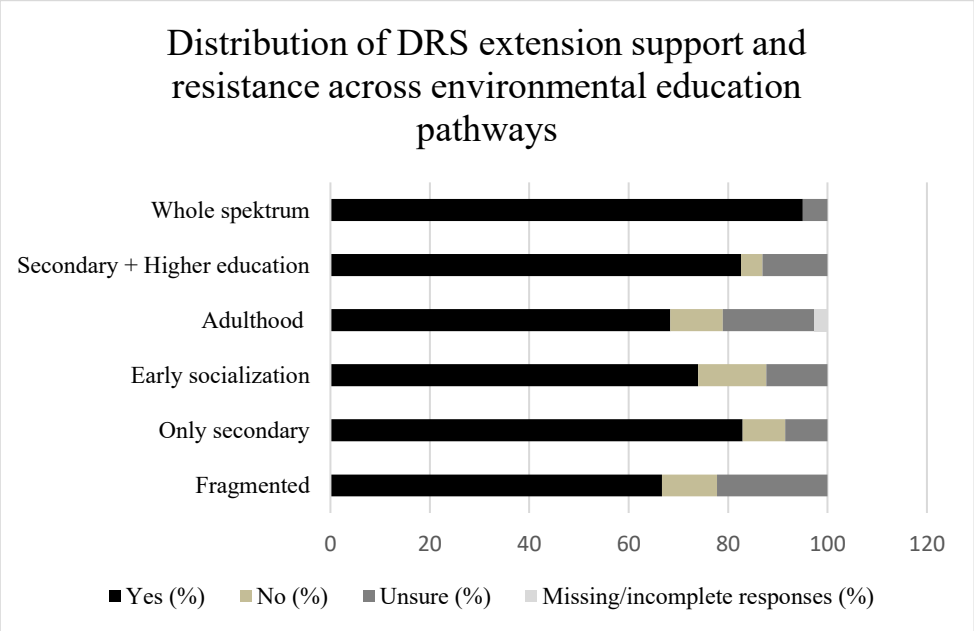


Figure 3 Descriptive distribution of DRS extension support across self-reported environmental education pathways. Subsample sizes across educational pathways: Whole spectrum (n=40); Secondary + Higher education (n=115); Adulthood (n=117); Early socialization (n=104); Only secondary (n=35); Fragmented (n=57). Distributions reflect descriptive observations within this specific convenience sample and should not be interpreted as causal developmental effects.

Author's own data collection via LimeSurvey, N=875; 2026

Among the five tested variables (gender, age, residence, education, income), only gender exerted a statistically significant influence on acceptance rates in the results (Table 3). However, Cramér's V still indicates a weak effect size, implying that while there is a statistically significant behavioral gap between male and female respondents, the divergence is minor and does not alter the overarching consumer consent in the studied sample. In contrast, none of the other socio-demographic factors examined in the sample (age, type of settlement, educational attainment, and income status) reached statistical significance ($p > 0.05$). This suggests that willingness to adopt the expanded DRS framework for cosmetic packaging remains consistently high and transcends generational, geographical, and economic boundaries (Table 3).

Table 3 Inferential statistical evaluation of socio-demographic variables against DRS extension willingness (valid adult sample sizes, $\alpha = 0.05$), Adjusted p-values (p_{adj}) were calculated using the Holm-Bonferroni procedure to control for multiple testing. Expected cell counts for all tables exceeded 5.

Demog-raphic Variable	n_{valid}	x^2	*df*	Raw p-value	Adjusted p-value (p_{adj})	Cramér's V	Interpretation
Gender	869	9.99	2	0.0068	0.034	0.100	Significant (weak)
Age	875	13.45	10	0.1994	0.5871	0.085	Non-significant
Residence	870	8.63	6	0.1957	0.5871	0.077	Non-significant
Education	870	3.94	4	0.4146	0.5871	0.077	Non-significant
Income	803	16.53	10	0.0854	0.3416	0.100	Non-significant

Source: Author's own primary dataset via LimeSurvey, N = 875; 2026.

Table 3b Contingency table of DRS extension willingness by gender ($n = 869$, undisclosed: $n = 6$). Percentages are calculated across rows based on valid responses ($n = 869$). A total of 6 respondents from the full adult sample ($N = 875$) did not disclose their gender and were excluded from this bivariate analysis.

Gender	Support (Yes)	Opposition (No)	Unsure	Total valid
Female	443 (76.5%)	61 (10.5%)	75 (13.0%)	579 (100.0%)
Male	203 (69.9%)	56 (19.2%)	31 (10.9%)	290 (100.0%)
Total	646 (74.3%)	117 (13.5%)	106 (12.2%)	869 (100.0%)

The complete cross-tabulation of gender and willingness to extend the DRS is given in Table 3b, so that the character and direction of the statistically significant association detected by the Chi-square test ($\chi 2 = 9.99$, df = 2, p = 0.0068) can be directly assessed. In this sample, the female respondents showed a higher level of active support and a lower level of active refusal than the male participants. This shows that women are slightly more enthusiastic and less resistant to extending the deposit-refund system; yet the effect size remains weak (Cramér's V = 0.100). In both groups, there are clear supermajorities in favor of extending the system (>70%), indicating a general agreement and not a significant socio-demographic divide. International literature from Greece, Portugal, Slovakia, Northern Ireland and Canada indicate that environmental attitudes are usually stronger in driving people's participation than the monetary value of the deposit. This is in part contradicted by Yu, who found that high income and high awareness do not always result in actual behavior: although the highest-income group was willing to pay the highest premium for green packaging, their lack of time (because of being actively employed) meant that their real, day-to-day redemption activity was less than had been expected (Yu et al., 2025). Since most of the literature shows similar findings, it was predicted that household income should not play a major role among the factors determining support for circular economy and sustainability systems, as intrinsic environmental values consistently exceed monetary motivations (H4).

The study revealed no associations that were practically significant between the various socio-demographic factors and consumers' attitudes as regards Research Question 3 (RQ3). Even though there was a statistically significant p-value for gender, the effect size was so small as to show only a negligible difference in practice. As a result, Hypothesis 3 (H3) could not be confirmed. Support from the public remains consistently high among all demographic groups. Among the different age groups, educational levels, types of residence, and income levels, there were no statistically significant differences in the acceptance of extending the deposit system.

The figures showing distribution by income group (Table 4) indicate that support for the theoretical position stayed at a high level (>73%) in every category. The inferential analysis revealed no statistically significant link between household income and support for extending the DRS. At first sight, this absence of difference is exactly in line with what was expected according to Hypothesis 4 (H4). Yet the fact that a null hypothesis is not rejected (that is, no difference is found) cannot be used to 'prove' or 'support' a hypothesis. Moreover, since the survey did not directly assess the underlying psychological factors by means of specific psychometric scales, the second part of H4 — that environmental values actively outweigh financial motivations — remains empirically unproven. Thus, although the behavioral data is in full agreement with the predictions of H4, the hypothesis itself cannot be officially confirmed.

Table 4 Descriptive distribution of DRS extension willingness across household income categories

Household Income category (EUR)	Support (Yes) (%)	Opposition (No) (%)	Unsure (%)
Below 702.5	74.50	12.70	12.80
702.5-1124	75.80	12.10	12.10
1124-1686	73.30	16.70	10.00
1686-2248	80.60	7.80	11.60
2248-2810	75.3	9.60	15.10
Above 2810	73.2	17.90	8.90

Source: Author's own primary dataset via LimeSurvey, N = 875; 2026

As for Research Question 3 (RQ3), the findings highlight that public support stays consistently high among all demographic groups, with no practical difference according to gender. Among the different age groups, educational levels, types of residence, and income subgroups, no statistically significant differences in the acceptance of extending the deposit system were found. With respect to the socio-demographic variables examined in relation to the willingness to expand the DRS, income status failed to show a statistically significant association, which means that Hypothesis H4 was not supported by the inferential analysis.

Perceived responsibility and distribution among market actors (RQ4, H5)

To answer Research Question 4 (RQ4) and evaluate Hypothesis 5 (H5), the survey examined how respondents distribute responsibility for improving the recycling rate of cosmetic packaging waste among four key structural actors: manufacturers, consumers, retailers, and the state/legislators. Because respondents could select multiple entities simultaneously, choices were statistically dependent, and Cochran's Q-test was conducted to evaluate overall differences in selection rates.

The global Cochran's Q-test indicated a statistically significant difference across the four actor categories ($Q = 467.56$, $df = 3$, $p < 0.001$). Post-hoc pairwise comparisons (McNemar tests with Holm-Bonferroni correction) confirmed that manufacturers were prioritized significantly more often (80.0%, $n = 699$) than all other actors (padj < 0.001). Individual consumers were ranked second (70.0%, $n = 611$), significantly exceeding both retailers (62.6%, $n = 548$, padj < 0.001) and the state/legislators (60.9%, $n = 533$, padj < 0.001), while the difference between retailers and the state was not statistically significant (padj = 0.448). These empirical patterns have direct implications for Hypothesis 5. H5 assumed that consumers would attribute significantly higher systemic responsibility to external market and state actors (producers and regulators) than to individual consumer behavior. However, because respondents placed individual consumers ahead of state/regulatory actors, H5 is not supported as originally formulated.

While the literature often portrayed blaming external actors as an indication of psychological self-serving bias (Hansmann & Steimer, 2015) the present findings point toward a shared, systemic responsibility rather than deflection of individual responsibility. Respondents identify the primary obligation of manufacturers in terms of product design and Extended Producer Responsibility, yet they acknowledge their own critical role as the second most crucial actor in circular waste management. According to the test results, these findings confirmed the Hansmann & Steimer, Birau & Faure, and Mielinger conclusions that consumers would demand shared responsibility rather than individual blame, and also confirmed the Mielinger findings that the participants feel that manufacturers should be obliged to assume greater responsibility, since, to the greatest extent, respondents placed the responsibility on manufacturers (Birau & Faure, 2018; Hansmann & Steimer, 2017; Mielinger & Weinrich, 2024). However, a surprising result was also obtained: as much as some of the literature examples and the preliminary expectations suggested, the respondents did not move away from responsibility, with the consumers group coming in second place, with 70% of participants also identifying themselves as responsible for the increase in recycling rates. This explicitly contradicts the statements of the research that focus on what defensive reactions consumer-blaming triggers in consumers in the area of plastic waste reduction (and thus recycling) (Mayer & Kohl, 2024). Concluding that people would use justifications to resolve the contradiction between their environmentally conscious principles and their actual, environmentally neglectful behavior would be clearly wrong and misleading for this study.

Summarizing the answers to research question RQ4, respondents primarily consider manufacturers (80%) to be the main economic actor responsible for increasing the recycling rate of packaging waste. Based on the statistical analysis, the psychological attribution bias assumed in hypothesis H5 can be partially confirmed, but in a much more nuanced form than expected. Although respondents clearly attribute the greatest systemic responsibility to external market actors (manufacturers), which aligns with the logic of self-serving bias, they also acknowledge their prominent individual role by ranking themselves second. The transfer of responsibility is therefore not complete: respondents view the challenges of the circular economy as a shared, systemic obligation, in which they consider manufacturers the primary catalyst, but also see themselves as active and responsible shapers, especially in comparison with the state and retailers.

Comparative Analysis of DRS and Alternative Waste Management Strategies

There are many other practices to prevent plastic waste from ending up in illegal landfills or in marine and aquatic life. The most extensive of these is municipal and separate collection. Examinations of the collection of light packaging waste reveal that, in some cases, it resulted in very low participation and the collected material tends to be too contaminated, which is why councils in some urban areas have stopped separate collection from the public and have instead switched to mechanical recovery from mixed municipal waste (Lubello et al., 2025; Thoden Van Velzen et al., n.d.). Also, street collection systems (where residents have to take their own waste to the collection point but get nothing in return) often only achieve a low selective collection rate of around 35% (Gadaleta et al., 2022). In contrast, it has been presented that a deposit system will increase recovery rates tremendously (Table 1), first due to the motivational factor of the deposit fee, and later due to the power of habit formation. Numerical data based on life cycle analyses also show that waste management in a DRS system significantly reduces the environmental footprint and greenhouse gas emissions of PET bottles: the

introduction of a DRS reduces the environmental burden in the categories of global warming, acidification, eutrophication and human toxicity by 30-40% compared to the traditional extended producer responsibility (EPR - door-to-door selective) system (Sevigné et al., n.d.).

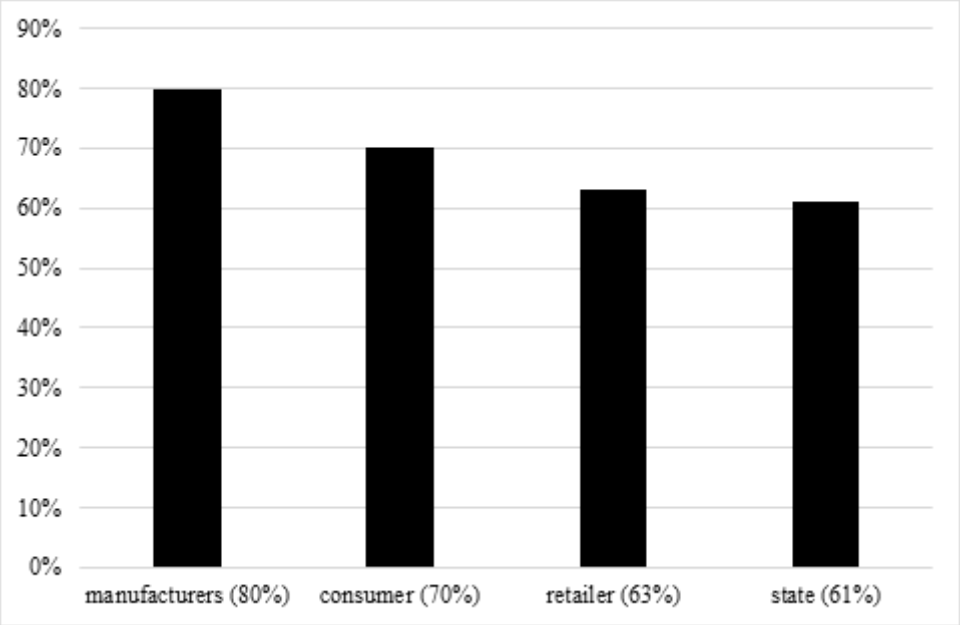


Figure 4 Public perception of circular economy responsibility according to individual structural actors (N = 875; percentage values show the percentage of marking for the given category)

Source: Author's own data collection via LimeSurvey, N = 875; 2026.

Earlier research warns that simply maximizing the rate of selective collection does not always lead to environmental benefits: it was shown that the extreme increase in the collection rate of PET bottles was accompanied by an exponential decrease in the purity of the collected material, as well as its global warming-reducing benefits (Haupt et al., 2018). This also supports the establishment of a dedicated deposit system, since the subsequent phases of the waste management system will already be prepared for the specific contamination that occurs there, and the collected waste will certainly not be contaminated with other waste, e.g. food waste. The effectiveness could be increased by modern recycling plants, which use automated, high-efficiency industrial washing processes, such as hot alkaline washing, to effectively remove stubborn residues from cosmetic packaging. These washing systems are integrated with on-site wastewater treatment plants designed to neutralize chemical ingredients before discharge (Gkika et al., 2022).

Refillable packaging is also a model that fits into the circular economy, in which case we can talk about reuse rather than recycling, significantly increasing the life cycle of product packaging (Kröhnert & Stucki, 2021). Because refillable packaging is typically made of less rigid material than its traditional, single-use counterparts, it is easier to transport and has a smaller environmental footprint, and it uses less material and energy to manufacture (Barreto et al., 2025; Keoleian & Spitzley, 1999). However, since they are also made of plastic, their positive environmental impact is far from being enough to solve the underlying problem. The overall environmental footprint of shampoo originally sold in a plastic bottle can be reduced by about 10% if the refill dispensers are sold in a plastic stand-up pouch, and the original bottle is used once, not infinitely refillable (Tasaki & Yamakawa, 2011).

Regulation (EU) 2024/40 of the European Parliament and of the Council of 19 December 2024 on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC. Official Journal of the European Union. (European Parliament & of the European Union, 2025). The market reception of them, however, is controversial, and its challenges affect both consumers and supermarket chains (Kröhnert & Stucki, 2021). The refill system requires completely different logistics from the traditional one and requires a significant behavioral change on the part of consumers (Coelho et al., 2020; Kunamaneni et al., 2019). The most frequently identified problems with packaging-free stores also affect beauty and hygiene products: it requires more effort from customers; they have to look for packaging-free stores, they have to change their shopping habits significantly, and they have to plan ahead and choose

from fewer products (Beitzen-Heineke et al., 2017; Marken & Hörisch, 2019). Eco-design solutions like refillable options still bring a lot of questions: for a product to be reused (e.g. refilled) by the consumer, the packaging must be robust and durable. If the focus of eco-design is on dematerialization (material reduction and thinning), the packaging will become more fragile, which will degrade or make reusability impossible (Gatt & Refalo, 2022).

There is no effective, widespread omnipotent alternative to traditional petrochemical plastic packaging in the cosmetics industry, and no system can adequately replace plastic bottles, yet. Overall, this document is not intended to criticize other methods, but to demonstrate that DRS is the most effective, measurable waste management circular method and should be applied in conjunction with other sustainability elements, as each addresses different problems.

Currently, no functional international precedent exists for integrating cosmetic packaging into a mandatory national DRS. Furthermore, the material complexity of cosmetic packaging—featuring harder plastics, multi-polymer laminates, internal metal components, and viscous chemical residues—makes it physically unsuited for processing through existing automated reverse vending machines (RVMs). For the time being, households are collecting these materials in recycling bins and are currently managed through standard municipal selective waste systems with existing sorting technologies, achieving higher material purity through a DRS expansion might necessitate adapted, manual, or alternative in-store collection methods. Psychologically, the high theoretical enthusiasm measured in this survey was anchored in familiarity with existing infrastructure. Whether this enthusiasm would translate into sustained action if consumers had to adapt to a modified collection routine is a critical question. To empirically address this, ongoing longitudinal research—observing actual household collection behaviors over extended periods—is currently being conducted to determine if consumers would participate as consistently as they do with beverage containers.

6. Conclusion

The aim of the research was to use a questionnaire to gauge respondents' openness to extending the deposit-return system (DRS) currently operating in Hungary to packaging types beyond beverage containers. The results showed a compelling 74.4% level of theoretical support among respondents, and the answers indicated that this was not motivated solely by the recovery of the deposit fee. Although the first analysis of socio-demographic data showed a statistical difference between women and men based on their responses, the practical effect size was negligible. Consequently, the sample of respondents shows no significant practical differences based on gender, age, place of residence, educational background, or income, but openness to DRS expansion remains consistently high across demographic groups. This finding contradicts earlier literature, which attaches great importance to the role of early formal education in shaping willingness and openness regarding sustainability-related issues and shows a slight statistical shift towards women.

The research findings aim to contribute to shaping the future of the circular economy. Based on their responses, participants in the study are aware of their own responsibility in increasing return rates. Although 80% identified manufacturers as the primary party responsible, 70% of respondents also identified themselves (the consumers) as economic actors bearing responsibility.

This research was based on self-reported data from a convenience sample rather than on actual observed behavioral patterns. These theoretical responses regarding system usage do not, in themselves, provide any indication as to the technological or logistical feasibility of a theoretical expanded DRS.

Future research should aim for more practical assessments to confirm or refute the actual realization of theoretical openness and willingness, while also incorporating longitudinal behavioral observations and examining technical feasibility. It is necessary to identify the challenges of collecting packaging beyond beverage bottles, considering practical perspectives from both consumer and waste management aspects (e.g., cleaning, sorting, and processing).

Overall, the expansion of the DRS could be a promising tool for decision-makers seeking to broaden circular economy elements within the current waste management infrastructure in order to achieve return targets.

Disclosure of AI use:

The author, being a non-native English speaker, used Gemini 1.5 Pro (an AI-assisted editing tool by Google) to translate the initial draft from Hungarian to English and to improve the English phrasing of the entire manuscript. After subsequent revisions, we carefully reduced the overall proportion of AI-assisted phrasing.

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Conflict of Interest Statement:

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

Ethics Statement:

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The research design, data collection protocol, and full questionnaire instrument were reviewed and approved by the Institutional Ethics Committee of the Hungarian University of Agriculture and Life Sciences (MATE). The

study involved voluntary, anonymous consumer feedback, ensuring strict confidentiality without collecting identifiable personal, clinical, or biological data.

The anonymized survey dataset, codebooks, and the reproducible R scripts utilized for the descriptive, Chi-square, and Cochran's Q analyses are available from the corresponding author upon request. The complete bilingual survey questionnaire is provided in Supplementary Material_Questionnaire_HU_EN.

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