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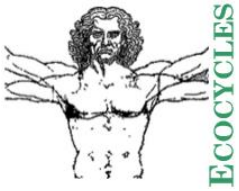

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RESEARCH ARTICLE

From Expectations to Experience: Consumer Perceptions and Behaviour in the First Year of Hungary's Deposit-Refund System

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Abstract – The Deposit-Refund System (DRS) was introduced in Hungary in 2024 as a new element of the country's waste management framework to strengthen circular economy objectives. Before the system implementation, consumer attitudes and expectations were explored in a large-scale survey conducted by Szűcs et al. (2024), which identified both promising support and considerable concerns regarding the system's economic, environmental, and practical implications. Building on this earlier research present study looks at the first year of the Hungarian DRS operation and focuses on how consumers experienced the system compared to their earlier expectations. Based on a nationwide reach consumer survey (N = 527) conducted in mid-2025, reveals that 96.6% of the respondents used the system at least once, and over 75% expressed positive or neutral experience. Overall environmental motivation and general understanding of the system were strong. However, technical problems such as machine malfunctions (reported by 72.7% of respondents) and practical issues (like limited storage space at home) still cause difficulties. Interestingly, respondents with higher environmental awareness tended to evaluate the system more positively, even when they encountered these problems. Although acceptance of the DRS has grown in some groups, ongoing challenges related to convenience, infrastructure, and communication continue to influence overall satisfaction. By comparing preliminary attitudes with implementation experiences, this study provides a systematic evaluation of the DRS's first-year performance and offers evidence-based insights for policymakers, system operators, and stakeholders to improve effectiveness and public trust in long term.

Keywords – Deposit-Refund System, circular economy, consumer behaviour, Hungary, recycling

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1. INTRODUCTION

In the 21st century sustainable development has become a defining framework for environmental and economic policy. Agenda for Sustainable Development by the United Nations provides a global roadmap for achieving environmental, social, and economic balance. SDG 12 of UN SDGs – Responsible Consumption and Production – addresses the problem and challenges of waste generation and resource efficiency. One of its specific sub-goals (12.5) calls for significant waste reduction by 2030 through prevention, reduction, recycling, and reuse (United Nations, 2015; European Commission, 2023).

In Europe, these global commitments have been translated into ambitious policy frameworks, such as the EU Circular Economy Action Plan (European Commission, 2020), which sets serious targets for packaging waste collection and recycling. A key driver has been the Single-Use Plastics (SUP) Directive (2019/904/EU), which requires Member States to ensure that by 2025, at least 77% of plastic beverage bottles are separately collected, increasing to 90% by 2029. Furthermore, it mandates that PET beverage bottles contain a minimum of 25% recycled content by 2025, and 30% by 2030. The latest Europe-wide estimates (2022) indicate a ~60% PET bottle collection rate and an average ~24% recycled content in beverage bottles, while PET beverage bottles sorted for recycling are estimated at ~75%. (Eunomia, 2020; PETCORE Europe). DRS mechanism has thus become a strategic instrument for EU Member States to comply with binding collection targets under the SUP Directive.

Despite those commitments, the packaging industry continues to grow rapidly. Market analyses estimate that the

global packaging sector will reach a value of 1.3–1.4 trillion USD by 2029, with annual growth rates of around 4% (Packaging Market Report, 2023). There is a quite strong increase in the amount of single-use beverage bottles, which takes most of the packaging waste stream. In 2023, around 3.3 billion beverage containers were placed on the Hungarian market, about 90% of which were single-use products. This corresponds to roughly 158,000 tons of bottles (Tamásné Szabó, 2023). At the EU level, market estimates suggest that approximately 85 billion single-use plastic beverage bottles are sold each year, equivalent to about 408,000 tons. The tonnage figures are calculated using average bottle weight to convert units into mass. Under the EU Packaging and Packaging Waste Directive, Member States are required to recycle at least 50% of plastic packaging waste by 2025 and 55% by 2030 (European Commission, Directive 94/62/EC as amended by Directive (EU) 2018/852). These targets also apply to Hungary however, the latest data indicate that the plastic packaging recycling rate stood at approximately 42% at the EU average, compared to around 23% in Hungary (Eurostat, Packaging waste statistics).

To address these challenges, European policymakers have increasingly turned to Deposit-Refund Systems (DRS) as a proven tool for achieving high return rates for beverage packaging. Refillable packaging, such as beer or soft drink bottles, has long demonstrated its environmental advantages e.g.: a reusable glass bottle can be refilled up to 40 times, resulting in up to 60 times lower environmental impact, compared to the single-use ones (Horváth & Stipta, 2007). By incentivizing consumers to return beverage bottles, DRS schemes are aligned both with EU targets and with broader social needs for more sustainable production and consumption patterns.

In line with these developments on 1 January 2024 Hungary introduced its own national DRS, including PET, metal, and glass beverage bottles. The aim of the system is not only to fit to EU obligations (European Commission, 2020) but also to modernize national waste management practices, reduce waste generation and littering, and increase recycling efficiency (MOHU, 2024). While international evidence points to great success (Eunomia, 2020), the actual effectiveness of the Hungarian DRS depends largely on consumer acceptance, infrastructure readiness, and the ability to handle pre-existing concerns (Szűcs et al., 2024).

Based on these processes, my article examines the early-stage implementation of the Hungarian Deposit-Refund System, with a special focus on consumer detection, behavioral responses, and early operational experiences during the first year of operation. By combining empirical consumer survey data with contextual analysis of the system design, the study aims to assess whether the Hungarian DRS is meeting its intended objectives and to identify key drivers and barriers influencing its effectiveness in practice within Hungary.
A recent article by Szűcs et al. (2025) provides a comprehensive evaluation of Hungarian consumer reactions to the deposit-refund system one year after its implementation. While their work documents changes in attitudes and perceived inconveniences, the present study adopts a complementary and analytically distinct approach. Rather than focusing on overall approval levels, this manuscript aims to explain why certain consumers adapt to the DRS while others remain dissatisfied or disengaged. Using ordinal logistic regression and qualitative thematic analysis of open-ended responses, I identify the key drivers and barriers shaping effective participation and interpret the Hungarian case as a policy-relevant example for countries introducing DRS under similar institutional and infrastructural conditions.

By moving from description to explanation and by explicitly addressing transferability, this study advances the existing literature beyond the available one-year follow-up evidence.

2. LITERATURE REVIEW

2.1 Plastic waste generation

In recent decades, global waste generation has increased rapidly, driven by urbanization, population growth, and the expansion of consumer-oriented economies (Kaza et al., 2018). According to the World Bank (2018; updated projections) the expected growth of global municipal solid waste from 2.24 billion tons in 2020 will be nearly 3.88 billion tons by 2050 if current trends continue. This rapid escalation means significant environmental, economic, and social challenges, particularly in relation to run-down of resources, greenhouse gas emissions, and the degradation of terrestrial and marine ecosystems.

Among the different waste streams, plastic waste has emerged as one of the most critical environmental concerns (UNEP, 2018). Since the invention of synthetic polymers in the early twentieth century, plastics have revolutionized industrial production due to their low cost, durability, and versatility (Andrady & Neal, 2009). However, these very properties have turned plastics into a persistent environmental threat: globally, only about 9% of all plastic ever produced has been recycled, while the majority has accumulated in landfills, been incinerated, or leaked into natural environments (Geyer et al., 2017). Plastic debris in oceans and waterways has consequently become a symbol of the "throwaway society," with severe implications for biodiversity and food chains (UNEP, 2021).

Packaging, and particularly single-use plastic packaging, represents the largest share of plastic waste (UNEP, 2018). Beverage bottles, caps, and similar packaging materials are regularly among the most commonly collected items in global waste-related surveys and clean-up efforts, including international coastal and river litter monitoring programs (Ocean Conservancy, 2022; Jambeck et al., 2015). Their widespread consumption, short lifespan, and improper disposal contribute significantly to environmental pollution. As a result, policymakers have increasingly recognized the need for targeted interventions in this area, ranging from bans on certain single-use products to systemic approaches that incentivize collection and recycling (European Commission, 2019).

2.2 Deposit-Refund Systems: Concept and International Experience

Deposit-Refund Systems (DRS) for beverage containers have been in use for several decades, with early forms introduced from 1980s onwards starting with countries such as Sweden, where the deposit system for beverage containers was implemented in 1984 (Lindhqvist, 2000; European Commission, 2020). In such systems, consumer pays deposit when purchasing a beverage, which is refunded once the empty container is returned to a designated collection point. The financial incentive encourages return behavior, hereby increasing collection rates and supporting high-quality recycling.

The effectiveness of Deposit-Refund system has been proven international. Countries such as Norway, Germany, and Lithuania have achieved return rates over 90%, creating closed-loop systems where bottles are recycled into new packaging (European Commission, 2020; Reloop, 2021). In Norway the introduction of DRS has resulted as one of the highest collection rates worldwide, with PET bottles and aluminum cans returned at rates above 95% in the 1990s (Infinitum, 2022). Similarly, Germany's system, established in 2003, has become a benchmark for Europe, covering a wide range of beverage types and successfully integrating reverse vending machines into retail environments (German Environment Agency, 2021). Lithuania introduced its DRS in 2016. As a result they increased the return rate from 34% to 92% within just two years (USAD, 2018), demonstrating the rapid impact such systems can achieve when well-designed.

Beyond Europe, countries such as Canada and certain U.S. states have long-standing deposit schemes, though with varying levels of success depending on deposit size, system coverage, and implementation (OECD, 2022; Container Recycling Institute, 2020). Growing of DRS worldwide reflects both its proven environmental benefits and its alignment with the principles of the circular economy, especially the transition from linear "take-make-dispose" models to resource-efficient, closed-loop systems.

2.3 The Hungarian Deposit Refund System

In January 2024 Hungary introduced its national Deposit-Refund System, joining the group of European countries committed to modernizing waste management practices through economic instruments. Hungarian DRS covers a wide range of beverage containers, including PET bottles, aluminum cans, and glass bottles, with unified deposits applied across product categories (European Commission, 2024; MOHU, 2024)

Policy initiation was motivated by several interrelated goals:

- increasing collection and recycling rates in line with EU directives,
- reducing littering and plastic pollution, and
- aligning national practices with the EU's Circular Economy Action Plan.

The DRS operates as part of Hungary's extended producer responsibility (EPR) framework, under a national concession model managed by MOHU MOL Waste Management Ltd., the concession company responsible for integrated waste management across the country. Infrastructure includes reverse vending machines placed in supermarkets, as well as manual return options in smaller retail outlets.

Despite thorough preparations, the rollout of the Hungarian DRS encountered significant technical and social challenges. Setting up the necessary return infrastructure proved complex, as thousands of reverse vending machines (branded as "REpont" automated return machines) had to be installed in supermarkets and other retail locations. Although the DRS has been officially introduced on 1 January 2024, the obligation for full market participation was postponed until 1 July 2024 following requests submitted by beverage producers for an extended preparation period, as reflected in the transitional provisions of the relevant government decree (Government Decree No. 450/2023 (X. 4.).

As with other countries, the Hungarian case illustrates that the success of DRS depends not only on regulatory design and infrastructure but also on consumer adaptation and acceptance. It is crucial to understand how hungarian consumers perceive and use the system after its first year of operation for evaluating its effectiveness.

2.4 Precondition: supportive consumer behaviour

The role of consumers is essential to the success of any DRS, as high return rates can only be achieved if individuals are willing to participate actively. Research has shown (Thøgersen, 2003) that participation is influenced not only by the economic incentive of the deposit but also by broader attitudinal factors, such as environmental awareness, trust in the waste management system, and perceptions of convenience.

International studies indicate that while deposits create strong behavioral nudges, the long-term sustainability of DRS participation depends on consumer satisfaction and the extent to which the system is seamlessly integrated into everyday routines (Thøgersen, 2003; OECD, 2016; European Commission, 2020). In Norway and Germany, for example, convenience and accessibility enabled by the widespread availability of reverse vending machines are consistently cited as key factors behind high return rates (Infinitum, 2022; German Environment Agency, 2021). In contrast, lower-performing systems often suffer from insufficient infrastructure, unclear communication, or public skepticism, which undermines consumer engagement and return behaviour (OECD, 2022; Reloop, 2021).

Beyond incentives and convenience, several studies emphasize the role of environmental knowledge in shaping pro-environmental behaviour. Liobikienė and Poškus (2019), extending the Value–Belief–Norm framework, demonstrate that action-oriented environmental knowledge plays a distinct role in strengthening both private-sphere behaviors, such as recycling, and broader public-sphere engagement. Their results show that understanding what happens exactly with the returned materials can reinforce pro-environmental attitudes and support people participation in environmental programs.

Before the introduction of the DRS in Hungary, Szűcs et al. (2024) conducted a large national survey to examine

consumer attitudes. Their results showed cautious optimism: many respondents acknowledged the potential environmental benefits of the system, but concerns were raised about convenience, possible cost effects, and the clarity of the communication about the system. These mixed views provided a useful starting point for later evaluating how the system is experienced in practice.

Examining the alignment - or misalignment - between pre-implementation attitudes and the first-year experiences provides an opportunity to better understand the social dynamics of the Hungarian DRS. It also highlights how existing concerns are being handled, how effective the communication strategy is and how consumer trust and behaviour change during the early stages of a major policy intervention.

3. METHODOLOGY

This study was conducted in Hungary using a self-administered online questionnaire distributed via Google Forms link. The aim of the survey was to explore consumer expectations and early experiences related to the Deposit-Refund System introduced under Government Decree 450/2023. Respondents were explicitly informed that the survey focused on the usage and user experience of Deposit-Refund System introduced in 2024.

Data collection took place between June and September 2025 through non-probability voluntary response sampling. The survey was disseminated via social media platforms (e.g., Facebook community groups) and professional mailing lists targeting individuals interested in sustainability, waste management, and public policy. The questionnaire was open to all Hungarian residents aged 18 and above. No pre-screening or registration was required; participation was anonymous and voluntary. In total, 527 valid responses were collected, representing a wide range of demographic and geographic segments.

The questionnaire consisted of 5 thematic blocks, including:

- Likert-scale questions (1–5) measuring perceptions, attitudes, and experiences with the DRS,
- Multiple-response items identifying perceived barriers,
- Yes/No questions assessing awareness and participation, and
- Open-ended questions capturing qualitative feedback on individual motivations and difficulties.

The structure and content of the questionnaire were informed by previous DRS-related studies (e.g., Szűcs et al., 2024; Eunomia, 2020), behavioral frameworks (Thøgersen, 2003), and guidelines on circular economy public engagement.

Quantitative data were analyzed using SPSS 28.0. Descriptive statistics (means, standard deviations) and inferential tests (Chi-square, Spearman's correlation, and ordinal logistic regression) were applied. For the qualitative responses, thematic clustering was performed manually. AI support (OpenAI Chat GPT 5.2) was used for exploratory categorization, ensuring human oversight and validation throughout. It is important to mention that ChatGPT 5.2 was not used to write text or generate tables but to count the open-ended question responses and categorize into the sufficient response category. AI could more quickly and efficiently do the classification. At most of the multiple-choice question I left "other" choice with the possibility to explain. The reason is that I would like to avoid missing a point of view, a barrier with people faces, I did not want to limit the choices to strictly.

No personal or sensitive data were collected. Respondents were informed about the purpose of the research, the anonymous nature of data collection, and their right to withdraw at any time prior to submitting the survey. Given the non-invasive, anonymous, and observational nature of the study, formal ethical approval was not required under Hungarian research ethics guidelines.

4. RESULTS

4.1 Sample Characteristics

The final dataset comprised 527 respondents and reflects a broad socio-demographic range in terms of age, education, settlement type, and regional distribution (Table 1). At the same time, certain groups are overrepresented in the sample, most notably women, respondents with higher educational attainment, and residents of larger urban areas, particularly in Central Hungary. These patterns suggest that while the survey captures diverse perspectives across population segments, the results should be interpreted with due consideration of these sample imbalances.

Table 1. Socio-demographic characteristics of the sample (N = 527)

Variable	Category	n	%*
Gender	Female	336	63.8
	Male	191	36.2
Age group	Under 18	4	0.8
	18–30 years	98	18.6
	31–64 years	363	68.9
	65 years and above	62	11.8

Education level	Primary	19	3.6
	Vocational	77	14.6
	Secondary / Graduation	148	28.1
	Higher education (BA/MA/PhD)	283	53.7
Settlement type	Village	73	13.9
	Community	67	12.7
	Small town	91	17.3
	Medium city	85	16.1
	Big city	210	39.8
Region	Western Hungary	170	32.3
	Central Hungary	277	52.6
	Eastern Hungary	80	15.1
Housing type	Detached house	318	60.3
	Apartment building	209	39.7

**Totals may vary slightly due to rounding.*

Overall, the sample composition offers a balanced and heterogeneous foundation for analyzing consumer experiences and attitudes toward the DRS after its first year of operation.

While the survey does not claim national representativeness, it provides a reliable and demographically comprehensive dataset for exploring behavioral and attitudinal patterns among Hungarian consumers.

4.2 Awareness and Behavioral Patterns

After the first year's operation the deposit refund system reached an exceptionally high level with the benefits of the system and the high participation rate. 98.9% of the respondents were aware of the system's introduction in 2024, indicating that the system's obligation and the extensive media communication effectively reached consumers nationwide.

Almost all participants (96.6%) reported that they had already returned beverage bottles at least once, indicating that the system is widespread and integrated into everyday consumer routines. Regarding frequency, most respondents indicated regular return activity, with 33.0% returning every two to three weeks, 30.7% weekly, and 27.1% monthly, the pattern illustrated in Figure 1. Only a small share reported infrequent or no returns (4.6% a few times per year; 2.7% never). These figures suggest that DRS participation has become a habitual behaviour among most of Hungarian consumers.

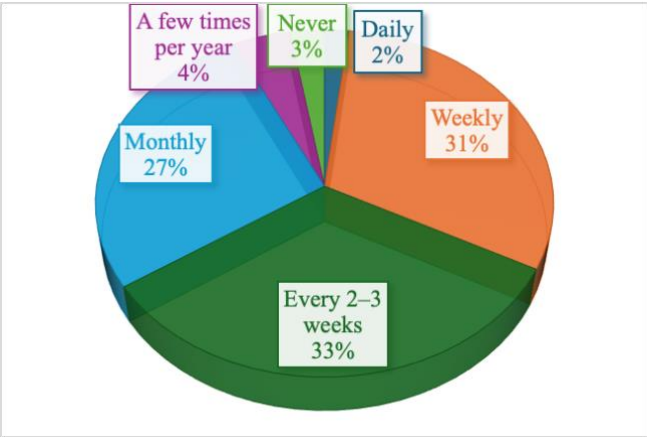

Figure 1. Return Frequency of Beverage Bottles under the Hungarian DRS (N = 527)
Source: Authors' own research, 2025

Perceptions of clarity and process understanding were overwhelmingly positive: 82.2% of respondents rated the return process as very clear (score 5 on a 5-point scale), while only a small minority (7.4%) found it moderately or slightly unclear. This indicates strong user comprehension of system rules and procedures, which is a critical element of sustained participation.

As shown in Figure 2, most of the respondents reported that they experienced at least one problem when using the DRS. While a smaller but significant share reported no difficulties, only a negligible proportion of participants had not used the system yet. This pattern suggests that although the DRS has achieved widespread uptake, operational and user-experience challenges are common during the early phase of implementation.

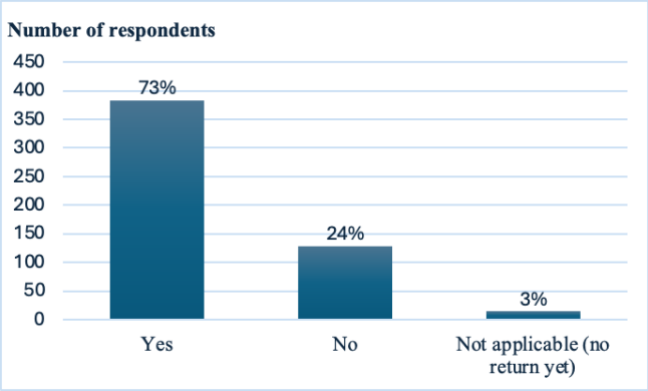

Figure 2. Experienced Problems in the Hungarian DRS (N = 527)
Source: Authors' own research, 2025

Accessibility is generally favorable: 51.0% of respondents reported having a RePont within 1–5 km of their home, and 34.0% within just a few hundred meters. Only 15% of respondents live more than 5 km from the nearest RePont. This coverage shows that the density of infrastructure is adequate, however respondents living in smaller settlements may still face limited convenience service (e.g.: no reverse vending machine, only manual return is available).

Overall, data show near-universal awareness, widespread participation, and strong commitment of the Hungarian DRS. Despite technical and logistical challenges which were also reported by some respondents the system quickly gained public acceptance and integration into everyday waste management practices in the first year of implementation.

4.3 Attitudes and Motivations

Beyond awareness and participation, understanding the underlying motivations and attitudes of consumers provides valuable insight into the long-term sustainability of the Hungarian Deposit-Refund System (DRS).

Understanding the motivations and attitudes behind consumer participation in the Hungarian Deposit-Refund System (DRS) is critical for its long-term success. In line with established behavioral frameworks, which emphasize that participation in environmental programmes is shaped by a combination of economic incentives, perceived convenience, trust, and environmental consciousness (Ajzen, 1991; Thøgersen, 2003), analysis identified three core components influencing actual behaviour: financial incentives, perceived convenience, and environmental values.

When asked about the motivating power of the 50 HUF deposit refund, respondents reported a high level of agreement, with an average score of 4.15 on a five-point Likert scale, indicating that the financial incentive functions as a strong behavioral trigger. As illustrated in Figure 3, the financial refund emerged as the chief motivation for participating in the DRS: fully 50% of respondents indicated that receiving 50 HUF per container was their primary reason for returning bottles. Environmental motives followed, with around 42% citing their desire to contribute to the circular economy and protect the environment. Other reasons — including "doing something good," the novelty of the vending machine, or not having returned bottles yet — accounted collectively for less than 8% of responses. These findings confirm that while pro-environmental values are present, the refund value remains the most potent behavioral driver.

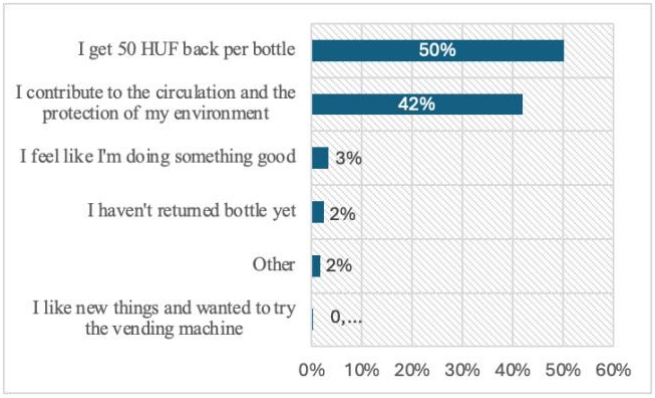

Figure 3. Main reason for bottle return (single-choice, N = 527)
Source: Authors' own research, 2025

At the same time, qualitative comments frequently referred to environmental considerations, suggesting that economic incentives often reinforce existing pro-environmental motivations rather than acting in isolation.

Perceived convenience also emerged as an important factor shaping participation. Respondents generally reported that returning beverage containers had become easier and that the system was clear to use, with an average score of 4.28 on the five-point scale, which can be interpreted as a strong positive evaluation. Although 72.7% of respondents indicated that they had experienced technical problems at least once, this did not appear to undermine engagement, as regular return behaviour remained prevalent. This coexistence of reported difficulties and continued use suggests the development of habitual return practices.

Environmental attitudes proved to be particularly strong among respondents. The importance of environmental protection received an average score of 4.53 on the five-point scale, representing the highest value among the examined motivational dimensions and indicating a pronounced pro-environmental orientation within the sample.

Environmental knowledge was assessed with a factual control question regarding the fate of returned beverage packaging. Large majority of respondents (89.8%) correctly identified that bottles are recycled as a new beverage packaging, demonstrating a high level of understanding of the circular logic of the DRS. However, a smaller share of respondents believed that bottles are incinerated (5.7%) or disposed of as mixed municipal waste (4.7%), indicating that some misconceptions exist despite the overall high level of awareness.

Beyond individual motivations, social influences were also evident. Several respondents reported that family members or peers either set an example or participated jointly in returning bottles, pointing to the role of social norms in reinforcing DRS-related behaviour. This pattern is consistent with evidence that social norms strengthen pro-environmental intentions, especially when recycling is visible and socially discussed (Liobikienė & Poškus, 2019).

4.4 Comparison of Pre-Implementation Expectations and Implementation Experiences

Before the introduction of the Hungarian Deposit-Refund System (DRS), consumer expectations were characterized by a high level of anticipated inconvenience. In the nationwide pre-implementation survey conducted by Szűcs et al. (2024,p. 104.), 39.1% of respondents agreed that the system would "cause a lot of serious discomfort to me." This concern appeared to be a general concern rather than tied to specific operational features, since the system was not yet in operation and respondents formed their views based on assumptions, media communication, or comparisons with previous selective waste collection schemes.

Present study provides an additional post-implementation assessment of expectation – experience alignment. Instead of hypothetical attitudes, respondents were asked to identify which concrete factors currently make bottle return difficult (multiple response, N = 527). The results indicate that inconvenience is indeed present, but its form has shifted from abstract anticipation to specific, experience-based barriers as illustrated in Figure 4.

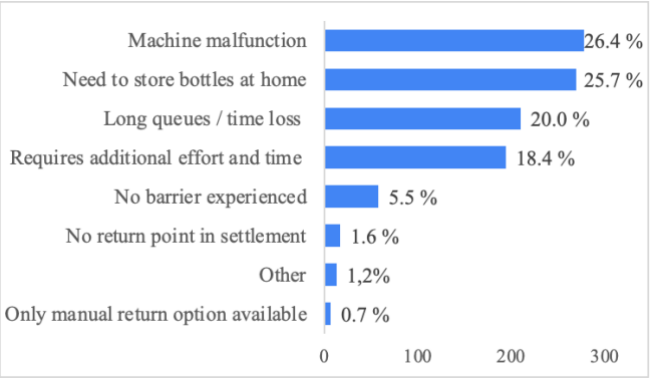

Figure 4. Most Frequently Reported Barriers to Bottle Return (Multiple Response, N = 527)

Note. Percentages exceed 100% because multiple responses were allowed.

Source: Authors' own research, 2025

The results reveal that while consumers initially anticipated major inconvenience, real-life experiences proved more favorable. The main issues cited were machine malfunction (26.4%), limited household storage (25.7%), and queuing (20.0%), suggesting that perceived barriers are specific rather than systemwide.

It is important to note that these barriers did not discourage participation: 96.6% of respondents used the system at least once, and many of them do so regularly. In fact, more than half (53.3%) rated the system positively (4 or 5 on a 5-point scale), exceeding the 28.6% who expressed negative opinions. This indicates that although the inconveniences exist, they do not outweigh the perceived benefits.

Open-ended responses highlighted additional concerns from experience. These included difficulties of using public transport with returnable bottles and if machine does not work it is tragic to carry them home, the frustration with full or malfunctioning machines, and hygiene problems at return points. In addition, several users reported confusion and lack of information about the returnability of multi-way bottles.

Although a minority of respondents (1.24%), mention these insights, they suggest the need for better communication, machine maintenance, and on-site management. These key areas, beyond technical efficiency, are important for improving user satisfaction.

Respondents were asked whether the return process had become easier, more difficult or remained the same since 2024. The aim was to assess whether the introduction of the mandatory deposit system had improved the perceived convenience of returning bottles. As shown in Figure 5, the sample is almost evenly divided between those who perceive improvement (42%) and those who experience no substantial change (40%). A smaller, but notable group (18%) reported that the return process has become more inconvenient compared to previous waste-collection practices.

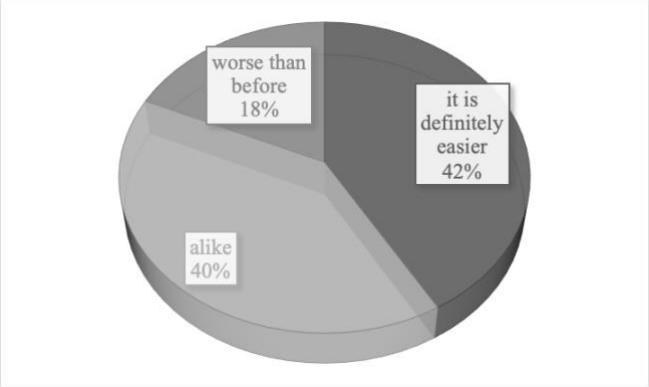

Figure 5. Change in the ease of return process since the system launched

Source: Authors' own research, 2025

While many consumers perceive the system as easier to use, nearly as many feel no change, highlighting that convenience remains uneven and context-specific. The 18% who report a worse experience typically cite technical or logistical issues such as machine faults or storage challenges.

4.5 Attitude - Experience Relationship

4.5.1 Geographical differences

A chi-square test was conducted to examine whether the perceived change in convenience ("ease of return") differs across settlement types.

Although descriptive patterns suggest variation between groups, the association was not statistically significant (χ^2 =

9.38, df = 10, p = .497), indicating that *the perceived usability of the DRS is not strongly determined by where respondents live*.
However, the distribution still reveals meaningful directional tendencies as shown in Figure 6.

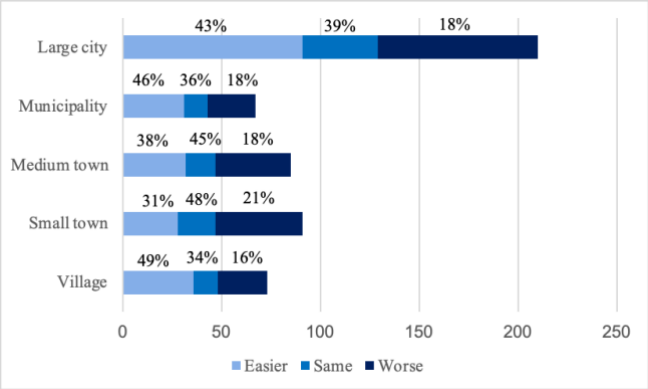

Figure 6. Association Between Perceived Ease of Return and Settlement Type (Chi-Square Test Results, N = 527)
Source: Authors' own research, 2025

Three observations stand out:

1. Villages and municipalities show the highest proportion of users reporting that the system has become easier (≈46–49%), which may reflect lower baseline expectations or fewer pre-existing selective collection routines.
2. Small and medium-sized towns show the highest share of "unchanged" responses, indicating neither clear improvement nor deterioration.
3. The proportion of users reporting that the system became worse is relatively stable across all settlement types (≈16–21%), meaning dissatisfaction is *not location-specific*, but likely driven by other factors (e.g., machine malfunction, queueing, storage space at home).

This supports the need for the further analysis: whether barrier type, rather than geographical context, explains negative experience.

4.5.2 Relationship between Environmental Concern and Positive Experience

To assess whether environmental attitudes influence how positively respondents evaluate the introduction of the deposit-refund system, a chi-square test was first conducted between the variables *environmental importance* (1–5 scale) and *positive experience* (1–5 scale). The association was statistically significant ($\chi^2 = 92.81$, df = 16, $p < .001$), indicating that the perceived value of the system is not random, but varies systematically with respondents' level of environmental concern.

As shown in Table 2, a clear positive trend can be observed: higher levels of environmental concern are associated with an increasing likelihood of evaluating the system more positively.

Table 2. Crosstabulation between environmental importance and positive experience

			Positive experience					Total
			1	2	3	4	5	
Environment importance	1	Count	4	0	2	0	0	6
		% within Environment importance	66.7%	0.0%	33.3%	0.0%	0.0%	100.0%
	2	Count	3	2	0	0	0	5
		% within Environment importance	60.0%	40.0%	0.0%	0.0%	0.0%	100.0%
	3	Count	22	12	11	4	8	57
		% within Environment importance	38.6%	21.1%	19.3%	7.0%	14.0%	100.0%
	4	Count	27	14	28	23	23	115
		% within Environment importance	23.5%	12.2%	24.3%	20.0%	20.0%	100.0%
	5	Count	49	17	55	59	163	343
		% within Environment importance	14.3%	5.0%	16.0%	17.2%	47.5%	100.0%
Total		Count	105	45	96	86	194	526
		% within Environment importance	20.0%	8.6%	18.3%	16.3%	36.9%	100.0%

Source: Authors' own research, 2025

To verify the relationship beyond categorical comparison, a Spearman rank-order correlation was performed. Results confirmed a moderate, positive, and highly significant association between the two variables ($\rho = .359$, $p < .001$, $N = 526$), meaning that higher environmental concern is reliably associated with more favorable system perception.

Those who perceive environmental protection as a personal priority are significantly more likely to evaluate the system positively, even when practical barriers exist. This aligns with prior research suggesting that *intrinsic pro-environmental motivation increases willingness to participate in circular consumption systems* (Szűcs et al., 2024).

4.5.3 Relationship between barriers and overall user experience with DRS

To further explore what shapes the public perception of the deposit-refund system, a series of chi-square tests have been used to examine the relationship between specific perceived barriers and positive overall experience. Each barrier was coded as a binary dummy variable (1 = barrier present, 0 = no barrier), as shown in Table 3.

Table 3. Bivariate Associations Between Barrier Types and Positive Experience

Barrier variable	χ^2 (df = 4)	p-value	Relationship direction
"Extra effort/time required"	64.95	< .001	Negative
"Takes up space at home"	73.25	< .001	Negative
"Long queues at reverse vending machines"	29.11	< .001	Negative
"Machine malfunction / full"	36.11	< .001	Negative
"Only manual return option available"	1.77	.778	Not significant
"No return point in the settlement"	6.73	.151	Not significant
"No barrier experienced"	34.00	< .001	Positive
"Other barrier (open-ended)"	—	—	Qualitative only

Source: Authors' own research, 2025

A clear pattern emerged: users who faced practical challenges—such as extra effort, lack of home storage, queues, or machine faults—were significantly less likely to report a positive experience ($p < .001$ in each case). In contrast, those reporting no barriers were more satisfied ($\chi^2 = 34.00$, $p < .001$). Structural issues like the absence of nearby return points or only manual return options showed no significant effect.

Open-ended qualitative responses provided important contextual insights. Several respondents highlighted mobility-related and infrastructural challenges, for example:
"Public transport makes it cumbersome; I can only carry a few bottles at a time."
"There aren't enough bins for non-returnable bottles."
"There's no built-in RVM nearby for reusable bottles."

These comments highlight that accessibility and convenience are key to user satisfaction and point to the need for improvements.

In summary, these results suggest the presence of a reinforcing feedback mechanism between perceived barriers and overall system experience. Respondents entering with negative expectations are more sensitive to practical inconveniences, which in turn amplifies the perceived impact of barriers and reduces overall satisfaction. In such cases, barriers not only prohibit usage but may also depress deeper engagement with the system.

A similar positive dynamic is also visible. Participants who are already engaged with the system—often due to stronger environmental values or previous positive experiences—are less likely to see minor problems as serious barriers. As a result, small operational issues tend to have a limited impact once bottle return has become a normal part of everyday life.

These patterns highlight the importance of minimizing operational barriers within the DRS. By reducing practical inconveniences such as machine malfunctions, queuing, or storage constraints, the system can not only improve the experience for already committed users but also help neutralize negative preconceptions among more skeptical consumers. A smoother user experience therefore plays a critical role in converting initial reluctance into sustained participation.

4.5.4 Ordinal logistic regression: predicting experience from perceived barriers

To assess how perceived barriers impact the overall experience with the Deposit-Refund System, an ordinal logistic regression was conducted using the 5-point

experience scale as the dependent variable. Seven barrier types were entered as dummy -coded predictors.
The model was statistically significant compared to the intercept-only baseline (χ^2 = 128.81, df = 7, p < .001), indicating that the inclusion of the barrier variables substantially improved the explanatory power of the model. Goodness-of-fit indices confirmed model adequacy (Pearson $\chi^2(137)$ = 143.68, p = .331; Deviance $\chi^2(137)$ = 141.35, p = .382), and pseudo R^2 values (Cox & Snell = .217, Nagelkerke = .228, McFadden = .081) reflected a moderate effect size, consistent with behavioral studies on perceived usability and satisfaction.
Table 4. presents the regression coefficients (B), Wald statistics, significance levels, and interpretation of each predictor. Positive B values reflect a decrease in the odds of reporting a more positive experience when the given barrier is present.

Table 4. Ordinal Logistic Regression Results: Predicting User Experience Based on Perceived Barriers (N=527, 5-point scale)

Predictor	*B*	*Wald*	*Sig.*	*Effect*
extra effort/time	.902	26.31	< .001	Significant negative effect
storage, extra space needed	1.137	34.20	< .001	Significant negative effect
long queue	.400	4.82	.028	Significant negative effect
machine malfunction/full	.471	6.63	.010	Significant negative effect
manual return only	.277	.29	.590	Not significant
no return point nearby	.227	.44	.507	Not significant
no barrier experienced	–.151	.19	.660	Not significant when controlli for others

Source: Authors' own research, 2025

Results show that four out of seven barriers significantly and independently predict a less positive user experience. The strongest predictors were the storage (B = 1.137, p < .001) and effort/time (B = 0.902, p < .001) barriers, confirming that logistical inconveniences (e.g. home storage, return trip planning) play a decisive role. Machine issues and queues also had significant but smaller negative effects. By contrast, structural barriers (e.g.: lack of nearby return points) were not significant, when other factors were controlled, indicating that daily usability challenges matter more than infrastructural limitations.

In summary, the more effort, time and discomfort the system requires from customers, the less positively users evaluate the system. These findings are consistent with prior behavioral models emphasizing perceived cost and effort as key determinants of engagement (Ajzen, 1991; Davis, 1989; Thøgersen, 2003).

5. DISCUSSION

Results shows that environmental attitudes and recycling-related knowledge play a critical role in how consumers experience the Hungarian Deposit-Refund System. It is important to note that these effects are exerted not only directly, but also through consumers' prior expectations of the system. Individuals who enter the DRS with positive expectations interpret operational difficulties as manageable frictions rather than crucial obstacles. Inner motivation reduces the feeling of discomfort and negative opinion about the system.
In contrast, respondents who were initially skeptical or doubtful about the system appeared more sensitive to practical obstacles. For them storage constrains, machine malfunctions, or the additional time required to returns often reinforced their earlier concerns and translated into lower overall satisfaction. This helps explain why users facing similar operational conditions can be nonetheless evaluate the system very differently.

These patterns are in line with earlier Hungarian findings. Szűcs et al. (2024) reported that environmentally conscious consumers will more likely to continue returning bottles despite infrastructural shortcomings. International studies likewise indicate that environmental concern consistently ranks among the strongest drivers of DRS participation, typically alongside to financial incentives. Where convenience is imperfect, intrinsic motivation often becomes the stabilizing factor.

From theoretical perspective, the results are consistent with the Value–Belief–Norm (VBN) framework (Stern et al., 1999), which theorizes that individuals with strong environmental values and beliefs develop internalized moral norms that guide pro-environmental behaviour. In the present case, these internalized norms appear to shape not only behaviour, but also expectations and post-implementation evaluations of the system. Moreover, the role of recycling-related knowledge suggests that informed

consumers are better able to align their expectations with the actual functioning of the DRS. Understanding the circular fate of returned bottles appears to enhance confidence in the system and strengthens long-term commitment, even in the presence of minor operational barriers.

The analysis of perceived barriers further highlights the importance of user experience in shaping acceptance of the DRS. Practical inconveniences (particularly related to time, effort, and household storage) significantly reduced positive system evaluations. However, users who did not experience barriers were significantly more satisfied, indicating the presence of strengthening feedback mechanisms. Where barriers are frequent and prominent, negative expectations may be confirmed and reinforced; where the system operates smoothly, positive experiences may reinforce commitment and enhance participation.

Taken together, these results submit the existence of both negative and positive behavioral feedback loops. Negative expectations can amplify the perceived impact of barriers and discourage sustained use, while positive expectations and early favorable experiences can neutralize minor frictions and support habitual behaviour. This highlights the importance of minimizing operational problems within DRS. Improving machine reliability, reducing queues, and solving storage-related constraints can not only increase satisfaction among already committed users, but can also help convince skeptical consumers by demonstrating that the system works smoothly in practice.

5.1 International relevance

This Hungarian case study could provide useful lesson for countries who are also planning to implement deposit-refund systems to meet EU targets. Presented results show that user satisfaction is primarily shaped by everyday conflicts -such as extra time and effort is required for returns, home storage limitations, queuing, and the reliability of RVMs- rather than a lack of knowledge or understanding of the system.
These findings align with international experiences where consumer engagement and system usability have proven crucial to the success of DRS implementation. For example, Slovakia introduced a DRS in 2022 and reported a return rate exceeding 70% in the first year, supported by strong infrastructure and communication (Ministerstvo životného prostredia SR, 2023). Similarly, Germany has consistently maintained return rates above 90% due to a well-established and mandatory system (UBA, 2022). Norway's DRS is widely cited as a benchmark, achieving return rates of around 95%, with high levels of public trust and industry cooperation (Infinitum, 2021). Compared to these cases, the Hungarian system's initial results—while promising—still face challenges related to convenience, trust, and clarity of processes. Cross-country comparison highlights the importance of long-term stability and transparency in fostering system loyalty and overcoming initial resistance.

5.2 Transferability and contextual limits

The Hungarian results should be interpreted considering the institutional specificities. The system combines a uniform deposit value for single-use beverage packaging with a network of retail take-back and recycling points operating based on a centralized concession model. The RePoints are operated by the concession company through an operating fee paid to the commercial units. The stores are interested in operating the Re-Points because they attract purchasing power (if you can return your bottle in the given store, you are more likely to buy there).
While issues such as time, effort, and storage are likely relevant in many return-to-retail systems, the magnitude of these effects may differ in other institutional settings. Depot-based models, systems with lower return-point density, different deposit levels, or alternative governance structures may generate different user experiences. For this reason, the Hungarian case is best understood as an analytically informative example rather than as a universally representative model. It offers insight into how consumers adapt to a newly introduced DRS within a particular regulatory and infrastructural context.

5.3 Limitations

Several limitations should be considered when interpreting these findings. The online, self-administered questionnaire may have introduced selection bias, potentially attracting respondents who are more digitally active or environmentally engaged than the general population. Although the sample includes diverse socio-demographic groups, it cannot be regarded as nationally representative.

In addition, self-reported measures are inherently susceptible to social desirability effects, particularly in relation to environmental attitudes. As a result, expressed concern may not fully correspond to actual behaviour.

While ordinal logistic regression was appropriate for modeling predictors of user satisfaction, other statistical methods might explore underlying causal relationships in greater depth. Moreover, the lack of directly comparable, post-implementation consumer data from other countries limited the extent of international contextualization. Nonetheless, relevant international examples were referenced in the discussion to benchmark the Hungarian experience. Future studies should consider larger, probabilistic samples and harmonized comparative designs across national DRS implementations.

6. CONCLUSIONS

The introduction of Hungary's Deposit-Refund System has characterized by a generally positive consumer attitude. Participation appears to be motivated not only by financial incentives, but also by environmental concerns and perceptions of usability. Although practical barriers – such as limited storage space or occasional machine breakdowns – affect the user experience, they do not appear to

fundamentally undermine the willingness to take back bottles.

The analysis highlights the importance of everyday convenience. Time- and space-related constraints were associated with less positive system evaluations, confirming that accessibility and smooth day-to-day functioning matter for sustained engagement. At the same time, respondents with stronger environmental concern and more accurate knowledge about recycling tended to evaluate the system more positively, even when they encountered minor operational difficulties. This suggests that intrinsic motivation can partially offset practical inconvenience.

Environmental awareness remains a notable feature of the Hungarian case. Most respondents demonstrated a clear understanding of the closed-loop recycling objective, and environmental protection was frequently described as part of everyday decision-making. Misconceptions about the fate of returned bottles were present, but they were not widespread, indicating that communication efforts have reached a large proportion of users.

Early phase of implementation shows a clear learning-by-doing dynamic**.** Returning is becoming increasingly integrated into our daily routines, while operational performance has improved as the system developing. This learning process helps to explain why participation levels are relatively high despite the reported friction. Rather than a static arrangement, DRS appears to operate as a system that evolves through use and adaptation.

Operational monitoring data also supports the conclusion above. By January 2025, more than one billion beverage bottles had been returned via RePont reverse vending machines. According to data reported by the system operator (MOHU RVM treacability, 2025) average, approximately 100 bottles are returned every second, while around 22 machines reach a “full bin” status every minute, reflecting rapid public uptake and high system throughput. By December 2024, the national return rate had reached 75.3%**,** an impressive outcome given that the DRS became fully operational only in June 2024 following the industry grace period.

Beyond collection volumes, the closed-loop structure of the system ensures a consistently high-quality material stream. According to waste sorting facility experts, DRS system doubled the amount of beverage packaging collected in a ready to recycle form as it is completely separated from the municipal waste stream and provides a clean and pre-sorted input with significantly reduced contamination. This can provide a solid foundation for a highly recyclable material stream and significantly advance Hungary's circular economy goals.

From regulatory and system design perspective findings point to a clear priority: making participation as simple, easy, and seamless as possible. Minimizing everyday barriers will help the efficient system operation and generate positive experiences—even for users who were initially skeptical. Persistent operational issues help reinforce negative expectations and restrain deeper engagement. Therefore, targeted efforts are essential to break down barriers - such as improving machine reliability, reducing queues, and resolving in-house storage issues - in order to strengthen user engagement.

In terms of practical implications, the study highlights clear directions for system improvement: regular machine maintenance, clearer communication on returnable packaging, and improved support in densely populated or underserved areas could substantially enhance user satisfaction. These insights are valuable for policymakers and operators working on fine-tuning the DRS in its early phase.

Theoretically, this research contributes to the limited literature on DRS implementation in Central and Eastern Europe. It offers empirical evidence on how economic and behavioral factors interact in a post-launch context and illustrates how perceived barriers translate into differentiated levels of user satisfaction. As such, the findings provide a useful framework for analyzing similar circular economy interventions.

Internationally, the study adds to the growing body of knowledge by providing comparative insights into how DRS schemes are perceived by users in their initial phase. While systems in Norway and Germany have long reached high return rates, Slovakia’s more recent implementation shows parallels with the Hungarian experience - suggesting that user education, infrastructure readiness, and transparent communication are recurring pillars of success.

For the near future and development strategy, an important question is what would be needed to increase return rates to over 90%, as already achieved by leading European DRS systems. The evidence suggests that financial incentives alone will not drive further progress. Instead, continuous operational refinement, systematic barrier reduction, and reinforcement of positive user experiences will be key. Comparative European analyses may provide valuable insights into how early success can be translated into consistently high performance.

The early performance of the Hungarian DRS shows strong and promising signs. If current trends are reinforced through adaptive management, barrier-focused improvements, and sustained communication, the system has the potential not only to meet regulatory targets but to evolve into a highly effective, socially embedded, and widely accepted pillar of Hungary’s circular economy.

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