# 35E00400 - Coordination of Supply Chains

## “Deposit Refund Systems as an incentive for consumer participation in E-commerce circularity”

Course Project – Group 8


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## Foreword

This paper discusses the theoretical potential of establishing a Deposit Refund System (DRS) for the e-commerce industry, analyzing the critical assumptions and pre-requisites of such an endeavor, and making general recommendation based on the research. There exists an observable trend towards circular supply chains across industries, and the authors’ fundamental assumption in this project is that DRS’, regardless of their executor, is a holistically beneficial solution to leverage that trend. Therefore, also considering the scale of this novel idea, this paper presents an exploratory ‘pilot study’ on the topic, and deliberately does not attempt to synthesize a monetizable idea or a business plan explicitly, but rather contribute grounds for expanded future research in the area. With that caveat, the intended audience for the paper should be SC practitioners and academics in general, policymakers, and the current circular SC ecosystem of non-profits/governmental organizations.

### Table of Contents

## Abbreviations

SC – Supply Chain

SCM – Supply Chain Management

E-com – E-commerce

CE – Circular Economy

DRS – Deposit Refund System

EPR – Extended Producer Responsibility

FMCG – Fast Moving Consumer Goods

CAGR – Compound Annual Growth Rate

EU – European Union

EC – European Commission

PPWR - Packaging and Packaging Waste Regulation

RVM – Reverse-Vending Machine

PALPA – Suomen Palautuspakkaus Oy

# 1. Introduction

Today the global e-commerce industry is a multibillion dollar one, estimated to be over $4trillion in 2024, with over 14% annual CAGR for the following years. The continental Europe e-commerce market accounts for roughly a fifth of this, with an estimated $633billion revenue for 2024, albeit with a slightly lower, 9% CAGR (Statista, 2024; Statista, 2023). This trend presents a sustainability issue well recognized in the industry; Increase in packaging-waste directly from increased volumes. E-commerce SC's have made significant efforts to mitigate this issue, as a cost-saving procedure and as a sustainability move. The public demand for environmentally sustainable products and supply chains, with complementary legislative pressures are directing the industry to seek efforts to minimize this waste.

One major aspect of this effort, both from industry and legislature -side is the implementation of Circular Economies to both product and packaging. Analysis of the largest e-com retailers in Europe (excluding FMCG and Electronics) shows that the industry is already acting on this with significant investments and internal operational overhauls (Table 1.). All of these companies are actively engaging in strategic implementation and seeking out innovations to have their businesses be 'Circular'. This is arguably the primary result of soon-to-be-approved EU legislation that stipulates strict rules for packaging materials; 5%, 10%, 15% reduction in overall packaging volumes by 2030, 2035, 2040, respectively, maximum 50% empty space ratio for grouped, transport and e-commerce packages, a mandate for manufacturers and importers to minimize the weight and volume of packaging, requirement of 100% recyclable packages, and minimum targets for recycled materials as portion of each package and for recycling of any waste generated. (European Parlament, 2024a; European Parlament, 2024b) The current measures of the industry seem to align with these regulations. It is notable however, that only three of the six major companies discussed reusable packaging, and only as a very tertiary goal. The general ambition of the industry seems to be to conform to whatever legislation is ahead of them, while only monitoring more advanced solutions and innovations. Inditex and Next were the only ones who brought up in any relevance return-infrastructure for their packaging.

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| Reporting from selected companies | Mentions CE as a Corporate Goal | Mentions CE as a Sustainability Goal | Specifies Recycled packaging materials for CE Goals | Specifies Reused packaging materials for CE Goals | Has a corporate partnership program, or equivalent, for CE- or Packaging solutions | Packaging Materials as proportion of COGS | Packaging Material cost | COGS | Fulfillment | |
|---|---|---|---|---|---|---|---|---|---|---|
| Amazon | No | Yes | Yes | No | No, but partners with gov-/non-gov organisations, focused on recyclable packages. | - | - | € 304 739 000 | € 90 619 000 | NOTE: 11% of deliveries are on 'Ships In Own Packaging' (SIOC), where the item is delivered in manufacturers packaging, shifting the responsibility. |
| H&M | Yes | Yes | Yes | No | Yes, 'The Laboratory', 'New Growth & Ventures', 'Green Bond'* | - | - | € 11 513 900 | - | * A €500mil issued bond which proceeds are allocated to sustainability projects. |
| Inditex | No | Yes | Yes | Yes, see page 245 of Inditex AR 2023 | Yes, 'Sustainability Innovation Hub', also a lot of external collaboration | - | - | € 15 186 000 | - | |
| Next | No | Yes | Yes | Yes, see page 100 of Annual Report/page 25 of Sustainability Report | No, but partners with gov-/non-gov organisations, focused on recyclable packages. | 60 % | € 2 113 640 | € 3 545 120 | - | NOTE: Packaging Cost Includes transport costs as well, as per Financial Statements |
| ASOS | No | Yes | Yes | No | No, but partners with gov-/non-gov organisations, focused on recyclable packages. | - | - | € 2 306 000 | - | |
| Zalando | No | Yes | Yes | Yes | No, but partners with gov-/non-gov organisations, focused on recyclable packages. | - | - | € 6 212 000 | € 2 458 000 | |

*Table. 1. Selected largest e-com retailers in Europe. Companies' key ambitions regarding Circular Economies and packaging solutions specifically. Despite the lack of accurate cost data on packaging, every company has stated development goals and demand for solutions on this area, acknowledging the regulatory and sustainability demand to innovate the industry practices regarding this. (ASOS, 2021; ASOS, 2023; Amazon, 2023; Amazon, 2022; H&M, 2023; Inditex, 2023; Next, 2023; Next, 2022; Zalando, 2023; Zalando, 2023)*

Based on this analysis, an assumption of a development timeline can be made; The endgame for policymakers is to reach the absolute minimum of generated waste in the EU (and UK), this is done by tightening regulations, which e-commerce companies have to follow (Extended Producer Responsibility). Ultimate expression of this endgame being that there is (close to) 0% virgin materials in circulation of packaging materials, with cost-optimised systems for the reverse-logistics and handling of these materials. In this scenario however, even legislation would not be (reliably) able to force the individual consumer to participate, in order to guarantee no material is discarded from the cycle. Corporations can be forced to do this, but infringing on the individual is less simple. Novel incentive-solutions need to be implemented to make the consumer want to inject the package they receive back into circulation. As Coelho, et al. (2020, p.9) put it: "For the general public, the 'feel-good factor' is not enough, and hence a financial incentive [underscore added] may be important to change consumers to switch to a [new] system."

## 2. Research Problem

The relatively nascent literature on Extended Producer Responsibility (EPR) as a force of policy seems to concur that the most elegant (yet pricy) solution to ensuring consumer engagement in circularity is a Deposit Return System/Scheme (DRS). (Deprez, 2016; Gupt & Sahay, 2015; Lai, Kuah, Kim, & Wong, 2022; OECD, 2022; Walls, 2011)

> As described by Walls, 2011*: "A deposit-refund system combines a tax on product consumption with a rebate when the product or its packaging is returned for recycling. Deposit-refunds are used for beverage containers, [and various other items]. --- By imposing an up-front fee on consumption and subsidizing "green" inputs and mitigation activities, a deposit-refund may be able to efficiently control pollution in much the same way as a Pigovian tax. Theoretical models have shown that alternative waste disposal policies, such as virgin materials taxes, advance disposal fees, recycled content standards, and recycling subsidies are inferior to a deposit-refund. --- the deposit-refund continues to have much to recommend it as a component of an overall socially optimal set of policies."*

There does not exist (to our knowledge) explicit literature on this topic in the context of e-commerce. (Excluding products covered in the DRS literature, coincidentally sold through electronic channels of e.g. Beverages, gas containers.) From Supply Chain literature this solution is implicated however, as novel applications of reverse-logistics to enable the use of reusable packaging identify customer engagement as a key variable to maintain that reverse-flow (Carrasco, et al., 2012; Lai, et al., 2022). Coelho, et al., 2020, discuss the economics of reusable packaging and even mention in passing: "Return rates vary between different systems and are positively affected by deposit fee systems." (p. 5)

As these trends in literature and aforementioned industry- and legislature signals suggest, there is a DRS shaped hole in the e-commerce industry. Hence the question becomes; How to best adapt a system like that for this multi-trillion dollar market?

# 3. Solution – Deposit Refund System for reusable e-commerce packaging

## a) Assumptions – EU mandates on reusable packaging

The issue of packaging waste has become a critical problem leading to the need of legislative action to mitigate it. The Packaging and Packaging Waste Regulation (PPWR), presented in 2022 with a general approach agreed in 2023 (Council of the European Union, 2023 & European Parliament, 2024), is expected to be adopted by the end of 2024, with implementation starting in 2025 (Krahl, 2024). Addressing the mounting packaging waste in the EU, where each European produces approximately half a kilogram of waste daily (European Green Deal: Putting an end to wasteful packaging, 2022), the PPWR aims to 1) prevent packaging waste generation, 2) ensure all EU market packaging is recyclable by 2030, and 3) increase recycled plastic use in packaging (Plastics, 2024). It also sets clear directives for biobased, biodegradable, and compostable plastics, setting responsibility schemes for packaging producers by 2024 (Packaging waste, 2024).

Along with the PPWR, the EU Plastic Strategy initiated in 2018, imposes strict requirements for plastic packaging, mandating that all packaging must be reusable or recyclable, effectively ruling out non-recyclable single-use materials. Under EPR, producers of plastic packaging and focal companies utilizing the packaging are held accountable for the entire lifecycle of their products, including collection, recycling, and disposal. This means that companies that produce plastic packaging are legally obligated to manage and finance the collection and recycling of their products.

Consequently, companies will need to switch to either reusable or recyclable packaging alternatives. Companies are already responding to this pressure by cutting their carbon footprint, reducing packaging, and constantly looking for cost-effective, environmentally friendly options. However, one of the critical questions for e-commerce companies is why they should opt for reusable packaging when recyclable packaging also meets regulatory requirements. The answer lies in two main factors: the EU's push towards a circular economy and the potential for cost optimization and packaging reduction for ecommerce companies.

Firstly, the EU's circular economy agenda emphasizes the need to keep materials in use for as long as possible to minimize waste generation. The proposed circular economy action plan has packaging sector as one of the focus industry for impplementing circular economy (Circular economy action plan, 2020). This means regulations are likely to evolve to not just focus on recyclability of materials but also encourage the design of reusable packaging and the use of recycled content in new packaging. This inherently supports the shift towards reusable packaging solutions.

Secondly, the cost of managing recyclable packaging from production to end-of-life under the EPR framework is quite significant. Ensuring that recyclable packaging is collected, processed, and effectively recycled can be costly for companies considering the logistics cost involved in the process. In contrast, although initially more expensive, reusable packaging can offer long-term savings if an efficient return and reuse system is implemented for the focal company.

However, currently the cost analysis will be positive for reusable packaging only if the reverse logistics for the package return is streamlined. For example, in 2022, the European Federation of Corrugated Board Manufacturers (FEFCO) conducted a study comparing recyclable and reusable packaging across the e-commerce value chain. They concluded that recycled materials are generally more sustainable than reusable ones unless key factors, such as return rates, the physical durability of materials, and the establishment of a coordinated system to redistribute containers, are improved to enhance the efficiency of reusable packaging (Recyclable Vs Reusable Packaging Project | Fefco, n.d.).

One major challenge for reusable packaging to be more sustainable is ensuring high return rates. A low return rate can lead to shortages, requiring the production of new items and potentially increasing emissions. However, if a streamlined return system is in place, reusable packaging can significantly reduce overall packaging costs and environmental impact.

McKinsey in an article (Gruenewald et al., 2023) also highlighted that pressure from both EU regulations and consumers is driving companies to adopt reusable packaging solutions, such as polypropylene boxes, which offer high reusability and reduced costs compared to traditional corrugated boxes. The success of this transition however relies on solving the reverse logistics problem, ensuring that reusable containers are efficiently collected, cleaned, and redistributed.

Considering all these factors and the strict EU regulations that are being put in place, we believe that in the upcoming years solving the critical question of “how might we increase the return rate of packages from customers” will be crucial for all major ecommerce companies.

## b. Alternative models for customer incentivization

Recognizing that the success of the solution hinges on maximizing the return rate of packages, three existing models for encouraging customers to return reusable packages were assessed. While some e-commerce pilots have achieved return rates of over 80% for reusable packaging without financial incentives (Tchibo, 2020), we anticipate that once reusable packaging becomes standard and mandatory for all companies, sustainability and goodwill alone may not sufficiently motivate the average person to prioritize returning a package. Therefore, we assessed three commonly used models for incentivization, which can also be applied to customer returns of reusable packaging:

### I. Discount/reward system

The reward system functions by giving the customer either a discount code or store credits once a package is returned. This model, which rewards customers for loyalty, could motivate them to firstly engage to receive rewards and secondly positively reinforce valuable customer behavior (Kivetz, Urminsky, & Zheng, 2006). In 2019, Zalando piloted a reusable packaging solution with discount system with Repack, a Finnish startup. However, they encountered issues with only a small percentage of the packaging being returned (Zalando, 2024). This suggests that a reward system, where the customer stands to gain without any loss regardless of whether the package is returned or not, might not maximize returns efficiently.

### II. Library system

Another option for incentivizing package returns is adopting the library model, where customers are fined if the package is not returned within a certain time period. While the system could motivate customers to return packages effectively because of loss aversion, it can also be seen as punitive because of its penalty-based approach, possibly leading to customer dissatisfaction and resistance as well as negative associations to the e-commerce company or logistics operator.

### III. Deposit system

The deposit scheme stands out as one of the most widely used and effective strategies for encouraging customer engagement in the reuse and recycling of materials (Walls, 2013). With this approach, customers pay a fee for the reusable package when purchasing a product. Upon returning the package, they are refunded the package fee. Due to its familiarity among customers, the deposit scheme not only emerged as the preferred incentive model over the library model but also achieved a return rate of 98% when mailbox returns were allowed, and the deposit was in a pilot program in the Dutch e-commerce sector (Ministry of Infrastructure and Water Management & Mission Reuse, 2023). The deposit system leverages both customers' aversion to loss and, unlike the library model, positive reinforcement too.

Along with an incentive model, sending the customer reminders of an unreturned package as well as providing the option for customers to return packages to brick-and-mortar stores of the e-commerce operator in question would likely further increase the return rate.

## b. Operator of the DRS

Three possible operators for the DRS scheme were identified: an individual company, the national postal service, and a syndicated non-profit.

### I. Individual e-commerce companies

Operating a DRS for reusable packaging as an e-commerce firm presents significant challenges in scalability, logistics, operational complexity, and financial considerations. For many e-commerce firms, establishing the necessary infrastructure, coupled with the technological and logistical demands, would be overly ambitious. While e-commerce giants like Amazon might possess the resources to act as a DRS operator, it is highly unlikely that they would become the predominant nationwide provider. However, individual e-commerce companies may opt to establish their own DRS to avoid liability to other producer responsibility schemes or participation in other ERP schemes when such systems are imposed by law (OECD, 2022). Nevertheless, each e-commerce company managing its own DRS would result in a costly, fragmented system characterized by significant inefficiencies, poor geographical coverage, and diminished customer convenience. Most importantly, this would worsen the environmental impact of the DRS, making the entire system less sustainable than the conventional approach employing single-use packaging.

### II. National postal service

Using the national postal service, such as Posti, as the DRS operator offers several advantages over individual companies. Posti has extensive reach across the country,

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and can leverage existing logistics and infrastructure, minimizing initial investments. Given Posti's status as a government-owned entity, Posti could also benefit from potential government funding and support for implementing the DRS. Additionally, it could create a decentralized system where cleaning and maintenance occur within individual distribution centers, reducing transportation costs and emissions (Fashion for Good, 2019). However, Posti has broader operational mandates that could dilute its resources and attention away from effectively implementing a DRS. Integrating the DRS into its existing logistics network could pose logistical difficulties and inefficiencies, potentially undermining the system's success.

### III. Syndicated non-profit

To ensure the success of a DRS and enable economies of scale, collaborative approaches are essential (Deprez, 2016; Zhou, et al., 2020; OECD, 2022). Given that the DRS is being implemented in response to newly enacted sustainability-focused legislation, a syndicated non-profit would be particularly suited to foster industry-wide cooperation among e-commerce companies, consumers, parcel delivery firms, and logistics providers. This collaborative approach operated by a non-profit would align with the objectives of the legislation, ensuring that the DRS has no conflicts of interest and operates in harmony with sustainability goals. A syndicated non-profit could facilitate a managed pooling system that collectively uses assets (reusable packaging) and taps into the existing infrastructure and resources of participants. The system would enable companies to share infrastructure for collecting, sorting, cleaning and delivering packaging. Standardizing assets across the DRS would reduce cleaning and logistics costs while pooling packages would decrease transportation distances, along with the related costs and emissions. Additionally, a unified return system would provide a streamlined experience, reducing barriers to adoption for consumers (Ellen MacArthur Foundation, 2023). The DRS operated by a non-profit lowers the financial burden on individual companies and benefits from economies of scale, making the collection, transportation, and processing of reusable packaging more cost-effective because of reduced administrative and operational costs. Furthermore, industry-wide collaboration is more likely receive government support and funding while also facilitating regulatory compliance of all parties of the DRS.

## c. Benchmark – The Finnish bottle recycling system

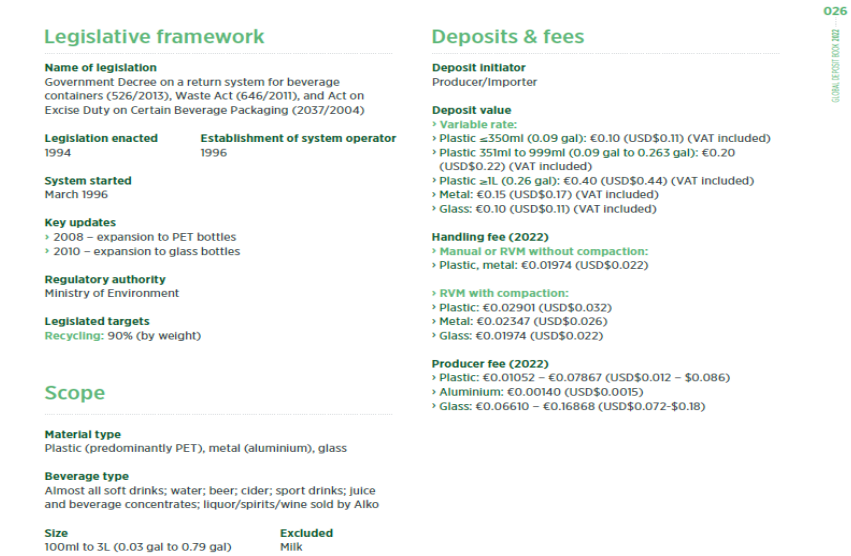
For the application of a DRS to e-commerce, a practical benchmark on understanding the operational and financial parameters is advised, as the flows and network setup of such a system is inevitably quite complex. For the purposes of this report, the DRS for beverages in Finland is used.

### I. Overview

In an international comparison, the Finnish system is very comparable as a standard return-to-retail model incentivized by a tax exemption for producers who join it. Retailers who want to sell these beverages, are however mandated to take in these packages and operate the Reverse-Vending Machines very visible at most grocery stores and supermarkets.(Figure 4.)

The system operator (PALPA) is a non-profit owned 50/50 between the major retailers and producers. The company is the material owner of the system, meaning the liability

of the empty packaging materials (cans, bottles) is on them. (Figure 1; Figure 2.) The company generates its revenues from Fees imposed on the producers per container, and unclaimed deposits, which are then used to manage the operation. (Wiesmeth & Häckl, 2011; Walls, 2011; Reloop, 2022; Palpa, n.d.; OECD, 2022) The recycling rate for these items is fairly high in Finland, 96% compared to European average of 90% for other single-use beverage DRS. (Reloop, 2022)



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GLOBAL DEPOSIT BOOK 2022

## Legislative framework

**Name of legislation**
Government Decree on a return system for beverage containers (526/2013), Waste Act (646/2011), and Act on Excise Duty on Certain Beverage Packaging (2037/2004)

**Legislation enacted**
1994

**Establishment of system operator**
1996

**System started**
March 1996

**Key updates**
› 2008 – expansion to PET bottles
› 2010 – expansion to glass bottles

**Regulatory authority**
Ministry of Environment

**Legislated targets**
Recycling: 90% (by weight)

## Scope

**Material type**
Plastic (predominantly PET), metal (aluminium), glass

**Beverage type**
Almost all soft drinks; water; beer; cider; sport drinks; juice and beverage concentrates; liquor/spirits/wine sold by Alko

**Size**
100ml to 3L (0.03 gal to 0.79 gal)

**Excluded**
Milk

## Deposits & fees

**Deposit initiator**
Producer/Importer

**Deposit value**
› Variable rate:
› Plastic ≤350ml (0.09 gal): €0.10 (USD$0.11) (VAT included)
› Plastic 351ml to 999ml (0.09 gal to 0.263 gal): €0.20 (USD$0.22) (VAT included)
› Plastic ≥1L (0.26 gal): €0.40 (USD$0.44) (VAT included)
› Metal: €0.15 (USD$0.17) (VAT included)
› Glass: €0.10 (USD$0.11) (VAT included)

**Handling fee (2022)**
› Manual or RVM without compaction:
› Plastic, metal: €0.01974 (USD$0.022)

› RVM with compaction:
› Plastic: €0.02901 (USD$0.032)
› Metal: €0.02347 (USD$0.026)
› Glass: €0.01974 (USD$0.022)

**Producer fee (2022)**
› Plastic: €0.01052 – €0.07867 (USD$0.012 – $0.086)
› Aluminium: €0.00140 (USD$0.0015)
› Glass: €0.06610 – €0.16868 (USD$0.072-$0.18)

*Figure. 1. Description of the Finnish DRS for beverages. Note: Unlike most other European DRS, Finland's DRS is voluntary; producers are not obligated to participate; however, if they do not create or join a DRS, they must pay a packaging tax to the government. This tax, in place since 1994, is levied in soft and alcoholic drinks. The rate is €0.51/L for product lines not part of the DRS.* (Reloop, 2022)

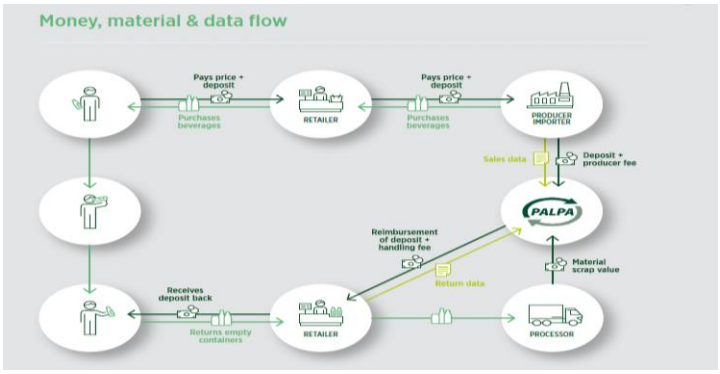
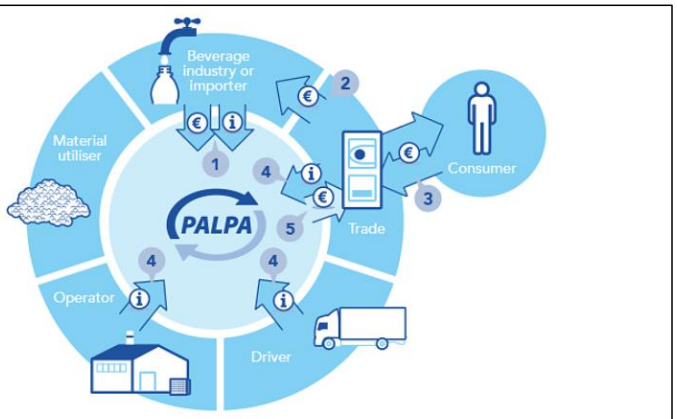



*Figure. 2. Flow of money, materials and information in the Finnish DRS.* (Reloop, 2022)




1. The manufacturer or importer of the beverage pays PALPA the deposit for the product delivered for sales
2. The manufacturer or importer of the beverage delivers the product for sales in a shop which pays the deposit to the manufacturer or importer of the beverage in the price of the product
3. The consumer pays the deposit when buying the product and receives it back when returning the empty package to a returning point
4. The return point and the processing plant report the returned packages to PALPA
5. PALPA pays the deposits to the return points in accordance with the number of reported returned packages

*Figure. 3. A more detailed description of the Finnish DRS from the perspective of the network operator, PALPA. A screenshot from the company's website.* (Palpa, n.d.)

## II. Pricing/cost structure in practice

PALPA does not release financial statement or reports, so the cost structure and actual revenues of the operation is unclear. This can however be estimated.

Given the announced return rates per Cans/PET-bottles/Glass-bottles (98%/90%/99%, respectively); the aggregate total returned amounts: 1,4 billion cans/662 million PET-bottles/ 125 million Glass bottles; PALPAS announced unit fees (Palpa, n.d.) and the deposit amounts (€0.15 cans/ €0.10 glass/ €0.23 PET[average of different deposits]);

In 2023 PALPA received €93 million from producer fees + €19 million from unclaimed deposits – fees to retailers around €57 million = €55 million Gross Profit.

This profit estimation of course doesn't take into account other operating expenses, namely transportation that PALPA covers between the collection point to the recycled material buyer. The another major cost in the model is the capital cost of the RVM's. Cost estimates for these range between €15 000 (Deprez, 2016) to €37 000 (OECD, 2022).

In 2022 there were 4 000 RVM's in Finland, therefore the capital required to build this DRS with its 96% success rate can be estimated to be in the range of €60-€148 million.

It is unclear how PALPA finances this network, but leasing in some countries has been a verified practice, whereby the manufacturer of the RVM generates their revenue

through a ‘throughput fee’ from each unit. (Deprez, 2016; OECD, 2022) Other financing solutions are most likely negotiable across the RVM industry.

### III. Technical adaptation

Assuming that RVM’s are the primary option for the e-com industry as well, application of that technology should be easily accessible. Beverage RVM’s of PALPA measure the containers dimensions, weight, and optical characteristics (e.g. color of the glass), and match this with the barcode individual for each container model to determine the size of the rebated deposit. This process also functions as a fail-safe for any exploitation by the users.

Practically this technology only needs to be re-sized for e-com packaging. This however also entails the ‘backroom’ part of the RVM, where it functions as a sorting machine for the different items. For larger packaging (parcels vs. cans/bottles) this implies that the sorting function needs to be resized as well. Therefore, a major barrier and a driver for success of such a system is the effective incorporation of standardized product design for the e-com packages with the intent to be compatible with a RVM. But with ample third-party reusable/recyclable packaging solutions in the market, and the industry’s apparent will transform their packaging practices, this could be overcome with enough industry collaboration.

*Figure. 4. Examples of current RVM systems in use. The technical solution has seen many different applications for different sized inputs over the years (cans/bottles/kegs)*

## 4. Addressable Market Size

Statista (2024) estimated that the size of the e-commerce market in the EU has reached 337 billion euros in 2023 and is expected to almost double by 2030 (Figure 5). The largest part of the whole e-commerce market is the fashion industry. Reusable packaging returns are especially relevant for the fashion e-commerce sector given that return rates in the sector can reach 45% in some cases (Figure 6).

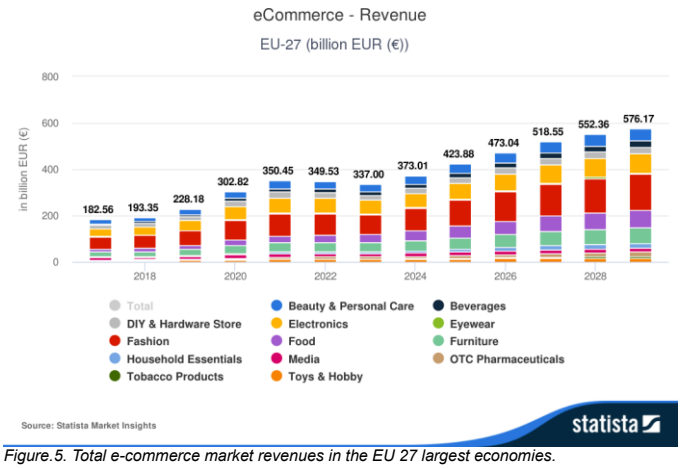



*Figure.5. Total e-commerce market revenues in the EU 27 largest economies.*

The largest e-commerce companies in the EU by sales in 2023 were Amazon (€53.3b), Zalando SE (€10.1b), eBay (€9.3b), Allegro (€2.4b), and AliExpress (no EU data) (Mordor Intelligence, 2024; Statista, 2024; Zalando, 2024).

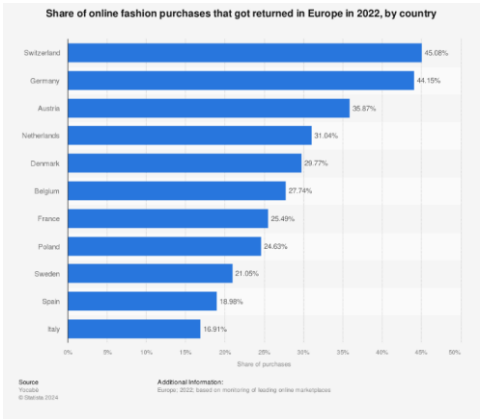



*Figure. 6. Share of online fashion purchases that got returned in Europe in 2022, by country.*

Figure 7 shows the estimated consumption of tertiary paper packaging induced by the e-commerce industry in the EU in recent years. In 2024, it is estimated that the e-commerce industry would use close to 4 million tons of tertiary paper packaging. Also, there is a stable and upward trend in the data. Note that there are other types of packaging than paper, but there is no reliable data available for other types.

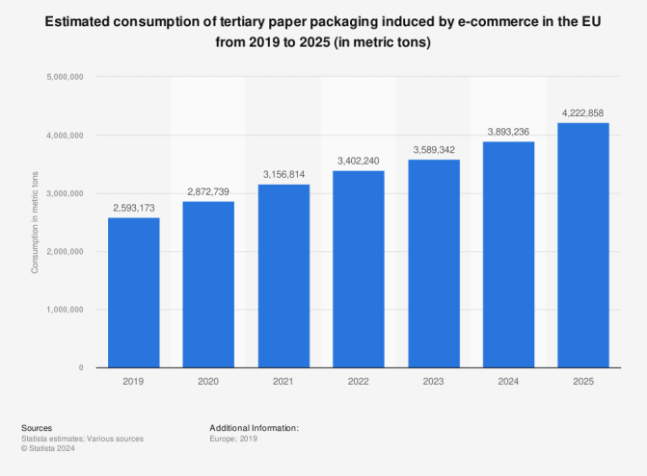



*Figure. 7. Estimated consumption of tertiary paper packaging by e-com in the EU, 2019-2025*

# 5. Quantitative analysis and recommendations

## a. Concept

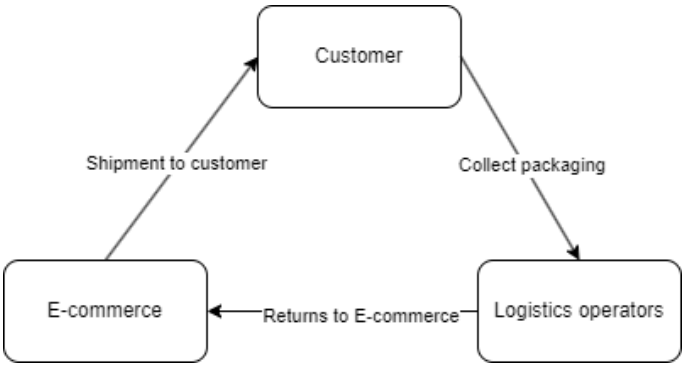



*Figure. 8. Suggested reusable packaging return scheme.*

The model shows a circular link between Customer and E-commerce use of renewable packaging through a third link of logistics operators. The logistics operators can be a Third-party logistics (3PL), Fourth-party logistics (4PL), or from the company own logistics systems. Our main aim through this model is to develop a framework to find the optimum deposit fee that incentivizes the customer to return the packaging back to E-commerce for reuse.

## b. Designing of incentives:

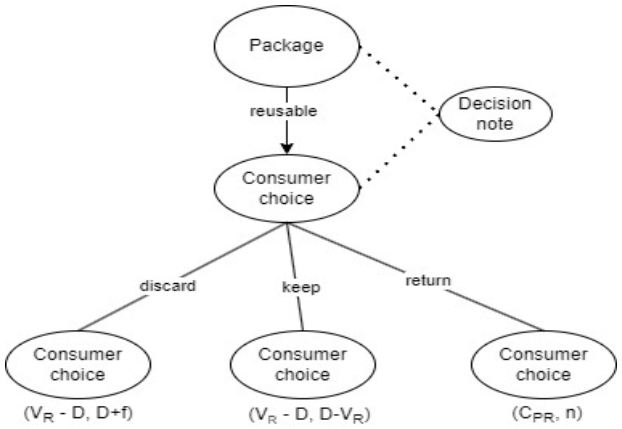



*Figure. 9. Game theory framework on Customer choice of dealing with reusable packaging.*

Based on (Hilary et al., 2007) research on game theory framework for cooperative management of refillable and disposable bottle lifecycles, a corresponding framework is derived to find the strategies that a customer could take and find the ways to nudge them into playing the E-commerce prefered strategy alternative. In graph X, it is assumed that Ecommerce only has one choice of reusable packaging because of EU legislation (as mentioned above). Therefore, a consumer after obtaining the shipment can decide on whether to dicard, to keep, or to return the packaging back with the Ecommerce costs on the left, and consumer costs on the right $(C_i^P, C_i^C)$. In this decision tree, $V_R$ is the value associated with returning the packaging, D is the deposit, f is the fee associated with post-use diposal fees, $C_{PR}$ is the cost associated with the package being returned. In addition, consumers may associate the act of returning packages with a nuisance cost n, in which case their costs will be represented by n to return, $D - V_R$ to keep, and D + f to dipose of a reusable package. In this case, the consumer will never return the reusable package if n is greater than $D - V_R$ and greater than D + f. Therefore, the Ecommerce may set $D > V_R$ to encourge return or defray the cost of lost package replacement, but such a deposit may make customers lose interest in the purchase altogether.

## c. Estimation of Deposit (D)

To encourage higher return rates, the deposit amount must be greater than the sum of value of returning the packaging and the nuisance cost associated with the act of returning it. We can consider factors such as time, effort, and any potential disruptions or hassles encountered during the return process. In particular, the deposit should be:

$$D > V_R + n$$

$$\rightarrow D > V_R + C_T + C_E + C_F + C_P + C_C$$

$$\rightarrow D > \alpha * C_{Packge} + C_T + C_F$$

Where:

$C_T$: Time cost, estimated by calculating the average time (in hours) taken for the return process and multiplying by the consumer's hourly wage or value of time.

$C_E$: Effort cost includes physical effort involved in carrying the package to the return location and the cognitive effort of organizing the return, dealing with the learning process of return.

$C_F$: Financial cost, which is expenses such as transportation costs or potential costs associated with the delay in receiving refunds or credits.

$C_P$: Psychological Cost which is any stress or frustration associated with the return process, which could be due to poor customer service, long wait times, complicated return procedures, etc.

$C_C$: Convenience Factors which are adjustments based on the accessibility and flexibility of the return options.

$C_{package}$: The actual cost of a reusable package.

$\alpha$: coefficient value denoting the share of the packaging cost is shared with the consumers.

## d. Optimal Deposit

In this calculation, the effort cost, psychological cost, and convenience factors are considered negligible due to the absence of a clear mechanism to quantify these costs. Additionally, the parameter α is initially set to 0.5, with the quoted cost per unit of packaging being €3.50.

To estimate the time cost, it is assumed that a person is 10 minutes away from the nearest postal collection point, resulting in a total travel time of 20 minutes, including the time required to successfully return the package. Using Finland's median monthly income of €3400, we calculate the average cost of time per return. This is derived by dividing the monthly income by 30 days per month, 24 hours per day, and 60 minutes per hour, which results in an approximate value of €1.57 for 20 minutes of time.

For the financial cost, it is assumed to be primarily from the cost of gasoline consumption. The current average price of gasoline is €1.87 per liter, and a 20-minute trip around the Helsinki region would consume approximately 0.8 liters of fuel. Therefore, the financial cost of fuel is calculated as 0.8 × €1.87, which equals approximately €1.50. Thus, the total value of the deposit can be calculated as follows:

$$Total\ Deposit\ =\ \alpha\ \times\ Cost\ per\ Unit\ of\ Packaging\ +C_F\ +\ C_T$$

$$Total\ Deposit\ =\ 0.5\ *\ €3.50\ +\ 0.8\ *\ €1.87\ +\ €1.57\ =\ €5.16$$

This calculation ensures that the deposit covers the estimated costs, making the return of the packaging financially justifiable for the consumer.

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