UNIVERSITY OF TURKU
Turku School of Economics

IMPACT OF THE EU PACKAGING AND PACKAGING WASTE REGULATION ON THE FINNISH BEVERAGE INDUSTRY

Operations and Supply Chain Management
Master's thesis

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16.02.2025
Helsinki

The originality of this thesis has been checked in accordance with the University of Turku quality assurance system using the Turnitin Originality Check service.

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Number of pages: 73 pages + appendices 3 pages

Date: 16.02.2025

The European Union's Packaging and Packaging Waster Regulation (PPWR) adopted in 2024 introduces new sustainability requirements aiming to reduce packaging waste by promoting circular economy practices in a variety of industries. Ready to consume packaged beverages sold in retail, a considerable source of packaging waste, is one of the impacted industries. The aim of this study is to examine the impact of PPWR on the Finnish beverage industry from a supply chain perspective, focusing on how industry stakeholders plan to meet the regulation's requirements.

A qualitative research using semi-structured interviews was conducted in order to reach the research objectives. First, a literature overview on circular economy of beverage packaging was performed. The reuse targets and recycled content requirements of PPWR, which are judged to impact the beverage industry the most were then explored. A theoretical framework was built from the interface of the studied literature and regulation, which served as the basis for the interview questions. Three interviews of industry experts were conducted. The interviewees represented relevant stakeholders of the industry, including grocery retail, packaging and beverage manufacturing and deposit return system (DRS) administration. The insight from the interviews was then gathered and summarized in a solution framework. Impacts and solutions concerning stakeholder collaboration and individual stakeholders are presented in the solution framework.

The findings indicate that PPWR's reuse targets and recycled content requirements will significantly affect supply chain operations in the Finnish beverage industry. Implementing a reuse system requires considerable investments from industry stakeholders. The financial burden of the required investments is asymmetrical due to limited capability of small-scale producers to invest in efficient equipment. The reverse logistics of used containers to the correct manufacturer is a challenging due to local market conditions. Operating reuse systems increases the administrative burden of industry stakeholders. Recycled content requirements may cause availability issues of single-use plastic bottles if the recycling rate of other industries is not increased.

Collaboration of industry stakeholders is found to be crucial in the implementation and operation of environmentally and economically efficient reuse systems. DRS with an accessible network of collection facilities is considered to be an effective way to promote high return rates of reusable containers. The co-ownership of DRS operators enables the alignment of interests, facilitating collaboration. The centralization of reuse cycle steps and standardization of beverage packaging is found to decrease logistical complexity and to promote environmental and cost-efficiency. However, competitive behaviour and conflicting interests of industry stakeholders may limit the willingness of economic operators to collaborate.

The main driver of the solutions that economic operators plan to employ to comply with sustainability regulations is identified to be business needs rather than sustainable values of companies. Legislators should therefore design sustainability legislation in a manner where business needs and environmental goals are parallel. Legislative vagueness is found to limit the planning of stakeholders. Clarity and preparedness should be pursued in legislation to support stakeholder planning.

Key words: circular economy, reuse system, packaging, sustainability, EU, legislation, supply chain management

Pro gradu -tutkielma

Oppiaine: Toimitusketjujen johtaminen

Tekijä: Otto Artjoki

Otsikko: EU:n pakkaus- ja pakkausjäteasetuksen toimitusketjuvaikutukset Suomen juomateollisuuteen

Ohjaaja: KTT Sini Laari

Sivumäärä: 73 sivua + liitteet 3 sivua

Päivämäärä: 16.02.2025

Euroopan unionin vuonna 2024 hyväksymä pakkaus- ja pakkausjäteasetus (PPWR) asettaa lukuisille toimialoille uusia kestävän kehityksen vaatimuksia, joiden tavoitteena on vähentää pakkausjätteen määrää edistämällä kiertotalouskäytäntöjä. Juomateollisuus, joka on merkittävä pakkausjätteen lähde, on toimiala, jota uudet vaatimukset koskevat. Tämän tutkimuksen tavoitteena on selvittää toimitusketjuvaikutuksia, joita PPWR:llä on Suomen juomateollisuuteen ja identifioida ratkaisuja, joita alan eri sidosryhmät suunnittelevat hyödyntävänsä asetuksen vaatimusten noudattamiseen.

Tutkimus suoritettiin laadullisena tutkimuksena. Aineistonkeruumenetelmänä käytettiin puolistrukturoituja haastatteluita. Haastattelukysymykset pohjautuvat tutkimuksen teoreettiseen viitekehykseen, joka luotiin kirjallisuuskatsauksen ja asetuksen relevanttien osien tarkastelun pohjalta. Tutkimuksessa suoritettiin kolme haastattelua alan asiantuntijoiden kanssa. Haastateltavat edustivat eri juomateollisuuden sidosryhmiä, kuten päivittäistavarakauppaa, pakkaus- ja juomateollisuutta sekä panttijärjestelmän ylläpitäjää. Aineiston keruun ja analyysin pohjalta saadut tulokset esitetään ratkaisuviitekehyksessä, joka käyttää tutkimuksen teoreettista viitekehystä pohjanaan.

Tutkimuksen tulokset osoittavat, että PPWR:ssä esitetyt juomapakkausten uudelleenkäyttötavoitteet ja sisältövaatimukset vaikuttavat Suomen juomateollisuuden toimitusketjuihin merkittävästi. Uudelleenkäyttöjärjestelmän implementointi edellyttää alan toimijoilta mittavia sijoituksia laitteistoon, joka kuormittaa pienempiä toimijoita suhteellisesti enemmän. Juomapakkausten paluulogistiikka on paikallisten markkinaolosuhteitten takia haastavaa. Uudelleenkäyttöjärjestelmä lisää hallinnollista kuormaa. Kertakäyttöisten muovipullojen sisältövaatimukset saattavat aiheuttaa saatavuushaasteita, ellei muiden toimialojen kierrätysastetta saada nostettua.

Sidosryhmien välistä yhteistyötä voidaan tulosten pohjalta pitää välttämättömänä taloudellisesti tehokkaan ja kestävän uudelleenkäyttöjärjestelmän luomisessa. Panttijärjestelmä kattavalla keräyspisteverkostolla on tehokas menetelmä edistää uudelleenkäytettävien pakkausten palautumista kuluttajilta. Panttijärjestelmän ylläpitäjän yhteisomistajuus eri sidosryhmien kesken tunnistetaan toimivaksi tavaksi yhteensovittaa risteäviä intressejä ja edistää yhteistyötä. Paluulogistiikan prosessien keskittäminen ja juomapakkausten standardisointi vähentää logistista monimutkaisuuta edistäen uudelleenkäyttöjärjestelmän kestävyyttä ja kustannustehokkuutta. Toisaalta sidosryhmien kilpailullinen toiminta ja risteävät intressit rajoittavat sidosryhmien halukkuutta yhteistyöhön.

Tutkimuksen tulosten mukaan yrityksen liiketoiminnalliset intressit ohjaavat yritysten päätöksentekoa vastuullisuussääntelyn noudattamisessa enemmän kuin yrityksen vastuulliset arvot. Vastuullisuussääntelyssä tulisikin ottaa tämä huomioon, ja pyrkiä yhteensovittaa liiketoiminnalliset intressit vastuullisuustavoitteiden kanssa. Lainsäädännön epäselvyyden ja keskeneräisyyden havaittiin myös rajoittavan yritysten kykyä valmistautua uusia vaatimuksia varten. Sääntelyssä tulisikin tavoitella yritysten suunnittelun tukemiseksi selkeyttä.

Avainsanat: kiertotalous, uudelleenkäyttö, pakkaukset, vastuullisuus, EU, lainsäädäntö, toimitusketjujen johtaminen

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1 Introduction

As a part of the European Union's (EU) goals linked to the European Green Deal, the EU enacted a Revision of the Packaging and Packaging Waste Directive (RPPWD) (European Commission 2022a). It aims to amend and repeal the Packaging and Packaging Waste Directive 94/62/EC of 20 December 1994 to further limit the production of packaging waste and to promote the reuse and recycling of packaging. Between 2009 and 2020, the amount of packaging waste created in the EU rose by 20 % (Ragonnaud 2024). The existing legislature was deemed insufficient to achieve the updated sustainability goals of the EU and the RPPWD was put forward in 2022. The revision was formally agreed and adopted by the European Parliament on the 24th of April 2024 and named Package and Packaging Waste Regulation (PPWR) (European Parliament 2024a).

The PPWR addresses packaging waste in various industries, including packaged ready to consume-beverages sold in stores. It includes requirements on the share of recycled content used in single-use plastic beverage bottles and targets for the reusability of beverage packaging. The novel requirements may have implications for different stakeholders in the industry, such as beverage manufacturers, the packaging industry, grocery retailers and other. The aim of this thesis is to identify the implications of the PPWR for stakeholders in the beverage industry from a supply chain perspective and to investigate the plans of the stakeholders to meet the requirements of the new legislation.

The scope of the study is limited to the manufacturing and sales of non-dairy and non-alcoholic beverages, such as water, soft drinks and juices and beer sold in ready to consume packaging in retail. When referring to beverages in this study, the products defined above are meant. The term *beverage industry* or *industry* refers to the industry linked to the manufacturing and sales of the above-mentioned products, including relevant suppliers, such as the packaging industry. This study focuses on the primary packaging of beverages, and the word *packaging* or *container* refers to the primary packaging of beverages unless stated otherwise. The words *container* and *packaging* are used interchangeably. The study focuses on reuse targets and recycled content requirements of beverage packaging. PPWR requirements concerning labelling are not addressed. The geographical scope are economic operators in Finland, but the study aims to uncover more general implications that are applicable in different member states of the EU. The study will retain a supply chain-oriented perspective and political and ethical analysis are excluded.

New sustainability legislation, both national and international, aimed to tackle environmental issues set increasing limitations, requirements and reporting duties to economic operators (Hummel & Jobst

2024). Soft drink sales produced roughly 7,9 million tonnes of packaging waste in 19 measured EU member states in 2022. The soft drink packaging materials contributing the most to this total is glass (~5 million tonnes) and PET plastic (~2.5 million tonnes). PET plastic from soft drinks represented 87 % of the total PET packaging waste. (De Laurentiis et al. 2024). In order to reduce the amount of generated packaging waste, the beverage industry is also targeted by sustainability legislation, such as PPWR. Finland does not have national legislation with reuse requirement for beverage packaging sold in retail or recycled content requirements for single-use plastic bottles. The novel requirements may have some impacts on the industry, and meeting these requirements demand new solutions by concerned stakeholders. Circular economy (CE) literature and practices offers sustainability solutions such as R-frameworks and waste hierarchy. CE fundamentals include preferring reuse over recycling and the usage of recycled raw materials over virgin raw materials. (Kirchherr et al. 2017). CE solutions have been included in the design of what would later be named PPWR, including regulations concerning the beverage industry, such as requirements for selling reusable beverage packaging and recycled content requirements (European Commission 2022b; European Parliament 2024a).

The impacts of the PPWR to the beverage industry have been estimated in impact assessments accompanying the RPPWD (European Commission 2022b; European Commission 2022c). Interest groups of the industry have also published some assessments concerning the effects of the PPWR, but they may not be considered as impartial studies. There is limited in depth and impartial studies assessing the future supply chain impacts of the novel regulation on the beverage industry. The objective of this study is to bridge this gap by estimating the impacts of the regulation to the relevant stakeholders in the beverage industry and to uncover solutions the stakeholders might employ to fulfil the requirements set by the regulation from a supply chain perspective. Based on the research objective, two main research questions (RQ1 and RQ2) have been formulated as follows:

- ***RQ1:*** *How will the Packaging and Packaging Waste Regulation (PPWR) impact supply chains and supply chain management in the beverage industry?*

- ***RQ2:*** *What are the plans of economic operators in the beverage industry to meet the requirements set by the PPWR?*

To answer these questions, qualitative research is conducted including a literature review and an empirical study using semi-structured interviews of professionals in relevant sectors. This study consists of 6 chapters. Chapters 2-3 serve as a literature review and provide a theoretical background for the studied subject. Chapter 3 addresses the relevant parts for the beverage industry of the PPWR

in more detail and presents a theoretical framework used as a base for empirical data collection. Chapter 4 introduces the scientific methodology used in the collection of empirical data. Chapter 5 presents the results of the empirical research conducted and Chapter 6 connects the results to the academic literature and previous research.

2 Circular Economy of Beverage Packaging

2.1 Key concepts of circular economy

Circular economy (CE) has been a trending term in sustainability literature in the past years. In the review article of Kirchherr et al. (2017), 114 definitions of CE in different academic literature were examined. Traditionally, CE has been defined from an environmental and economical dimension as economical model complying to environmental laws with the goal to increase sustainability with reducing used resources, reusing resources instead of disposing them and recycling used resources (Zhijung & Nailing 2007). The means are condensed in three fundamental terms, reduce, reuse and recycle, also called the 3R framework. The 4R framework introduces recover as an additional fundamental mean. Some studies include more CE means in their framework, such as Sihvonen & Ritola (2015) and van Buren et al. (2016) with the addition of means such as refuse, repair, refurbish, remanufacture, and repurpose. The R frameworks often include a waste hierarchy, meaning that the mean presented earlier should be prioritized over the mean presented after it. In 4R frameworks, waste hierarchy means that reducing should be prioritized over reusing, reusing over recycling and recycling over recovery. (Kirchherr et al. 2017; Sihvonen & Ritola 2015; van Buren et al. 2016).

More recently, the system perspective has been used increasingly in defining CE. From this perspective, CE is seen as a system that is designed to be restorative and regenerative, with a closed loop material flow (Lieder & Rashid 2016). The systems perspective studies CE systems from different levels of observation. The macro-systems perspective considers the adjustment needs of the industrial composition and structure of the whole economy. It includes general policies and policy tools that enhance the integration of CE principles to cities, regions and nations. Micro-systems perspective studies CE systems in individual enterprises, products and consumers. It discusses subjects such as product, packaging and labelling design, business processes and models and consumer behaviour. Meso-systems are identified to be between micro- and macro-systems. This level examines the efforts among firms to collaborate in order to achieve CE goals. Eco-industrial and eco-clusters are concepts of this systems level. (Tomassini et al. 2024; Kirchherr et al. 2017; Nikolaou & Tsagarakis 2021)

2.2 Reusable beverage packaging

Reusable packaging is defined by ISO 18603:2013 (2013) as packaging or packaging component that has been designed to accomplish or proves its ability to accomplish a minimum number of trips or rotations in a system for reuse. The Provisional agreement on PPWD (2024, 106—107) essentially

deems packaging as reusable when the packaging is designed with the objective to be reused multiple times, to accomplish as many rotations as possible in conventional modes of use and fulfils the health, safety and hygiene requirements set in the directive and can go through the rotations without being too damaged for reuse. The minimum number of rotations for different packaging is to be set later.

The primary packaging types of the studied beverages are PET plastic bottles, cardboard boxes, aluminium cans and glass bottles. (Morgan 2022; TOMRA 2023). Some other packaging materials exist, such as biodegradable plastics, stainless steels, ceramics and bamboo but see limited usage in the beverage industry mainly related to their cost or performance (Ramos et al. 2015).

The environmental impact of reusable glass bottles compared to single-use glass bottles has been studied in numerous articles. Landi et al (2019) found that the usage of reusable glass bottles within a local wine consortium resulted in significant environmental benefits. The additional resources needed for actions enabling the reusage of the bottles was calculated to be less important than the resources needed for the recycling and remanufacturing of bottles from cullet. The recycling and remanufacturing of bottles requires a significant amount of energy, making the reuse of glass bottles to be a viable option instead of recycling. The standardization of packaging and diminishing the amount of different bottle types was highlighted as a driver enabling the reuse of glass bottles, simplifying logistics. Morgan et al (2022) came to similar results in by studying the carbon footprint of packaging in small breweries. Using reusable glass bottles, compared to single use glass bottles, could significantly decrease the carbon footprint of beer packaging, especially in short term deliveries. Recyclable aluminium cans were also found to be more sustainable than single use glass bottles. Ferrara et al. (2021) found that reusable glass bottles have a similar environmental impact than single-use PET-bottles, which both outshine single-use glass bottles. Almeida et al (2017) found reusable glass bottles to be the most sustainable packaging choice for Brazilian soft drinks.

Some studies have concluded that reusable packaging is not always more environmentally friendly than recycled beverage packaging. Ferrara et al (2021) found single-use PET bottles to be more sustainable than reusable glass bottles when packaging natural (non-sparkling) mineral water. In packaged carbonated mineral water, PET bottles and reusable glass bottles were found to have a similar environmental impact, mainly due to the higher weight of the PET bottles compared to natural water PET packaging. The containment of carbonated beverages requires stronger bottles and thus use more plastic per bottle. The environmental performance of reusable packaging improves when the number of rotations increases (Ferrara et al. 2021). Almeida et al. (2017) found reusable glass bottles to be more sustainable than PET-bottles and aluminium cans if they are reused enough times.

If there is no viable reuse system in place, single use packaging was found to be more sustainable. On the short run, the environmental impact of reusable and recyclable packaging is also dependent on the existing infrastructure for reuse and recycling. If a CE system for beverage packaging is designed especially for recycling, it may be the most environmentally efficient alternative. (Kouloumpis et al. 2020).

The energy required for the production of a reusable package determines the target number of reuse cycles to achieve environmental gains. Packages that require comparably more energy to produce, for example glass bottles and stainless-steel containers, need to be reused a higher number of times in order to be more sustainable than single use packaging. The number of required cycles is packaging with less energy-intensive production, such as PET plastic. (Coelho et al. 2020).

When determining the most sustainable packaging option for a beverage, characteristics of the contained beverage and distance of distribution should be considered (Ferrara et al. 2021). Context specific assessment is needed, as the environmental strain of reusable beverage packaging is not automatically smaller than with recyclable options as per the studies presented above. Almeida et al (2017) agree that the choice of packaging should be made considering the context, particularly by the distance of distribution and the availability of infrastructure suitable for reuse or recycling.

The usage of reusable packaging in EU countries has been decreasing in the past decades. Between 2000 and 2015, the share of the total beverage market for drinks sold in reusable containers across Europe decreased from 41 % to 21 %. In Finland glass bottle reuse has declined the most of EU countries, from a high of 81 % to 6 %. This happened during the period in which a Deposit Return System (DRS) for single-use packaging was introduced. In Denmark, the usage of reusable glass and PET plastic bottles decreased notably and has been replaced with aluminium cans and single use plastic bottles. This shift is explained by a prior ban on canned beer and soft drinks and extending DRS to single use containers. The market share of reusable containers fell from 90.3% in 2000 to 16.9% in 2017. The decline in reuse has contributed to the increase in overall packaging waste. The reason customers prefer single-use packaging over heavier reusable ones is attributed to on-the-go consumption. (European Commission 2022c).

2.3 Recyclability of most common beverage packaging

Ready to consume beverages in the scope of this study are commonly sold in aluminium cans, glass bottles and PET-plastic bottles. These are also the packaging materials that are included in DRS. (Morgan et al. 2022; TOMRA 2023). Other container types, such as carton packages are also used,

but are normally excluded from DRS systems, since their recycling is complicated and thus less cost efficient due to their complex layering (TOMRA 2023).

The different packaging materials have different qualities concerning the efficiency of their recycling and the possible uses of the recycled materials. The recyclability of aluminium cans is highly efficient in terms of energy and salvageable material. Producing aluminium cans from recycled aluminium uses 95% less energy compared to producing them using virgin materials. Aluminium cans are relatively light compared to glass bottles, and they are crushed to a compact and dense form after recycling. The value per tonne is high compared to other materials, making their transportation more economical. Nearly all the material used in the can may be salvaged and reused as materials for cans or wide variety of other products. (Capuzzi & Timelli 2018; PALPA 2024a; Kiffaya & Bdeir 2008).

Recycled glass bottles are milled to smaller fragments of glass called cullet. Cullet may be used in the production of new glass bottles, given that clear and brown glass are separated. Other uses for cullet include foam glass used in insulation and other construction materials. The energy savings from producing glass bottles from recycled bottles compared to virgin materials is considerable but less than with aluminium cans. Producing bottles from cullet uses 20-30% less energy than using virgin materials. The advantage of glass is that if recycled properly in a close-loop cycle, it may be recycled indefinitely. (Ferrara & De Feo 2023, Silva et al 2017; PALPA 2024a). Contamination from food items, lids and labels is a challenge in the recycling of glass (Ferrara & De Feo 2023).

Recycled PET plastics (rPET) bottles may be used in the production of new plastic bottles. Alternative uses for recycled plastics including PET have been extensively researched and applied during the last years. Common uses include textiles, packaging materials for non-food items and construction materials. The usage of rPET in food and beverage packaging is subject to strict requirements due to hygiene and food safety concerns. The sorting of rPET of different qualities is important for it to be suitable for usage as beverage packaging. (Benyathiar et al. 2022). Producing PET bottles from recycled materials is also more energy efficient than using virgin materials, saving 60-70% (Benavides et al 2018). Compared to glass and aluminium, the disadvantage of recycling PET plastics is that it may degrade as a result of usage and recycling actions, losing some thermal and mechanical properties. This reduces the times PET plastics may be recycled. (Al-Salem et al 2009).

2.4 Reuse systems in beverage packaging

Beverage packaging is usually recycled rather than reused. Recycling waste aims to produce raw materials out of the recycled waste. The process has typically 5 stages: consumer (1) disposal by

consumers, (2) collection, (3) sorting, (4) reprocessing, and (5) production of recycled materials. (WRAP 2024).

As efforts to increase CE practices in beverage packaging continue, actions to climb the waste hierarchy ladder are needed. In common R-frameworks, the preferred step before recycling waste is reusing it. Reusing materials decreases the need to use virgin raw materials and may potentially conserve energy by eliminating steps of production. To enable reuse of waste, including beverage packaging, a reuse system designed for this CE action needs to be implemented. (Kirchherr et al. 2017; Sihvonen & Ritola 2015; van Buren et al. 2016). Reuse systems are defined by ISO 18603:2013 (2013) as "established arrangements (organizational, technical or financial) which ensure the possibility of reuse". Reuse systems are further divided into close loop systems, where the packaging is reused again by the company or co-operating companies. In open loop systems the packaging is reused by unspecified companies.

Zeeuw van der Laan et al. (2019) categorizes reuse systems for FMCG packaging to systems where the consumer keeps and takes care and reuses of the packaging and systems where the consumers return the packaging, which is then circularly processed by someone else. Muranko et al. (2021) categorize reuse systems similarly and respectively *into exclusive reuse systems* and *sequential reuse systems*. In the context of this paper, only the systems where the packaging is returned, or sequential systems, is considered and denoted with the terms reuse and reusability system. Systems where the packaging is taken care of by the consumers are denoted as refill and refilling systems.

Common steps in of a reuse system include (1) collection, (2) sorting and inspection, (3) cleaning and sanitization, (4) quality control, (5) refilling and (6) redistribution. (Muranko et al. 2021; Landi et al. 2019)

(1) Collection refers to the collection of beverage packaging intended for reuse from the consumers of the beverages. Financial incentives, such as Deposit Return Systems (DRS) have been found to be an effective method to encourage consumers to return beverage packaging to designated collection facilities increasing return rates. (Abila & Kantola 2019; Gibovic & Bikfalvi 2021; Konstantoglou et al. 2023). The coverage of the collection facilities contributes to the effectivity of beverage packaging collection. Collection rates are positively impacted if the location of collection facilities is easily accessible to consumers and the facilities are fast and easy to operate by the consumer (Linderhof et al. 2019; Konstantoglou et al. 2023). An example of an accessible and high coverage collection network are the DRSs employed in Finland. Finland has a tax of beverage packaging, but economic

operators may be exempt from it by taking part in an approved DRS (Verohallinto 2024). As a result, the majority of retailers have a DRS collection facility in their store. (PALPA 2024b).

(2) Sorting and inspection refers to the part of the reuse process where the collected beverage packages intended for reuse are separated by material, size, type and manufacturer. The aim of this step is to ensure that the packages are returned to the correct manufacturer for reuse. An initial inspection of the returned packages is done to detect damaged or contaminated packages that are not suitable for reuse. The packages that are deemed unsuitable for reuse are moved to a recycling system. In a market with a wide variety of different reusable bottles, the sorting of the bottles in order to return them to the correct manufacturing is more complex than with standardized bottles. It is often done manually, making it labour intensive and increasing the costs of the reuse system. (Ada et al. 2023; Molina-Besch & Pålsson 2014; Siegfried & Bührdel 2022). Siegfried and Bührdel (2022) present RFID tags as a solution to sorting. Despite concerns about the durability and negative recyclability impacts of the tags, they argue that they be effective in diminishing costs associated with sorting, especially in closed loop systems where the tag may be used multiple times. Another commonly presented method to facilitate sorting in reuse systems is the standardization of beverage packaging. Standardized reusable packaging eliminate the need for sorting the packages and simplify the reverse logistics so that manufacturers would receive the correct packaging, resulting in reduction of costs and labour associated with that part of the process. (Ada et al. 2023; Ko et al 2012). Additionally, standardization of beverage packaging may include other benefits, such as cost reductions in inventory management due to inventory pooling. (Ko et al. 2012). Standardization efforts for improved reusability have been made for example in South Korea, where prominent soju manufacturers and the Ministry of Environment agreed voluntarily in 2009 to use standardized glass bottles. The aim was to decrease manufacturing costs and to facilitate their reuse by simplifying the reverse logistics of used packaging, eliminating the need to sort the bottles. The agreement was not enforced by law and faced difficulties when new soju brands in non-standard packaging were introduced to the market with commercial success. (Dong-hwan 2019).

(3) Cleaning and sanitization of the sorted containers aims to remove any residue left in them and to eliminate bacteria and other potential health hazards that could contaminate the refilled drink. The intent is to ensure that the reused packaging does not threaten the quality and safety of the drink. The hygiene and safety regulations of food and drinks is comparably strict. Reusing packaging may be a risk to the compliance to the regulations, so caution is necessary in this step. (Lacourt et al 2024).

Reuse systems require the development of infrastructure for cleaning and sanitizing the packages by the provider of the reuse system, such as industrial cleaning facilities. (Muranko et al. 2021).

(4) Quality control - when the collected packages have been sorted, inspected, cleaned and sanitized, their quality is controlled. The final evaluation if the packaging is suitable for reuse is conducted. The structural integrity of the packaging is examined and packaging that is considered too damaged for reuse is removed and recycled. The packages are tested for contaminants. If contaminants are found, they may be reprocessed by step (3) or recycled. If the quality of the used packaging is deemed high enough, it is approved for step (5).

(5) Refilling – The processed packages that have been deemed suitable for reuse are refilled by the manufacturer with the intended beverage and possibly relabelled.

(6) Redistribution – Once refilled, the beverage stored in the reused packaging is redistributed to the consumer. When the beverage is consumed, its packaging has completed a use cycle. The packaging may be introduced to the collection phase again and the process starts again.

Figure 1 illustrates a simplified reuse system for beverage packaging including the steps presented above. The steps are based on Muranko et al. (2021) and Landi et al. (2019). In the figure, there are three locations where the different steps take place. (1) The collection of the beverage packaging is done at a retail store. The collected containers are transported to a reuse facility, that serves multiple retail stores. At the reuse facility, the beverage packages are (2) Sorted and inspected. Packages deemed unfit for reuse are removed from the cycle and added to a recycling system. When sorted and inspected, the containers are (3) Cleaned and sanitized. Packages that cannot reach the desired cleanliness are recycled. The sorted and cleaned containers are then transported to the correct beverage manufacturers. The beverage manufacturer (4) performs a quality control of the packaging. If they do not pass the quality control, they may be returned to the cleaning and sanitization step or recycled. If they pass, the packages are (5) refilled and transported as beverages to a retail store to be (6) redistributed to the consumer. An additional step, (7) consumption was added to the figure. The location of consumption is not determined. After consumption, empty containers are returned to the collection facility in retail stores, and another reuse cycle commences. Some containers are disposed by other means than reuse systems, such as littering, reusage by the customer or entered to a recycling system.

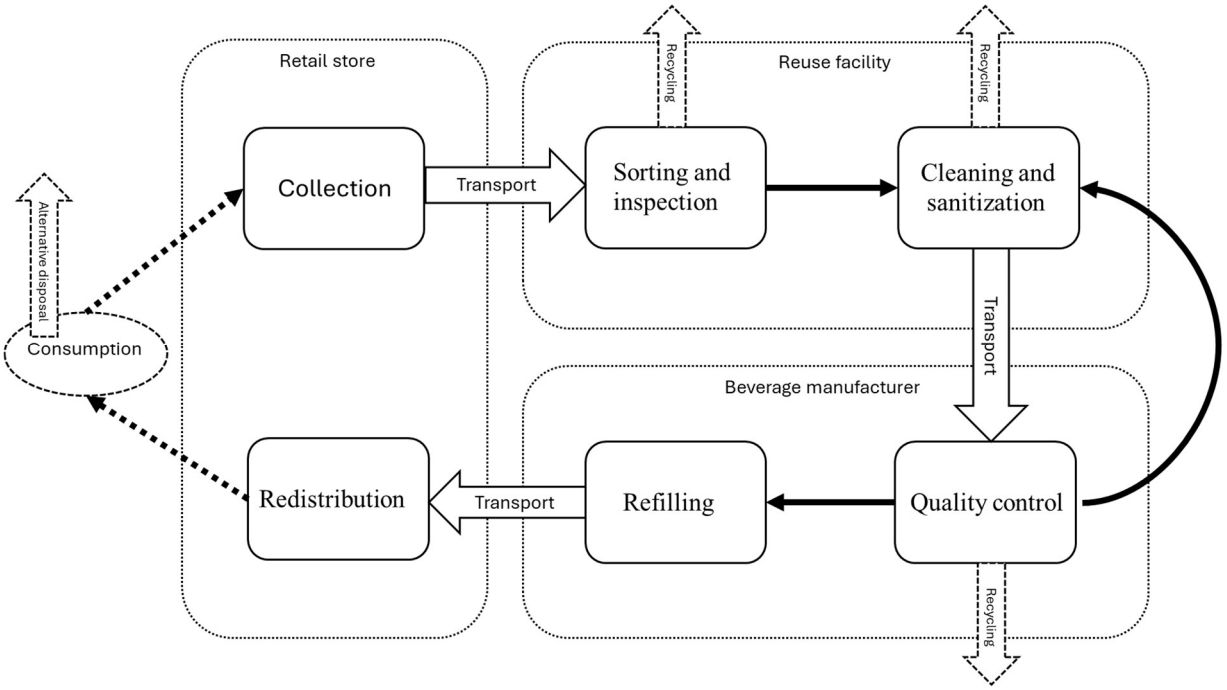

Figure 1 A generic reuse system for beverage packaging

The feasibility, viability and successful implementation of a reuse system is affected by various factors. The factors may be interlinked, but they can be divided into the following groups: economic factors, supply chain factors, environmental factors, factors linked to packaging design, consumer engagement factors and legislative factors.

Economic factors are related to the implementation and operation of reuse systems. An economic factor impacting the creation of reuse system are high initial investment needs. Reuse systems are dependent on suitable infrastructure. The required initial investment is a barrier to transitioning to reusable packaging. (Coelho et al. 2020; Morgan et al 2022; Muranko et al. 2021; Dace et al 2013). Required investments to implement a reuse systems are warehousing for the packaging that are meant to be reused, collection points for recovering the used containers for reuse, additional logistics equipment to transport the used containers from economic operator and reuse step to another, cleaning equipment to efficiently cleaning and sanitization step of the reuse process, technological investments in software to manage the function of the system and a reusable packaging pool due to the increased need for packaging in the system. (Circular Economy Portugal 2021).

In addition to investment needs, reuse systems involve operational costs to upkeep the operations associated with it presented in Figure 1. The maintenance of the operations is an additional cost to the expenses associated with performing the processes themselves. An additional economic factor associated with investment and operational costs of reuse systems is the size of the market and the average daily volume of the reuse system. A market has to be sizeable enough for reuse systems to

be attractive from a financial point of view. The daily volume of packages processed by the system has to be high enough to be economically viable. A sufficient flow of products enables economies of scale, resulting in the decrease of the cost per unit to reuse a package. (Coelho et al 2020; Circular Economy Portugal 2021).

The question how costs of operating a reuse system are divided along stakeholders. Ultimately, it may be argued that it is the consumer who renumerates these costs that are reflected in the price of the product, however, some solution has to be made on who covers the direct costs (**LÄHDE**). The Finnish DRS operated by the limited liability company PALPA, which is a recycling system rather than a reuse system, may be used as a solution to this question. PALPA recycles the majority of containers that have a deposit and are included in the DRS for beverage packaging in Finland. PALPA is a joint venture of two major grocery chains and sizeable beverage manufacturers in the country. Finland has a tax on beverage packaging, but products that are a part of an accepted DRS system are exempt from it. The packaging tax is an economic incentive to take part in a DRS, resulting in more competitive pricing of beverages compared to beverages paying the packaging tax. The operational costs associated with the system are split among the beverage manufacturers and grocery chains. including collection facilities in stores is a financial burden, but the benefits associated with being exempt from the packaging tax outweigh it. (PALPA 2024a; PALPA 2024b).

Supply chain factors are related to the organization, transportation and operation of the reuse system. The supply chain design of a reuse system is dependent on the reuse model (exclusive or sequential) and the properties of the product (Muranko et al. 2021). The operational steps included in a generic reuse system for beverage packaging are illustrated in Figure 1. Centralization of sorting and cleaning operations is advisable due to economies of scale. Centralization streamlines the operations and reduces logistical complexity. Additionally, centralization has the added benefit of standardizing the quality of the reuse operations. (Circular Economy Portugal 2021). The success of a reuse system is dependent on vertical integration of supply chain stakeholders. Stakeholders include packaging manufacturers, manufacturers, retailers, consumers and CE operators. Coordination between the members is needed to ensure that the used containers return to the correct manufacturer in a cost-effective and timely manner. (Ada et al. 2023; Molina-Besch & Pålsson 2014).

Legislative factors contribute to the formation and success of reuse systems. Coelho et al. (2020) find that legislation has an important role in promoting more sustainable packaging designs and systems. Suitable legislative measures may decrease entry barriers for reuse systems and improve the competitiveness of reusable packaging compared to single-use packaging. Taxation is a common

legislative tool to promote CE practices. Milios (2021) proposes a taxation framework with this aim. The framework includes taxation of usage of raw materials, a waste hierarchy tax and tax reliefs for repair/reuse. Supporting legislative measures, such as tariffs so that raw material taxes do not shift production abroad are necessary for a successful implementation. The taxation framework is argued to address market failures and internalized external costs linked to raw material usage and waste management. In addition to taxation, the implementation of other CE policies is seen as effective. Milios (2018) highlights the need for policy mix to attain CE goals, such as bans of unsustainable materials, extended producer responsibility (ERP) -policies making manufacturers accountable of the end-of-life of their products, eco-design regulations, reuse and remanufacturing policies and informative instruments such as labelling, certifications and public campaigns, an addition to taxation tools. When implementing a policy for comparable goals, harmonization is important in order to avoid fragmentation and inconsistency of the policies. A comprehensive approach is recommended. (Losa 2023). Chi and Yang (2024) studied factors affecting business compliance to sustainability compliance. Regulatory clarity and the level of enforcement were identified as drivers of compliance to public sustainability regulations. Clear regulations are crucial for businesses to understand their legal obligations. Regulatory clarity was found to encourages innovation and proactive measures in businesses in addition to willingness to comply. Ambiguous or inconsistent regulations lead economic operators to struggle to comply effectively. The non-compliance can be both unintentional and due to avoiding costly innovation. Mandatory regulations were found to be more effective when strict enforcement mechanisms were employed. Examples of enforcement mechanisms are regular inspections, penalties/fines and legal actions. A company's perception of the efficacity of the diligence mechanism and severity of retributions due to failure to comply were found to be key motivators for compliance to sustainability regulations. A company estimates the likelihood on being caught with non-compliance to be higher when a thorough and visible enforcement mechanism is in place. This mechanism combined with an economic cost that is deemed high enough as a consequence of non-compliance is effective in promoting to operate in accordance with sustainability regulations. Carefully designed and enforced legislative measures may be more effective in promoting CE practices than voluntary sustainability agreements, as voluntary agreements are vulnerable to commercial opportunism (Ko et al. 2012; Dong-hwan 2020).

Packaging design contributes to the success of a reuse system. Choices in packaging design affect the physical form and feature of the packaging. Packaging that is intended to be reused has to be designed for this purpose. Reusable packaging has to be durable enough to withstand multiple reuse cycles. The packaging has to be designed to withstand exposure during consumption and return and the other

processes in the reuse cycle, such as sorting and cleaning, without losing its material integrity. The durability extends to the packaging's capability of resisting smaller damages as well, such as scratches. (Tenhunen-Lunkka et al. 2024). The smaller damages are a hygiene concern but also affect the consumers' willingness to purchase a product in a reused container – a beverage in a visibly scratched container may not be as attractive to the consumer to purchase as an undamaged one. (Greenwood et al. 2021). The size of the beverage packaging affects its environmental impact. The volume a conveniently shaped package holds grows faster than its surface area, making bigger packaging more sustainable by volume unit of beverage. (Coelho et al. 2020). It may be hence argued, assuming that reusable packaging is more sustainable than recycled one, that if a variety of beverage sizes is available and only a part of the packages has to be reusable, smaller drinks should be provided in reusable packaging as the marginal sustainability increase by switching to reuseable packaging is higher. It may also be more logistically convenient for reuse due to the mentioned volume/surface are ratio, since a higher number of individual packages and packaging material may be transported and stored in a fixed space. Bigger containers are comparably more efficient to transport and store when crushed, which makes the containers unfit for reuse but suitable for recycling.

Standardized designs of packaging are often brought up as a solution to facilitate reusable packaging. Its advantage is that it simplifies steps in the reuse systems. Collection and initial storing may be better designed to accommodate the fewer different packaging types. Transportation may be more efficient as the packages may be more efficiently organized. Sorting is less complex and requires less complex machinery. Cleaning and sanitization may be more efficient as machinery may be specialized for fewer container types. Standardization enables the usage of a common pool of containers between manufacturers. This pool inventory simplifies the return logistics to the manufacturers and may help to lower packaging costs by enabling economies of scale. The redistribution may be streamlined for similar reasons. (Ada et al. 2023; Circular Economy Portugal 2021; Landi et al. 2021; Molina-Besch & Pålsson 2014). Standardization is the result of cooperation of supply chain stakeholders, and insufficient cooperation leads to outcomes that hinder CE measures such as packaging designs that complicate recycling and reusability (Ada et al. 2023).

Consumer engagement is a driving force for successful reusability systems. Consumer engagement is affected by motivation, accessibility, financial incentive and hygiene and safety concerns. Consumer willingness to engage in sustainable actions has been an increasing trend. However Greenwood et al. (2021) identified a gap has been identified between communicated intention to engage in reuse and actual behaviour. In their study, a significant number of participants expressed positive attitudes towards reuse, but practical engagement was limited. The limited usage was

influenced by perceived convenience, available infrastructure and familiarity of reuse systems. Addressing these hindering factors may narrow the identified intent-behaviour gap. The accessibility of collection facilities for the empty beverage packages to consumers affects how high the collection rate of the system is. If the collection facility network is comprehensive and usage is deemed convenient enough, collection rates are higher. (Linderhof et al. 2019; Konstantoglou et al. 2023). Financial incentives in reuse systems, such as DRS may increase participation in reuse systems (Abila & Kantola 2019). Beverages sold in reusable packaging has to be competitively priced compared to beverages in single-use packaging. The motivation of consumers to pay extra for the product to be in reusable packaging is limited, and a considerably higher price compared to products in single use packaging decreases the likelihood of a consumer purchasing the item and participating in a reuse system when both options are available. (Coelho et al. 2020). Hygiene and safety concerns affect consumer willingness to consume products with reusable packaging. Sufficient hygiene has to be communicated to the consumers, one way being with packaging that is not too damaged. (Greenwood et al. 2021).

Environmental factors are a balance of environmental benefits of the reuse system and environmental costs associated the processes involved in the reuse system. The most significant trade off in reuse systems are environmental advantages of decreased demand of virgin raw materials and smaller amount of energy consumed compared to the production of new packages on one hand and the negative environmental impact with additional need for transportation and energy consumption of processes such as sorting and cleaning. (Coelho et al. 2020). The environmental impact of material choices is discussed in chapters 2.2 and 2.3. Reuse systems and reusable packaging cause additional emissions from transportation. The used containers have to be re-transported to the manufacturers. Reusable packaging also occupies more space in vehicles compared to crushed packages that are intended to be recycled, decreasing energy efficiency. (Coelho et al 2020). The intended distance of distribution affects the environmental impact of reusable packaging and reuse systems. Reusable packaging is generally more heavy than single-use ones, and the added weight causes the net environmental benefit to decrease as the energy required for transportation is higher. (Morgan 2022). Morgan (2022) and Coelho et al. (2020) suggest preferring reuse systems for products where distribution distances are relatively short and recycled single use containers for longer distances. The choice of transport mode also affects the environmental impact of transportation. The additional processes in addition to backwards logistics in reuse systems, namely sorting and cleaning consume energy and resources such as water and contribute to the environmental cost. Using machine washing is preferable over handwashing for its water efficiency. (Coelho et al. 2020). The presented

environmental factors affect the net sustainability increase (or decrease) of reuse systems. The environmental benefits and costs need to be weighted when considering the implementation of a reuse system.

2.5 Financial incentives and deposit return systems

Financial incentives have been identified to encourage recycling behaviour. Abila & Kantola (2019) studied the effect of "pay as you throw" (PAYT) schemes to consumer's willingness to recycle. PAYT-schemes, where a predetermined sum of money is paid to the recycler of a particular waste item in a designated recycling point. Such deposit systems are implemented in Finland for beverage packaging made of plastic, glass and aluminium. 62,2% of respondents agreed that such incentives motivated them to recycle. The study identified that environmental risk awareness, belief in recycling benefits and availability of information were other significant drivers for recycling. Gibovic & Bikfalvi (2021) also found that financial incentives encourage recycling behaviour.

Deposit Refund Systems (DRS) are subtype of PAYT-schemes that have been proven to be effective in increasing recycling rates of beverage containers. DRS promote recycling by adding a deposit to the price of a product whose packaging is aimed to be recycled, such as a beverage. Consumer receives the deposit back when the container is returned to be recycled in a designated place. (Walls 2012). Linderhof et al. (2019, 843) characterizes DRS essentially as a tax and subsidy system, where the concerned products are taxed when buying them, but subsidized when they are properly disposed of. DRS for beverage containers are used in EU countries such as Finland, Denmark and Germany. Other major countries in the EU like France and Germany have not implemented it. (Roca et al. 2022).

The application of DRS systems in various countries has been found to be beneficial, nevertheless at an economic cost. Visgø (2004) conducted a cost-benefit analysis of the DRS system in Denmark for beverage containers made of PET, glass or aluminium. The findings revealed that the DSR has considerable social costs compared to its benefits. Social costs were caused by collection, sorting and transportation of recycled containers. Benefits were found to be environmental rather than economic. Comparably, the usage of containers as energy was found to cause smaller social costs. Linderhof et al. (2019) investigated the effectiveness of DRS in the recycling of small electrical appliances and batteries. The application of DRS was found to be effective in promoting recycling of the studied items. A novel DRS is more effective in increasing recycling rates in items where the current rate is relatively low, meaning that applying a DRS to items that are already recycled quite effectively has limited benefits. If the recycling rate of the item is relatively low, a DRS is effective in encouraging its recycling. Integration into existing infrastructure for rewarding recycling promoted

recycling behaviour. Increased costs to consumers and administrative costs of operating the DRS should be considered when designing DSR. Dace et al. (2012) also highlights the consideration of costs and balancing the costs with the intended benefit. Producers would face increased packaging costs due to service charges to cover DRS operations, leading to higher consumer prices. Balancing interests of all stakeholders, producers, retailers and consumers was found to be important to the success of the DRS. Costs should not exceed benefits. The benefits of DRS are also considered to be environmental rather than economic, in line with Visgø (2004) and Linderhof et al. (2019). Lavee (2010) argues that DSR has also worthwhile economic benefits in addition to environmental ones. Economic benefits include reducing alternative waste and disposition systems and the reduction in landfill usage. Lavee concludes that the total benefits are 35% higher than it costs and thus economically advantageous. An additional social benefit of recycling is that it generated jobs (Lavee 2010; Abila & Kantola 2019). Introducing a DRS for beverage packaging from scratch is a considerable investment (Dace et al 2013).

Konstantoglou et al. (2023) surveyed DRS effectiveness from a consumer's perspective in a pilot DRS system in Greece. Moral environmental motives were found to be key drivers in participation. The process was seen easy to understand, but the limited numbers of recycling points and technical issues of recycling points were drawbacks of the DRS pilot from consumers' perspective. For DRS to be a viable recycling system for beverage packaging, the network of rewarding recycling centres must be dense and reliable enough to be attainable and meaningful to consumers. Effective communication is also highlighted as a driver for adaptation for the public.

Individual compliance through producer-managed deposit-refund systems can be more cost-effective for producers, especially when packaging materials have a high recycling value. These systems offer better control over the take-back network, supporting sustainable practices and enabling producers to optimize recycling outcomes (Özdemir-Akyıldırım 2015)

According to the DRS expert interviewed as a part of this study, the administration of DRS may be organized in different manners. In Finland, the majority of beverage packages that are included in a DRS are recycled under the administration of Palpa Oy. Palpa is owned jointly by sizeable grocery retailers and beverage manufacturers and is in charge of the administration of the system. Palpa does not own DRS collection equipment or facilities for the recycling of the collected packaging. The organization is thus lean compared to an important Danish DRS operator. The Danish counterpart produces more inhouse solutions for DRS operations and recycling, and thus its staff is manifold. It is comparatively a more asset and cost heavy administration model. The DRS expert recognizes that

this heavier administrative model has the advantage of swifter and more effective implementation of novel ideas and processes. (DRS expert interview 2024).

2.6 Beverage industry in Finland

Main stakeholders in the beverage industry of Finland are beverage manufacturers, grocery retailers, DRS operators and the packaging industry. The biggest beverage manufacturers in terms of revenue are Olvi, Hartwall, Synebrychoff, Finnspring and Refresco. In addition to soft drinks, Olvi, Hartwall and Synebrychoff brew beer and other alcoholic beverages. Beverage manufacturers tend to have their production in one centralized facility, serving the whole market. (EY 2020).

Grocery retail is a highly concentrated sector in Finland. The top three retailers, S-group, K-group and Lidl Finland, with market share of 48,3%, 34,3% and 9,6% respectively, hold a market share of 92,2%. (PTY 2024a). Kiosks and other smaller vendors are a considerable retailer of beverages but are excluded out of the scope of this study since they are not included in the reusability requirements of the PPWR, further discussed in chapter 4.1. As of 2024, there are 2545 grocery retail stores that have a store space of above 100m^2 (PTY 2024b).

Suomen Palautuspakkaus Oy (PALPA) is the principal operator of the Finnish DRS. Oy Tomra Ab is an important manufacturer of machines used in DRS. (EY 2020). PALPA operates the DRS of S-group and K-group which represent together 82,6% of the grocery retail market. The majority of beverages sold in Finland are included in a DRS due to a packaging tax, which may be avoided by having beverages included in a DRS (Verohallinto 2024).

3 Impact of the Packaging and Packaging Regulation (PPWR) on the beverage industry

PPWR was formally adopted in in April 2024 by the European Parliament. The provisional agreement between the European Parliament, Council of the European Union and European Commission was reached on 4th of March 2024 (Council of the European Union 2024). The European Parliament and Council of the European Union agreed on some alterations to the Proposal for a regulation on packaging and packaging waste (PRPPW), which is the regulation document made by the European Commission that was presented to the European Parliament and the Council. In this chapter, the requirements of the PPWR that affect the beverage industry the most are presented and discussed. First the requirements in PRPPW are presented, and after that the alterations made by the European Parliament to PRPPW resulting in the agreed PPWR. The main results of the impact assessment (European Commission 2022b; 2022c) will be then explored. A theoretical framework on the supply chain impacts of the PPWR to the beverage industry is then presented, combining main points of the literature overview with legislative implications form the regulation.

3.1 Requirements of PPWR

3.1.1 Reusability requirements

PRPPW included the following reusability requirements for non-dairy and non-alcoholic beverages in Article 26, paragraph 6 (European Commission 2022, 71):

The manufacturer and the final distributor making available on the market within the territory of a Member State in sales packaging non-alcoholic beverages in the form of water, water with added sugar, water with other sweetening matter, flavoured water, soft drinks, soda lemonade, iced tea and similar beverages which are immediately ready to drink, pure juice, juice or must of fruits or vegetables and smoothies without milk and non-alcoholic beverages containing milk fat, shall ensure that:

(a) from 1 January 2030, 10 % of those products are made available in reusable packaging within a system for re-use or by enabling refill;

(b) from 1 January 2040, 25 % of those products are made available in reusable packaging within a system for re-use or by enabling refill.

The proposal includes multiple exceptions and clarification concerning these reusability targets. Micro-companies and other economic operators that place less than 1000kg of packaging on the market during the calendar year are exempted from the requirements (PRPPW Article 26 paragraph 14). Economic operators with a sales area of less than 100m^2, including all logistical areas, are exempted (PPWR Article 26 paragraph 15). Specific packaging formats are exempted if reaching the targets would risk hygiene, food safety or cause environmental issues (PPWR Article 26 paragraph 16). The proposal aims to protect small scale businesses for which the reuse targets could be economically unfeasible with these exemptions.

Article 27 of the PRPPW contains rules on the calculation for reaching reuse targets. Concerning beverages, the article states that final distributors shall calculate the number of units of sales of beverages that are made available in reusable packaging within a system of re-use and in other packaging in a calendar year. Article 28 orders that economic operators that bound by this regulation shall report to the competent authority data concerning attaining the reusability target in the correct time and format. PPWR amended that the calculation may be based on total volume of beverages in addition the number of units of sale.

The provisional agreement on PPWR had some alterations concerning the reuse targets. Importantly, reuse and refill were separated as targets, meaning that refilling beverage packaging do not count towards reuse targets. The agreement states that economic operators shall *endeavour* that at least 40% of beverages are made available in reusable packaging by 2040, a higher target than the proposed 25% but implying less severe consequences if targets are not met. Final distributors are ordered to contribute fairly to the targets with possible private label-beverages and to implement a return system. Importantly in the geographical scope of this study, final distributors may be operating in remote and sparsely populated areas may be exempted by the member state are exempted from the targets. Islands with less than 2000 inhabitants and municipalities of under 5000 inhabitants with a population density less than 54 persons/km^2. Paragraph 14 of the PPWR allows member states to permit final distributors to form pools between themselves to meet the reuse targets for beverages. These pools may not exceed 40% of the market share of the beverage category and is limited to 5 final distributors. The paragraph underlines that these horizontally collaborative pools need to comply with EU competition rules and may not be used to collaborate outside of meeting the reuse targets set by PPWR. (PPWR Article 26 paragraph 14). In the concentrated grocery retail market of Finland, such pools may not be advantageous to the two market leaders. This may however benefit smaller final distributors that are bound by the discussed reuse targets of PPWR.

3.1.2 Recycled content requirements

Proposition for PPWR (2022, 58) sets requirements on the minimum recycled content in plastic packaging. Article 7 states that by 1 January 2030, plastic parts used in single use plastic beverage bottles shall contain a minimum of 30% recycled content recovered from post-consumer plastic waste. By 2040, the requirement is 65%. The methodology for calculating and verification of recycled content is to be established later. PPWR (p. 96– 101) further specifies the requirements. The recycled plastic shall be collected in accordance with EU directives concerning plastic recycling. The recycled content shall be calculated as an average per manufacturing plant and year, instead of singular packages.

3.1.3 Deposit and return systems

Article 26 of PPWR requires that the beverages in reusable packaging shall be made available within a system of reuse. Article 44 of PPWR requires member states to implement deposit and return systems that collect 90% per year by weight of single use plastic and single use metal beverage containers with the capacity of up to three litres. Beverages which are consumed within the premises of HORECA services are exempt from the DRS requirement. The DRS requirements concern all the beverages in the scope of this study. The deposit is required to be charged at the point of sales. Member states reaching a collection rate of 80% for the concerned products are exempt from the DRS requirement. Containers that are smaller than 0,1 litres and bigger than 3 litres may be exempt from the DRS requirements due to technical constraints.

3.1.4 Penalties for failure to meet the requirements

The consequences for a failure to comply with the requirements of the Packaging and Packaging Waste Directive set by the directive are discussed in Article 62 of PPWR. The penalties shall be administrative fines. The imposed fines shall be *effective, proportionate and dissuasive*. While further specifications of the size of the fines are not provided by the directive, they are instructed to be severe enough to steer economic operators of the industry to act in accordance with the requirements. Chi and Yang (2024) found fines to be an effective method to promote compliance of sustainability regulations.

3.2 Impact assessment

As a part of the PRPPW, an impact assessment (European Commission 2022b; 2022c) was conducted. Legislators interacted with different NGOs and interest groups and their opinions are expressed in the

impact assessment. Concerning the reuse targets of the beverage industry a contrast between CE NGOs and industry interest groups is distinguishable, as illustrated by this extract:

> "NGOs stressed that reuse should always be the first option, while some industry stakeholders favouring in recent years single use (especially food and beverage industry or paper packaging industry) expressed that reusable product could lead to trade-offs in terms of food safety, food security, food waste risks or environmental performance. They were not very supportive of a general reuse target but are more open to differentiated targets by sector and type of packaging, and clearly opposed to 100% targets. A majority of stakeholders argued for mandatory instead of voluntary targets to ensure security of investment, to avoid undermining the single market through heterogeneous implementation and to enable economies of scale. Opposing views on target levels were expressed from 'not ambitious enough' to 'unrealistic and unachievable'." (European Commission 2022b)

Enforced reusability requirements are considered generally burdening by industry stakeholders, while environmental organisations support actions in accordance with CE principles, such as R-frameworks and waste hierarchy.

The impact assessment judges that mandatory reuse requirements are more effective than voluntary ones in promoting CE practices. The implementation of the targets is facilitated by suitable enforcement and appropriately sized sanctions in failure to comply. The reporting duties are recognized as an administrative burden. The investment needs to implement reuse systems are recognized to be sizeable. Stakeholders are not supportive of mandatory reuse targets. NGOs are expressed to be very supportive of ambitious mandatory re-use. Reuse systems, including products that are outside the scope of this study are estimated to have a 4 billion € economic impact by 2040. SME operators may experience difficulties in setting up required re-use systems and may be placed at an economic disadvantage. The impact assessment advises that smallest economic operators should be exempted from reuse requirements and that pools may be formed to reach targets by SME's. (European Commission 2022c, 394 - 400).

3.3 Framework for supply chain implications of PPWR

Based on the literature review, a research framework on the impacts of the PPWR on supply chain stakeholders of the beverage industry was formed (Figure 2). The identified phenomena from the literature, including responsibilities, impacts, decisions to make and solutions are categorized into stakeholder specific questions and questions concerning stakeholder collaboration. Additionally, legislative questions are grouped into their own category, as they simultaneously are a stakeholder of their own but concerns each stakeholder. The selected stakeholders in the theoretical framework are consumers, grocery retailers, reuse system operators, beverage manufacturers and the packaging

industry. The stakeholders in the framework are modelled after the generic reuse system for beverage packaging illustrated in Figure 1.

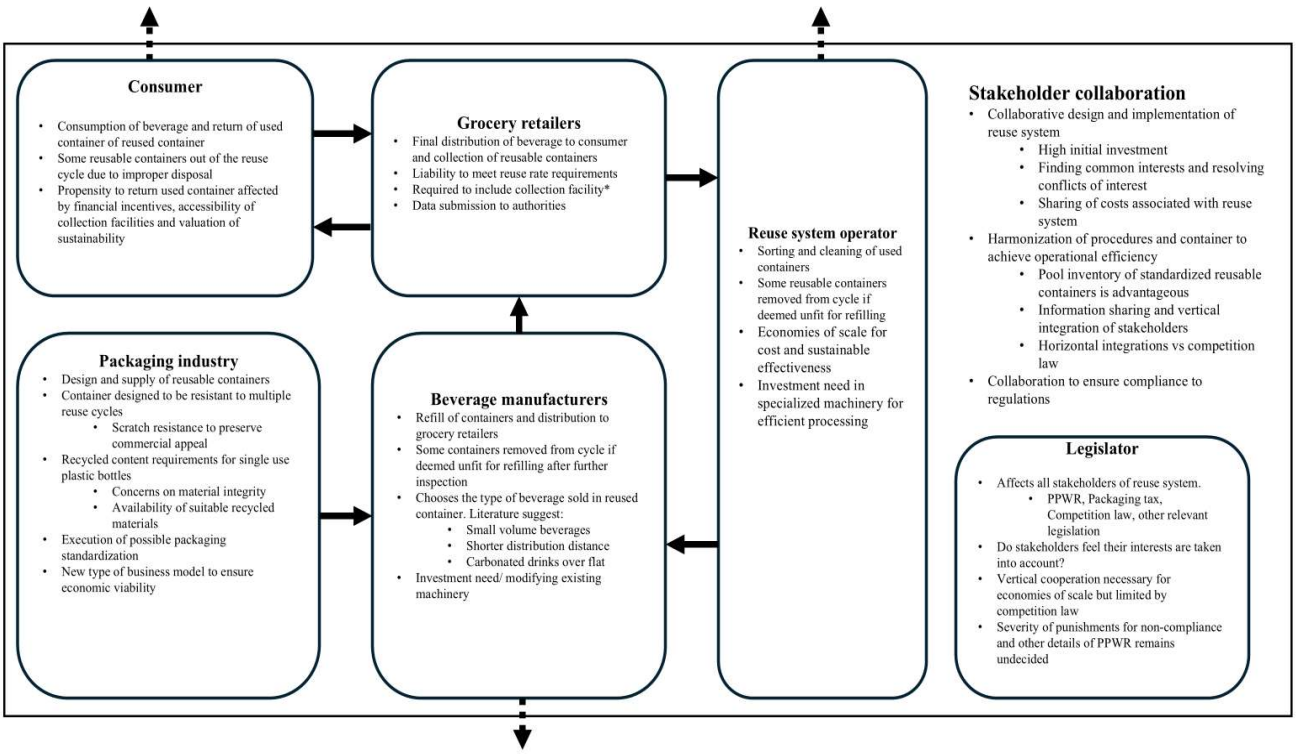

Figure 2 Theoretical Framework for supply chain impacts of PPWR to the beverage industry

The consumer stakeholder is the final consumer of the beverage and trusted with the return of the reusable or recyclable packaging to the collection facility of the reuse system. The consumers propensity to return the packages post consumption is affected by financial incentives, accessibility of collection facilities and the consumer's appreciation of sustainability. Some reusable containers are removed by this stakeholder from the reuse cycle due to improper disposal of containers. (Abila & Kantola 2019; Konstantoglou et al. 2023; Linderhof et al. 2019).

The importance of the reuse system operator stakeholder is dependent on the design of the reuse system and the decisions made by other stakeholders in it. Process steps in the reuse cycle may be performed by the other stakeholders, such as sorting by the grocery retailer and inhouse cleaning of used containers by beverage manufacturers. An alternative design are centralized facilities for processing the reusable containers, where the reuse system operator is more important. (Circular Economy Portugal 2021). Especially if a DRS is included to the reuse system, the reuse system operator may, at the very least, act as an administrative stakeholder that focuses on the validation of new containers to the system, logistical planning so that the correct bottles are transported to the

correct manufacturers and control the included cash flows (Circular Economy Portugal 2021; Linderhof et al. 2019). In a centralized model, the reuse system operator is a separate stakeholder that achieves economies of scale to process the reused containers efficiently. Sizeable investments are required to finance the machinery for the effective processing of containers. Inspection of the containers is performed during sorting and after cleaning, and containers that are deemed unfit for reuse are removed from the reuse cycle. (Coelho et al. 2020; Morgan et al 2022; Muranko et al. 2021; Dace et al 2013).

The packaging industry supplies the beverage market with packaging. The design of the containers is affected by the needs of the customers. This stakeholder of the framework includes multiple economic operators, such as raw material suppliers for packaging, manufacturers of preforms in PET-plastic bottles and marketers of ready-to-fill containers. Reusable containers need to be designed to withstand multiple reuse cycles. They need to have a sufficient material and chemical integrity and to have a degree of scratch resistance to retain commercial appeal. The recycled content requirements set by the PPWR on single-use plastic bottles may cause some concerns over the material integrity of the packaging. (Tenhunen-Lunkka et al. 2024). The availability of recycled plastics of sufficient quality may be a bottle neck, as recycled content requirements are adopted in a multitude of product groups as a result of sustainability regulations. The usage of reusable containers reduces the amount of packaging sold to the beverage industry if consumption is constant; this has to be considered in pricing, and the possibility of novel business models is an interesting subject to explore.

Beverage manufacturers refill the reusable containers and distributes them to grocery retailers. The usage of reusable containers may require some investments or alterations to existing machinery (Coelho et al. 2020). The beverage manufacturer influences what type of beverage is marketed in reusable containers. From a sustainability point of view, literature suggests that small volume, carbonated beverages that have limited distribution distances are the most efficient to be offered in reusable containers. Coelho et al. 2020; Morgan 2022; Ferrara et al. 2021). Some containers are removed from the reuse cycle if deemed unfit for refilling.

Grocery retailers perform the final distribution of packaged beverages to the consumer. The PPWR demands grocery retailers of sufficient size to include a collection facility for reusable containers, so the collection is performed at this stakeholder. The liability to meet the reuse targets is placed on grocery retailers. If they fail to achieve the targets, they suffer the penalties. They are also required to submit the relevant data to the correct authorities. (PPWR Article 26). The liability to meet reuse targets may require commercial action from grocery retailers. It may also be in the interest of the

liable party to cooperate with beverage suppliers so that the requirements may be attained in an effective manner.

In addition to stakeholder specific points of interest, many impacts and solutions of the beverage industry relating to the PPWR are dependent on stakeholder collaboration. In the theoretical framework, these are divided into the collaborative design and implementation of reuse systems, harmonizations of practices and containers to achieve operational efficiency and collaboration to ensure compliance with regulation. Collaboration in the design of reuse systems is affected by high initial investments, resolving conflicts of interests and sharing costs associated with the reuse system (Muranko et al. 2021; Dace et al. 2012; Circular Economy Portugal 2021). Standardization of containers and the usage of pool-inventories is presented as an effective solution to issues caused by reusable containers (Ada et al. 2023; Circular Economy Portugal 2021; Landi et al. 2021; Molina-Besch & Pålsson 2014). The importance of collaboration between stakeholders, both vertical and horizontal, is identified as an important facilitator of successful and efficient reuse systems (Ada et al. 2023; Molina-Besch & Pålsson 2014). The latter, however, is often limited by competitive law (Dunne & Maher 2020) and may thus hinder the necessary cooperation to achieve an efficient reuse system.

Legislative issues affect all the stakeholders in the industry. In addition to PPWR, other legislation such as competition law and in the case of Finland, packaging taxation burden and limit economic operators the market. As a result of the details on punishments for non-compliance to the PPWR remaining undecided, some uncertainty on the effects of the PPWR may affect stakeholders. This study does not address the legislative process or politics behind the PPWR, but the relation between economic operators and legislative bodies is still an important aspect to uncover to gain a comprehensive understanding of the topic.

4 Research methods

4.1 Research approach and methodology

The objective of this study is to form an understanding to the supply chain impact of the EU Packaging and Packaging Waste regulation. Quantitative data is scarce, as the subject of the study is dealing with a future phenomenon. Qualitative research is considered useful in situations where little is known about the subject (Eriksson & Kovalainen 2008). To form an understanding of possible consequences, a multitude of perspectives from different stakeholders need to be investigated. Qualitative research is suited to explore complex phenomena and is helpful in examining different perspectives. (Creswell & Creswell 2018). Therefore, qualitative research will be the research approach employed in this study.

The research method of qualitative studies should be chosen based their ability to provide answers to the study's research questions through analysis (Eriksson & Kovalainen 2008). Koskinen et al. (2005) divide the main categories of research methods for qualitative research as interview and observation methods, documents, narratives and conversational data. Creswell & Creswell (2018) and Hirsjärvi & Hurme (2008) find interviews are an effective method to gain insights into participant's perspectives, experiences, and motivations when conducting a qualitative research. Interviews are a common way in qualitative business research to collect primary data of the studied phenomenon. Interviews may be in a structured, semi-structured, and unstructured format. Semi-structured interviews include predetermined themes and are to some extent systematic and comprehensive between interviews, facilitating their analysis. However, they offer flexibility to probe deeper in interesting topics if they arise. (Eriksson & Kovalainen 2008; Eskola & Suoranta 2018). Semi-structured interviews are fitting for this research, as the explored major themes are outlined in the theoretical framework, but they enable gathering unanticipated insights from the interviewed experts if they arise.

This study uses semi-structured interviews to gain insights on the supply chain impacts from different stakeholders of the beverage industry. The interviews are aimed at professionals working for different stakeholders of the beverage industry identified in the literature overview. The chosen stakeholders are beverage manufacturers, grocery retailers, CE system operators and packaging manufacturer. The aim of the interviews is to gather insights from professionals of the field, confirming, contradicting or to further expand on the theoretical framework based on the literature overview and analysis of the

regulation. The results are analysed in relation to the theoretical framework with the objective of answering the thesis' research questions:

- RQ1: How will the Packaging and Packaging Waste Regulation (PPWR) impact supply chains and supply chain management in the beverage industry?
- RQ2: What are the plans of economic operators in the beverage industry to meet the requirements of the PPWR?

4.2 Research process

4.2.1 Preparatory phase

The research problem and objective were defined when the formal agreement and adaptation of the PPWR by the European Union in April 2024 seemed inevitable. Tough impact assessment of the regulations effects on the beverage industry were performed as a part of the RPPWD, the supply chain implications of such regulations to the chosen industry has not been widely addressed in academic literature, revealing a research gap. When it comes to force, the regulation will impose new requirements on economic operators in the industry and their supply chains. The uncertainty on the effects caused by the novel requirements was identified as a relevant research problem to address, from which the research objectives of uncovering the supply chain impacts and solutions of industry stakeholders was formulated. The research problem and objective were further defined after private conversations with industry experts and the supervisor of this thesis.

A literature review was conducted between September and December 2024 based on the identified research problem and objective. Following the increased understanding of the subject, a theoretical framework was developed on the subject on which the interview questions were based on. The need to interview experts of multiple stakeholders in the industry was identified as crucial to gain a holistic understanding of the studied subject. The interview questions, presented in the interview guideline in Appendix 1, included questions that targeted the interviewed stakeholder specifically and questions concerning collaboration of stakeholders that were asked from each interviewed expert. The questions were formed to explore the major themes that had arisen from the literature review and following theoretical framework, with the objective of gathering data with which the research questions could be answered. The interviews were planned in a semi-structured form with the preparation of an interview guideline with a limited number of questions, deliberately leaving time in the interview for arising topics and questions.

4.2.2 Collection of data

The data collection of this research was performed by conducting three interviews in the end of the November and beginning of December 2024. The interviewees, presented in Table 1, were selected from different stakeholders of the industry. The stakeholders in the theoretical framework, represented by Figure 2, are simplifications and not always fully representative of the market in practice, but consideration was given in the selection process to choose experts that are sufficiently representative of the framework stakeholder. The interviewees were approached in LinkedIn, by text message or by e-mail. In the inquiry, the purpose of the interview was explained, and the themes of the questions were given. Interviewees were informed that the interviews would be anonymized to encourage objectivity in their answers. The permission by the interviewee to record the interviews and to use direct quotations was confirmed before commencing the interview.

Interviewee name in study	Stakeholder in framework	Accurate stakeholder	Interviewee Title	Date of interview	Duration	Mode of interview (+location)
DRS expert	Reuse system operator	DRS operator	Director	28.11.2024	1h 12min	In person, Helsinki
Retail expert	Grocery retailer	Grocery retail chain	Development manager	2.12.2024	54min	In person, Helsinki
Packaging expert	Packaging industry + Beverage manufacturer	Recycling facility + packaging and beverage manufacturer	Chairman	9.12.2024	27min + 34min	2 phone interviews during the same day

Table 1 The interviewees with corresponding stakeholder name in theoretical framework, description of stakeholder in a real-world context, title of interviewee in their organization and other details.

An experienced director working at a sizeable DRS operator in Finland was selected to represent the reuse system operator-stakeholder of the framework and to answer corresponding stakeholder specific questions. Though not a reuse system administrator anymore, the DRS operator has past experience in standardized and reusable packaging solutions. The DRS expert's insight on circular economy practices in the beverage industry was judged to be more than sufficient to represent the discussed framework stakeholder in the scope of this study.

A development manager specialized in sustainability and packaging was chosen as the interviewee for the grocery retailer stakeholder. The company where the retail expert works is a sizeable grocery wholesaler. The company's business model does not include their own grocery retail stores. However, their customers that are privately operated grocery stores operate under the wholesaler's brands and have a close-knit relationship with it. Therefore, a representative of the wholesaler from this are of

expertise was judged to be sufficiently representative of the grocery retailer stakeholder and to possess valuable insight on this matter.

To represent both the packaging industry and the beverage industry, an entrepreneur working at multiple companies across the supply chain was selected. The group operates a recycling facility that specializes in recycling plastic bottles into rPET that is suitable as raw material for PET preforms. amongst others. The concern has considerable beverage production, chiefly in alcoholic beverages. Additionally, the concern also produces packaging for their own needs from their recycled rPET. This vertically integrated company's chairman was judged to be a desirable interviewee for its multi-tier experience.

The interviews were conducted as semi-structured interviews as was originally planned. All the questions in the interview guideline were presented, with additional questions outside of the guideline presented by the interviewer to further elaborate answers if needed. The semi-structured format proved itself to be an effective way to methodically go through the themes from the study's theoretical framework with pre-planned questions, but ensuring greater freedom to gather in-depth insights from arising subjects, sometimes even unexpected ones.

The interviews were recorded using an electronic recorder. After the interviews, the interview recordings were transferred to two password protected clouds, the university cloud software Seafile and a personal Onedrive file, after which they were deleted from the recording device. The recordings were then transcribed with the assistance of a transcribing software Otter.ai. During the transcribing process, the interviews were anonymized. Interviewee names were replaced by the names presented in the list. Company names were also given generic describing names in the transcripts. After transcribing the interviews, the transcripts were stored in the above-mentioned clouds and deleted from the transcribing software.

4.2.3 Analysis of data

Eskola & Suoranta (1998) find thematical analysis as a suitable data analysis method to solve practical problems. If the research design includes a clear and practical research problem, thematical analysis is helpful in extracting relevant data from the bulk. Thematical analysis facilitates in raising a collection of solutions and results to the explored research questions. Therefore, the results from this analysis serve practical interests the best. Tuomi & Sarajärvi (2018) find thematical analysis to be an effective method to split and categorize qualitative data in arising themes. It is thus possible to

compare the presence of a specific theme in different materials or interviews. The idea is to find views and answers from the interview material that describe and belong to a certain theme.

Due to the qualitative nature of the study and the inclusions of practical research problem concerning the supply chain effects of PPWR, thematic analysis was chosen as the data analysis method for the interview material. The analysis process followed the guidelines for material-based content analysis of Tuomi & Sarajärvi (2018). The material, which is three interview transcripts from different stakeholders in the beverage industry, was thematically analysed using MS Word. The material was first explored in a general manner. Then, citations tackling a certain predetermined theme from the theoretical framework or arising theme were found and highlighted with different colours representing the various themes. Citations belonging to different themes were then collected in separate lists by said theme. If a citation was fitting to multiple themes, it was assorted in multiple groups. This completed the reducing of data, which is necessary in qualitative analysis (Tuomi & Sarajärvi 2018). Following the grouping of citations into initial general themes, one theme at a time, the citations were examined. Possible similarities and differences concerning a certain topic or theme were then searched between the different transcripts. Citations within the identified general theme were then categorized in subgroups, and these subgroups further into fitting bigger groups, and thus main themes from the material was derived. Some identified main themes were adjacent to the themes of the theoretical framework, while others were from outside the framework, which was a desired outcome supported by the employed semi-structured research method.

The data analysis and conclusion of the research were performed in December 2024 – January 2025. After the thematic analysis of the interview materials, the results were presented in chapter 5. The results are divided by theme and follow a similar challenge-solution structure that is used in the research questions. The empirical results were then compared to the studied literature in chapter 6. The most significant differences are summarized in a solution framework presented in chapter 6, which uses the theoretical framework as a basis. The research questions are answered combining results from literature and empirical data form interviews.

4.3 Research quality

Eriksson & Kovalainen (2008) present reliability and validity as two classic criteria for assessing the quality of a research. Reliability in the context of qualitative research refers to the consistency of the study. A reliable study would provide similar results for one subject if the same study is conducted again, i.e. the study is replicable. Another way to judge the reliability of a study is if two independent analysts would reach the same conclusions based on the same results. Therefore, it is important that

research actions are documented appropriately. (Eriksson & Kovalainen 2008; Hirsjärvi & Hurme 2008). In this research, the reliability of the research was performed by documenting the research actions. The research process is presented in chapter 4.2, starting from the preparation of the research, data collection and data-analysis. The interviews were recorded and transcribed and then stored in two separate locations. The supervisor of this thesis was given the right to inspect the recordings and transcripts. The documents used in the thematic analysis were also stored in an organized manner. The materials were stored till the approval of the study by the Department of Marketing and International Business of Turku School of Economics. Additionally, the choice to interview only experts from relevant stakeholders adds to the reliability of the study. The interviewees experience in the industry ranged from 7 to + 20 years, which increases their credibility. It should be noted, however, that a qualitative study only reflects the subjective opinions of the subjects. The limited number of interviewees, of which all represent different stakeholders, decreases the reliability of this study. To attain a greater reliability, multiple experts from each stakeholder should be interviewed to assess if the stakeholder specific answers are representative of the group or the individual interviewee. However, due to the practicality of the research problem and questions and the business-oriented approach of the interview questions and selection of interviewees, the replicability of this research is assessed to be sufficient.

Validity assesses whether the conclusions made in the research portray and explain the studied phenomenon accurately enough. It judges the truthfulness of the findings, and the evidence presented to justify the conclusions. (Eriksson & Kovalainen, 2008). Validity may be divided into predictive, structural, internal and external validity. Predictive validity denotes the capability of the research observations and results to predict outcomes of future research. Structural validity assesses if the theoretical, methodological and conceptual choices are appropriate for the research. Internal validity refers to how causalities are isolated in the research, meaning that cause and effects are correctly identified, and other possible causes are ruled out. External validity refers to the general applicability of the results or if the findings may be generalized to a wider theory. (Hirsjärvi & Hurme 2008). In this study, structural validity was increased to choosing correct research methods for the studied phenomenon. Research methods for this study, such a qualitative semi-structured interviews and the usage of thematic analysis for the material were chosen based on epistemological literature referred by University of Turku faculty members. The choices are explained with references in chapter 4. The internal validity of this research is enhanced by interviewing multiple experts instead of one concerning the same theme and with interview questions aimed to uncover the interests of the interviewee, which aids in source criticism. Additional research choices enhancing the validity of this

study is basing the interview questions on the conducted literature overview and specifying the topics that the interview will address to the interviewee before conducting the interview.

5 Results

In this Chapter, the results of the thematical analysis performed on the interviews are reviewed. In line with the theoretical framework, the results are grouped under the following themes: stakeholder collaboration, legislative issues and stakeholder specific challenges and solutions to PPWR. Additionally, themes that emerged outside of the framework are explored in its own section. Further conclusions and discussion as well as theoretical contributions are presented in Chapter 6. In this chapter, the interviewees will be addressed by the following acronyms: DRS Expert as DE, Retail Expert as RE and Packaging Expert as PE. It is worth noting that PE has also professional experience in beverage manufacturing, so their insight will be used for topics concerning the beverage manufacturer stakeholder.

5.1 Stakeholder collaboration in a reuse systems of beverage packaging

5.1.1 Investment needs

The interviewee all agreed, in accordance with the studied CE literature, that the investment needs to create a reuse system for beverage packaging are considerable. RE stresses that the additional required storage room required to store the reusable containers is a burdening challenge in limited floor space. This is supported by DE. While recycled containers may be crushed directly after their return, reusable containers may not. Currently, the backrooms of deposit return systems that are included in grocery stores are sized to contain crushed containers for recycling. The reuse requirements increase the need for storage in these backrooms, which require investments. On top of the costs caused by this upgrade in storage capacity, allocating floor space to storage instead of commercial usage may be considered an indirect cost of the PPWR sustained by grocery retailers. RE judges that the added labour costs in operating the collection facility is comparatively less important than the spatial consequences discussed before.

The investments needed to clean and sanitize the returned containers were judged by DE and PE to be sizeable. DE described these investment needs as a *heavy issue*, PE highlighted how expensive this investment is. DE recognizes that the investments on cleaning equipment burdens different beverage manufacturers asymmetrically depending on their market share:

> "…if everybody has mandate to be part of the fulfillable system, for the bigger breweries, they have more resources to invest. But going down to the small breweries, small operators, small producers, they have different position in the market to invest, especially when the machinery or the production line. I guess there are small scale systems or there are big scale systems. But anyway, investment is an issue. Talking about the production

> volumes in breweries, if you have 2 million bottles, or you have 200 million bottles to refill or wash, the investment payback is absolutely different way. ” (DRS expert, 28.11.2024)

This view is strongly supported by PE. The cleaning machinery investments are described as expensive, especially for small scale operators. PE also argued that cleaning reusable containers requires considerably more water, energy and chemicals than the cleaning of recycled plastic bottles that are shredded. It is worth noting that PE has a business operating in the plastic recycling market and may not in this way be completely unbiased in analysis comparing reusable containers to recyclable ones. The asymmetrical burden of novel investments linked to the reuse system may according to the estimates of DE and PE lead to opportunistic behaviour concerning the centralization of reuse operations. This will be further discussed in Chapter 5.1.2.

In addition to the above-mentioned investment needs DE noted that existing refilling machinery may need modifications to accommodate the usage of reusable containers. This may be seen as an investment linked to the creation of a reuse system. The implementation and usage of this updated machinery is supported by experienced employees at beverage manufacturers according to DE. They have know-how from the time when some beverages were still sold in reusable containers in Finland.

These investment needs raise the issue on how the financial burden is shared between supply chain stakeholders. The interviewees agreed that each stakeholder will likely finance the investments that concerns them. RE found it natural that grocery retailers will finance the collection facilities and initial sorting of the containers. DE and PE are certain that the investments required to clean and sanitize the containers will be financed by Beverage manufacturers, regardless of the location of the cleaning machinery: in-house or in centralized facilities. RE also judges the costs associated with cleaning and backwards logistics should be directed to beverage manufacturers. The division of the financial burden is thus solved by not excessively dividing the burdens between stakeholders at all. While discussing sharing the financial burdens of the reuse system, RE noted that *the consumer pays, at the end*, meaning that eventually the extra costs associated with a reuse system will translate in higher store prices the beverages with which the costs will be covered. All the interviewees agreed that a collaborative operator for the administration and information management of the reuse system and DRS is beneficial, even necessary. The division of costs generated by this operator will be a matter of negotiation, but nevertheless this part of the reuse system will likely result on cost division.

5.1.2 Centralized facilities vs. in-house solutions

The execution of added process steps of reuse systems compared to recycling systems, notably sorting, cleaning and backwards logistics is a challenge set by the PPWR to the industry. The studied literature seems more favourable towards centralized facilities where the sorting and cleaning steps of the reuse cycle are performed compared to in-house solutions as a solution to this challenge (Figure 1). The identified benefits are sustainable and operative efficiency, reducing the environmental and economical burden of such systems.

The interviewees agreed that the execution of these process steps is challenging. Concerning centralization as a solution to this challenge, they had mixed estimates on the benefits of centralized models and likelihood that such facilities will be created.

DE judges that centralized facilities would provide economies of scale and make the processing of containers more efficient. Centralized facilities are seen especially attractive to small scale beverage manufacturers, who may have limited capabilities to invest in the suitable machinery. The downside of centralization is possibly increased logistical complexity if the supply chain configuration of such a system is poorly designed. A potential hygiene issue is identified: cleaned and sanitized bottles may be contaminated during the transportation to the beverage manufacturer from the facility. DE estimates that some manufacturers may feel a loss of business control if parts of the process are performed by external entities. DE notes that external stakeholders will likely include a profit margin to their service and thus increase costs. Beverage manufacturers with sufficient means to invest in in-house solutions may calculate that performing these steps in-house may be more cost effective and thus a more attractive solution compared to centralized models. In-house solutions eliminate the hygiene concern of centralized facilities and provide better control over these process steps. The downsides of in-house solutions are higher investment costs. Smaller manufacturers with limited volumes may experience limited capacity utilization form their investment, increasing the unit cost of containers that are cleaned.

The likelihood that beverage manufacturers will employ centralized facilities as a solution to the discussed process challenges depends on factors concerning the standardization of containers, possible competitive actions of manufacturers and the alignment of interests. If reusable beverage containers are standardized, centralized facilities may be found to be the most cost-efficient solution due to decreased logistical and operational complexity and thus a more likely solution. If, however, beverage manufacturers wish to keep using heterogenous brand packaging, in-house solutions are more likely. DE seems to find that the existence of efficient centralized facilities is dependent on top

manufacturers participating in it and supplying it with enough volume to be economically feasible. Competitive interests may also act as a barrier to collaborative solutions to the challenges of PPWR. Big manufacturers may identify the asymmetrical capability of different sized competitors to invest in required machinery. If economically viable centralized facilities are dependent on the participation of high-volume manufacturers and smaller manufacturers might struggle to implement cost-efficient in-house solutions, it may be in the interest of big manufacturers to choose in-house solutions, denying smaller competitors the advantage of cost-efficient centralized facilities to gain market share. DE summarized the decision-making logic of beverage manufacturers concerning this topic to them acting in accordance with their interests. Economic operators are willing to cooperate if it is their interest and unwilling when not.

RE did not express strong favour for either model, communicating that this matter is not a top concern of grocery retailers. However, RE presumes that centralized washing facilities may provide efficiency gains, both economic and environmental. From the point of view of the grocery retailer, centralized facilities with sorting are estimated to reduce logistical complexity. Instead of sorting the containers in-store and handing them over to the carrier that transports them back to separate manufacturing locations, the containers may be transported directly to one destination where sorting is completed. Comparably to DE, RE highlighted that the decision belongs to the beverage manufacturers, and the configuration to process the reusable containers will be influenced mostly by their business interests. Cooperation is possible when interest of different parties is sufficiently aligned.

PE recognizes the economies of scale and following reduced cost-per unit as advantages of centralized models. Cost savings is mentioned as the single most prominent advantage. Small-scale manufacturers may benefit from this model the most due to their limited capability to invest in in-house solutions. Centralized sorting is also estimated to reduce logistical complexity, further supporting the views of DE and RE. PE also judges that large-scale manufacturers may also choose to favour in-house solutions if it is in their interest as they have a better capacity to invest in cost-effective solutions this way. PE agrees that there is a possibility that these manufacturers may choose in-house solutions to deny the advantages of centralization to smaller manufacturers, but unlike DE, RE finds it possible that smaller manufacturers may produce enough volume that centralized facilities are economically feasible. In unison with the other interviewees, PE sees that the willingness to collaborate is driven more by business needs rather than sustainability goals.

5.1.3 Standardization of containers

The studied literature recognizes strongly heterogenous packaging in reuse systems to increase logistical complexity and thus act as barrier for their efficiency. As a solution to this challenge, literature suggests decreasing the variety of container types by standardizing containers. Standardized containers enable the usage of pool inventories, a more advanced harmonization action. Pool inventories of standardized bottles are recognized by the literature as the most operationally efficient packaging solution for reuse systems. The interviewees all identified the benefits of standardized containers, expressing strong support for their usage in reuse systems. Pool inventories were also recognized to be a beneficial model. However, the interviewees identified barriers for the standardization of bottles linked to competitive measures of beverage manufacturers.

All interviewees agreed that a large variety of containers are a challenge in creating an efficient reuse system. Logistical complexity caused by the wide-spread usage of brand bottles and resulting variance of bottle designs was identified by all interviewers as challenging to implement a successful reuse system. DE noted that in a recycling system, the brand bottles cause no considerable issue as long as it is compliant to the constraints set by the DRS collection machines.

All interviewees stated that sorting is challenging with heterogenous containers. They all identified that using reusable brand bottles burdens grocery retailers by increasing the sorting needed at the store. In the past reuse system in Finland, containers were first sorted in-store and then transported to the beverage manufacturer directly, as recalled by PE and DE. Some containers were standardized, but the usage of reusable brand bottles was widespread. PE reminisced that the past reuse model with brand bottles resulted in inefficiencies. The precision of the initial in-store sorting was limited, since the grocery retailer was not incentivized to allocate extra resources to the process step. This resulted in brand packaging often being transported to the incorrect manufacturer, requiring further sorting at bottling facilities. PE recalled that a multitude trucks were constantly transporting the resorted containers to the correct destination between manufacturers. This extra transportation is judged to be wasteful, especially due to the transported loads being light regarding their volume.

DE analysed that the market conditions in Finland for the retail sales of beverages makes the usage of reusable brand packaging especially challenging for beverage manufacturers that are not a part of the *big three*. The market is determined by small volumes combined with long distances of distribution. Small-scale manufacturers, more than a hundred companies spread across the country, make their products available in thousands of retail stores distributed across the country. The sales volume per individual store and consequently the volume of returner containers is limited.

Manufacturers generally resort to one bottling facility supplying the whole market with their products due to the limited size of the market, where the reusable containers ought to be returned in a reuse system. The sparse and decentralized population results in comparatively long transportation distances. This combination of a large amount of small volume manufacturers and collection facilities distributed across the country over long distances makes the sorting and logistics of reusable brand bottles highly challenging. DE finds it difficult that this logistical challenge could be organized in a sustainable manner, both costs-wise and environmentally.

PE and DE find that standardized bottles and the usage of pool inventories are an efficient solution to the logistical challenges described above. DE judges that due to logistical challenges caused the local market conditions, small-scale manufacturers will very likely choose standardized containers over brand bottles. DE judges that even the market leaders may resort to standardized bottles to simplify the involved logistics. After all, the costs associated with backwards logistics and attached process steps will be targeted to the beverage manufacturers. The most important advantage of standardization and pool inventories according to DE is its cost-efficiency. The choice will ultimately be based on the calculations of beverage manufacturers weighing the commercial benefits of brand packaging against the costs generated by the increased logistical complexity. The manufacturers will choose the option that they estimate will benefit them the most.

As contrast to the analysis above, DE estimates that in central Europe the market conditions enable the usage of brand packaging in a reuse system in a comparatively feasible way. The higher population density increases volumes and enables a decentralized bottling configuration. As a result, transportation distances are shorter and brand packaging of a certain manufacturer may generate enough volume to be transported by economically and environmentally sensible full truckloads. If the manufacturers judge that brand packaging is a beneficial commercial choice, they may choose to use them under these market conditions.

PE displayed strong support for standardized bottles. Being involved in comparatively small-scale beverage manufacturing themselves, PE judges the benefits of standardized packaging, pool inventories and centralized facilities to outweigh the commercial benefits of brand packaging significantly. In parallel with DE, PE identifies cost-savings due to reduced supply chain complexity as the main benefit of standardization of packaging. PE presented an even more in-depth harmonized and centralized solution to smaller manufacturers: co-owned bottling facilities where the cleaning and refilling of reusable standardized containers is performed. The advantages of such a facility were sharing the burden of investments in machinery and reduced unit costs of cleaning and refilling

containers as a result of economies of scale. PE does not find it likely that big manufacturers would partake in this type of collaborative bottling facility, because it would provide advantages to their competitors when they have the capacity to invest in in-house solutions.

RE expressed support for standardization as a feasible and efficient solution to the challenges of reuse systems using brand bottles. Standardization would considerably reduce the need for sorting and logistical complexity. RE focused more on the advantages of standardization brings to grocery retailers by decreasing the need for sorting at the collection facility but noted that beverage manufacturers may find this solution to be in their interest as well. In addition to cost savings from reduced logistical complexity, RE stressed the sustainability benefits caused by it.

RE's support for standardized bottles is best displayed by this answer when questioned if the interviewee sees the usage of standardized bottles and a pool inventory as likely:

> "Yes, it is the most likely solution in what I can at this point predict." (Retail expert, 02.12.2024)

However, RE displayed caution when questioned if the reuse system could use brand bottles according to their estimate, RE did not completely disregard the option:

> "…in case other efficient way of fulfilling the requirement is presented, other other solution might be possible. But I don't see any, I don't see any efficiency in different designs. Or... but it's on a retailer mindset, it doesn't make probably a lot of difference if the bottles are different" (Retail expert, 02.12.2024)

Similarly to their point of view to the centralization of the reuse process, RE underlines that ultimately the decision on standardization depends on the beverage manufacturers and their willingness to cooperate. Grocery retailers may provide suggestions to manufacturers, but due to the costs associated with sorting and backwards logistics being likely directed at the retailers suppliers and not the retailer itself, the issue does not concern the retailers as profoundly.

All the interviewees feel that brand bottles offer manufacturers an opportunity to differentiate their products from competitors and thus provide a commercial advantage. This commercial advantages is identified by all interviewees as a possible hinrance to the adoption of standardized packaging whicha has been estimated by CE literature and confuirmed by interviewees to be an effective solution both sustainably and form a cost perspective. The experts have however mixed estimates on the probability that beverage manufacturers will determine brand bottles' commercial beenfits to outweigh the downsides of it and choose to offer their products in reusable brand bottles. RE finds that suppliers will unlikely choose brand bottles in light of the disadvantages to it. DE and PE find this choice

amongst larger manufacturers to be more probable than RE, but not certain. DE and PE both recognize that commercial pursuits linked to differentiation may lead larger manufacturers with bigger brands to offer their products in brand bottles. The probability of this is again highlighted to come as a result on the cost-benefit analysis of manufacturers and acting according to their interest. Comparably to cetralized facilities, suppliers are willing to cooperate and take part in standardization if it is in their bes interest.

In the past, some beverages where part of a reuse system using a pool inventory of standardized bottles, *Ekopullo*. The gained experience and know-how from this solution is judged by all interviewees as a factor that facilitates the re-implementation of a pool inventory of standardized bottles for a reuse system. DE and RE noted that the Ekopullo association still exists under the administration of a leading Finnish DRS operator. The existing solution and association would streamline the implementation process if manufacturers choose this alternative, acting as a driver towards this solution. DE finds that the experience of administering a pool inventory is an advantage compared to countries with no similar experience. DE assessed that beverage manufacturers have long-time employee with experience from Ekopullo. This human capital would facilitate the reimplementation of standardized reusable containers in a reuse system on the manufacturer's facilities.

5.1.4 Alignment of conflicting interests

CE literature finds vertical and horizontal collaboration of stakeholders to be necessary to guarantee the success of a reuse system. However, collaboration is hindered by conflicting interest of different stakeholders.

All interviewees identified conflicts of interests between industry stakeholders that may affect the collaborativeness of stakeholders. DE and PE recognize that the competition between beverage manufacturers is a barrier to horizontal collaboration, effecting for example their willingness to partake in centralized reuse facilities and adopting standardized packaging solutions. DE conjured that grocery retailers and beverage manufacturers may have conflicting interests in their view of the most efficient way to achieve the reusability requirements set by PPWR, concerning which beverages to offer in reusable containers and which ones to offer in recyclable ones. RE admitted that grocery retailers and suppliers may have some misaligned interests, but they may be resolved by negotiations. DE implied that beverage manufacturers and grocery retailers have additionally conflicting interests with DRS. It is in the interest of beverage manufacturers and grocery retailers that their products are exempt form packaging tax by being a part of a DRS. However, DRSs need to control attributes of

containers to ensure operational efficiency. This sets constraints on packaging designs which is not the interests of manufacturers.

All interviewees agreed that collaboration is necessary to implement and operate a successful and viable reuse system. RE finds that most of the solutions to address the challenges of implementing a reuse system is *a matter of cooperation*.

As a solution to resolve the above-mentioned conflicts of interests and to promote the necessary collaboration between stakeholders, interviewees expressed strong support for collaborative operators for DRS and reuse system administration that is co-owned between different stakeholders. DE and RE represent stakeholders that are involved in a co-owned DRS. DE describes that the collaboration between involved stakeholders is *very deep*. Co-ownership ensures a degree of equity between stakeholders if sufficient neutrality procedures are in action. Neutral treatment of stakeholders is beneficial in promoting collaboration between parties. Co-ownership serves as a mean to align interests of stakeholders that may be conflicting. PE finds using collaborative models to the challenges of PPWR is reasonable. RE estimates that the level of cooperation between parties involved in the DRS is good. RE finds that a co-owned DRS operator to be one of the key stakeholders when cooperating with different groups of interest and should be a driving force for all involved stakeholders *to come together with this matter*. RE's supporting views of a co-owned DRS + reuse system administrative operator are again visible from the following answer to the question "How should the cooperation of stakeholders be arranged to facilitate the design and implementation of reuse system?":

> "It is made for similar situation before to make this returning scheme. So I think it's really natural that Finnish DRS Operator is, is the one that arranges the forum for us to go get together and talk about this and work on this together." (Retail expert, 02.12.2024).

Benefits of co-owned administrative models in aligning conflicting interests were identified: DE, representing a DRS operator themselves, identifies that co-owned models facilitates discussions and the negotiations between parties. This is supported by RE, who underlines the beneficial effect on cooperation from this model in multiple occasions. Concerning on question and possible conflict on what beverages should be offered in reusable containers, RE estimates that the DRS operator will be crucial stakeholder facilitating decision making by taking everyone's views into account and finding a compromise that each party will be content with. The model facilitates negotiations between parties. When asked if RE feels that co-owned DRS and reuse administrative models are a likely option, they demonstrated their strong support for it with the following answer:

> "Yes, I, in my opinion, it's the only solution, the centralized model. And that it's good that in Finland we are, we have, as I mentioned, Finnish DRS Operator and reusable food container solution. We are... we have done good cooperation with similar things before."(Retail expert, 02.12.2024).

The importance of a neutrality of co-owned DRS operators was heavily stressed by DE. If a stakeholders feel that the operator acts in a neutral manner, their willingness to partake in the system is enhanced. On the contrary, if the action of the operator is felt to be biased, stakeholders may estimate that there is a possibility for the operator to favour other parties at their expense. This risk results in decreased willingness to participate in this collaborative solution. The neutral stance of the DRS operator is illustrated with the following quote by DE:

> "…But then we also have our, let's say, "one rule for everything" -rule here that we don't make any rules different rules for different parties." (DRS expert, 28.11.2024).

Expecting parties to comply to the rules that have been collectively agreed upon without making exceptions serves as a basis for the neutrality policy that increases willingness to cooperate. Other neutrality measures that DE described are facilitating effective communication and integration, allowing equal access to shared systems for members and resolving conflicts of interest by negotiating and compromising.

DE and RE both agreed that the discussed model for administering the DRS and reuse system is a possible solution only when parties feel that being a part of it is in their best interest. If parties estimate that not partaking in this collaborative model is not in their interest, they are less willing to collaborate. The starting point of such a model is that different stakeholders feel a need for it, summarized DE. Parties are more likely inclined on partaking in it if the model's offering is attractive enough, which constitutes of a lighter administrative burden, enhanced flow of information, a streamlined negotiation process and subsequent cost savings.

5.2 Legislative issues

The interface between relevant regulation and affected economic operators were investigated in the interviews. Three affective outcomes were identified: 1) uncertainty caused by the undefined parts of the PPWR, 2) dissonance from perceived necessity of collaboration between stakeholders limited by competitive legislation and 3) dissatisfaction in the reuse requirements.

During the interviews, PPWR was under corrigendum, meaning that some alterations to the regulation were still possible (European Parliament 2024). DE and RE expressed that this ambiguity causes uncertainty and inhibits the degree of planning of stakeholders to prepare for the implementation

PPWR. When the stakeholder's level of planning for the PPWR was inquired, RE expressed that the planning is at a general level. More detailed planning awaited the result of the corrigendum. RE assessed that generally, corrigendum does not result in significant alterations. However, in the context of the corrigendum and resulting alterations to the EU deforestation regulation (Reuters 14.12.2024), which were at the time of the interview recent and judged to be a *total mess* by RE, the degree of perceived uncertainty over the final form and implications of the PPWR were consequently high. As a result, the planning for actions for PPWR requirements is inhibited. Both DE and RE expressed a hope that interest groups could still influence the regulation in their favour, but significant alterations were judged unlikely. DE also noted that their preparations are inhibited by the uncertainty caused by the final form.

The discrepancy between the need for collaboration and competitive law limiting collaboration was an identified theme in the interviews. DE points out that rules on collaboration between retailers are included in the regulation but lack clarity since the rules lack details on how the market shares are measured. It is difficult at this point to estimate if the competition law allows enough room for collaboration that would result in an efficient reuse system. However, DE noted that competition law may enhance the collaboration capabilities of small economic operators by discouraging market-leaders to exclude them from collaborative solutions in an unfair manner.

RE stressed that due to the concentrated nature of the Finnish grocery retail market, all cooperation between REs employer and its competitors demands caution to remain compliant with competition law. RE highlights that they are keen on complying with all regulations, and always double check possible compliance issues of vertical collaboration with a retail interest group to continue operating in a law-based manner. Despite being competitors, RE notes that they have collaborated with their main competitor in other projects, meaning grocery retailers are open to collaboration if it in their interest and if competitive law allows them to.

All interviewees expressed a degree of dissatisfaction concerning the reuse requirements of PPWR. The cause of the are comparable: reuse systems are perceived as less efficient than recycling systems and the investing and operating the system is considered somewhat burdensome. DE explained that they have lobbied against reuse targets during the legislative process by communicating how the existing model in Finland that promotes DRS with a packaging tax results in high collection rates and that the collected containers are efficiently recycled. DE notes that concerned stakeholders feel that the return to using reusable containers is a step back in progress. RE suspects that a reuse model will be less sustainable than the current system. PE expressed the strongest dissatisfaction with the reuse

requirements. PE described how they personally lobbied against reuse in favour of recycling. They proposed increasing recycled content requirements as an alternative to reuse. DE and PE both estimate that entities from bigger EU Member States such as France and Germany, that have more widespread reuse systems in use, influenced the regulation in their favour. All interviewees stressed that despite their dissatisfaction with the reuse targets, they will comply with the regulations.

Concerning recycled content requirements of PET bottles, PE estimates that some economic operators may engage in fraudulent behaviour. Due to present market conditions where virgin PET is less expensive that rPET, some opportunistic stakeholders in the packaging industry may attempt to process cheaper virgin PET to make it appear as rPET and unlawfully place it on the market as rPET. PE underlines that credible enforcement is necessary to ensure compliance and discourage fraudulent behaviour. In order to enforce the requirements and discourage unlawful behaviour, audits need to be performed systematically at the right stage of the supply chain and the sanctions need to be sufficiently severe.

5.3 Stakeholder specific challenges and solutions to PPWR

5.3.1 Reuse system operator

Advanced CE practices like DRS and reuse systems increase administrative burden. Their function requires sharing information and collaboration between different stakeholders in the industry. Stakeholder interests are not always aligned, and CE practices generate costs but no significant commercial benefits. The increase of administrative burden and sharing costs related to advanced CE practices is challenge the beverage industry will face due to PPWR.

Literature suggests collaborative models as a solution to resolve these issues. DE, RE and PE all agree that co-owned collaborative CE models are an effective way to resolve the described challenges. They facilitate cooperation and information sharing and lightened the administrative burden of involves economic operators, chiefly grocery retailers and beverage manufacturers. At the present, most beverage containers are involved in a DRS, and the majority of the returned containers are under the management of one DRS operator. The interviewees estimate that the reusable containers should be included in a DRS and their management could be trusted to a co-owned reuse system operator.

The different levels of administrative models of DRS operators were discussed with DE. The DRS organisation where DE is associated is co-owned by two major grocery retail chains and important beverage manufacturers. The capital structure of the DRS operator is light. It does not own reverse

vending machines, recycling facilities or transportation equipment. The reverse vending machines are owned by the grocery stores and are in accordance with the requirements of the DRS operator concerning machine specifics, maintenance and what data is required from them. The returned recyclable containers are sold by the operator to recycling businesses and the transportation is procured from external suppliers. In this model, the operator's role is concentrated on administrative and data management related to the DRS. The operator validates new containers to the system by ensuring their attributes, such as size, material and labelling complies with the given requirements. The operator is in charge of payment transfers, which is crucial in order to give consumers the freedom to return the used containers to a store of their choice, increasing the convenience of the DRS and thus increasing collection rates. This model is contrasted to a model used by a significant Danish DRS operator. In the *Denmark model*, the system is comparatively scaled up, providing more in-house solutions. The reverse vending machines are owned by the operator, and the operator is more directly involved in the recycling process of returned containers. According to DE, this scaled up model has the advantage of increased control over the system. Decisions are made and implemented more efficiently compared to the lighter Finnish model, where decisions such as the implementation of new ideas, new operational processes require more discussion and negotiation between involved stakeholders. However, this scaled up system is more burdensome. It requires more attached capital and a manifold personnel increasing labour costs.

DE RE and PE both agreed an effective reuse system requires the containers to be involved in a deposit return scheme. DE summarizes their view on the efficacity of DRS to promote collection rates with the following quote:

> "Only way to get them back to the refilling is the true DRS system." (DRS expert, 28.11.2024)

RE and PE find a co-owned DRS operator that is in charge of administration, data management and payment transfers to be a desirable solution to the administrative challenge of CE systems. DE, recognizing their disqualified position and maintaining objectivity, held back from praising their model as a solution to the described challenges. DE expressed that they do have an adequate readiness to manage the administration of the reuse system, if stakeholders see such an arrangement necessary. All interviewees agree that experience in recycling DRS is an advantage in the implementation of a reuse DRS. DE explained that the reusable containers are not difficult to adapt in the existing DRS:

> "Yeah, what we have seen so far that thinking about actual containers in the system, they can be easily adapted to be part of the Finnish DRS Operator. They are containers, as the one-way packages are, for us. They have some material requirements. They have some

> recognition specifications so that the consumers get the deposits back." (DRS expert 28.11.2024).

Cooperation is necessary for container standardization. The interviewed DRS operator has experience from standardized container solutions through its subsidiary. DE and RE both find that it is advantageous that standardization, if stakeholders resort in it, is managed by a co-owned entity in order to align conflicting interests and finding compromises that are advantageous to all involved parties.

5.3.2 Beverage Manufacturer

Beverage manufacturers will need to invest in new equipment and modify existing bottling machinery to accommodate the usage of reusable bottles. The burden of the investments, administration and operating costs of reuse systems is asymmetrically divided between different sized producers. These issues are discussed more in depth in chapter 5.1.

Due to reuse targets, beverage manufacturers are challenged by the choice on what beverages to offer in reusable containers and which ones in one-way containers. Consumers seem to prefer one-way containers, which is reflected in the trend of a decline of the proportion of drinks sold in reusable containers (European Commission 2022c). In parallel with the Impact assessment of the European Commission (2022c), DE recognizes that an increase of on-the-go consumption of beverages has resulted in the decline of the popularity of reusable containers. One-way containers are lighter, and they are easier to dispose of than reusable ones. They judge that reusable containers are better suited for home consumption. Even in home-consumption, consumers tend to prefer lighter one-way packaging. This is evident in the increased sales of beer offered in aluminium cans compared to heavier glass bottles. The heavier weight of reusable containers is also an issue in DRS. The used containers need to be transported back to reverse vending machines by consumers, which diminishes the attractiveness of heavier containers. PE finds that there is not a way to make reusable containers considerably lighter; in order to sustain multiple reuse cycles, they have to be thicker. Weight-wise PET-plastic is more attractive solution than glass as a raw material for reusable containers. RE added that reused containers, even if cleaned and sanitized appropriately, may jeopardize the taste of water and other lightly flavoured drinks, resulting the customer to think the beverage *tastes off*.

The interviewees could not yet give precise estimates on what beverage types will eventually be offered in reusable containers. However, DE and PE agreed that that cost-effectiveness and business needs will determine more profoundly which drinks are offered in reusable containers rather than sustainability factors. The competition between beverage manufacturers is described as heavy by DE and PE.

5.3.3 Packaging Industry

The packaging industry, including packaging manufacturers and their suppliers will be affected by PPWR reuse requirements and recycled content requirements. The biggest challenges relate to the design of reusable containers and availability of recycled plastic of sufficient quality.

PE has experience in multiple stages of the beverage packaging supply chain. Their company produces rPET that is suitable for preform fabrication. The company also produces preforms that are made form 100 % rPET and blow them open for their own beverage production. PE considers PET as a suitable option for reuse alongside glass bottles. In terms of design and production, manufacturing reusable PET bottles instead of single-use ones is not considered challenging. To increase the material integrity of the container to withstand multiple reuse cycles, reusable containers need to be thicker and consume more material. Increasing scratch resistance of reusable containers to retain commercial appeal is brough up in the literature. When questioned about the possibilities to increase scratch resistance in PET bottles, RE answered that the possibilities are limited. Sleeves and excessive labelling are also limited, so some scratching is inevitable. Scratching may be limited by the usage of proper crates and dollies to store the reusable containers, decreasing the wear on the containers due to them rubbing against each other. According to PE, the recycled content requirements for single use plastic bottles are not an issue in terms of material integrity. Sorting is necessary to prevent the usage of low-quality recycled plastic that could be against industry standards. The sorting is not deemed challenging with the right equipment. PE finds that the recycled content requirements could be even higher since are capable of producing bottles using 100 % recycled PET.

The improper usage of containers by consumers is found to be a challenge of reuse systems according to PE. Consumers may for example store gasoline in plastic bottles and then return them to a collection facility. The cleaning of reusable container is more difficult than recycled and shredded materials, thus harmful chemicals may remain in the containers after washing. Contaminated containers that are unfit for reuse are detected by chemical identifying *bottle sniffers* after which they may be rewashed or removed from the reuse cycle. The improper usage of reusable containers could be controlled with communication.

PE identifies that the recycled content requirements cause an availability challenge for raw materials. Recycled content requirements are applied to a multitude of packages in PPWR, increasing the demand for recycled plastic in addition to voluntary sustainability measures. However, RE assesses the recycling of plastic outside of DRS is inefficient. Industries producing other products that use rPET as a raw material are competing for the same resources that are most efficiently collected by

DRS in beverage industry. If the recycling rates of other plastic products is not sufficiently increased, raw materials may be scarce and costly. In PE's opinion, a solution to the availability challenge is to implement DRS to other consumer product packaging as well. The possibility of PPWR requirements to significantly alter industry business models is estimated to be small. PE estimates that price increases are inevitable, increasing packaging costs of beverage manufacturers.

5.3.4 Grocery Retailers

PPWR sets the liability to meet the reuse targets to the final distributor, grocery retailers in the context of this study. Necessary commercial actions to reach the target were discussed with RE and DE. DE finds commercial actions in stores to be crucial in order to reach the target. The in-store beverage offering has to direct customers to choose beverages in reusable containers in sufficient quantities, as illustrated by this quote when discussing how the stores will reach the reuse targets:

> "It's not the producer issue to reach the 10 %. What happens to that product? How will they actually sell that 10 %? That is the responsibility for the retailers, not the producers. And that is an interesting way of seeing the legislation that, how do the retailers secure the 10% of the sales? --- And what products they are? Who [which manufacturer's products] is the one taking care of the whole 10% --- And attracts the consumers to buy them. It's not enough that they are on a shelf. They also need to be bought by the consumers." (DRS expert 28.11.2024).

DE finds pricing to be a significant factor in reaching reuse targets. They note that beverages in reusable containers have higher packaging costs. If this additional cost is included fully in the shelf price, it may decrease consumer willingness to purchase the product. DE uses the bulk beer market as an example. Price competition is fierce, due to customers being attracted by low prices. Products with higher packaging costs included in shelf price may not be commercially attractive enough and cause difficulties in reaching the target. It is unclear if the increased packaging costs could be in a way subsidized by having a proportion included in the pricing of products in one-way packaging. DE and RE both recognize the freedom of choice of customers and its effect on reaching reuse targets. Beverages in reusable containers need to be commercially attractive enough to customers so that they are willing to purchase the products. In the following quote, DE analyses that a failure to attract customers to purchase the product is a risk:

> "But if then it comes into final NPS [Net Promoter Score], if that, if the consumers don't buy these products for some reasons, if there's something that they don't like, if the price is not good, or the way they are packed, are they good to consume, bring home, bring back. If those things appear and you still have an option with the traditional one-way packaging, which has been, we know what to do and how it works. Then all the parties are in trouble. They have invested on the production, but the consumption doesn't really

> rise up enough, enough. Because people don't buy. Who can, who can make you buy you don't like that? Nobody.” (DRS expert 28.11.2024)

DE and RE find the competitive pricing of beverages in reusable containers as a commercial solution to reach the reuse targets. Offering the right beverages in reusable containers is also mentioned by all interviewees as important. Consumers dislike buying beverages in reusable containers for on-the-go consumption. Additionally, RE finds that using reusable containers for water or other lightly flavoured beverages may affect their taste negatively and should thus not be offered in reusable containers.

DE and RE find collaboration between grocery retailers and beverage manufacturers to be crucial in order to offer commercially attractive products in reusable containers to meet the reuse targets. DE finds that due to the concentrated nature of the Finnish grocery retail market, retailers possess bargaining power and are capable of influencing their suppliers' decisions. Due to this market dynamic, they speculate that grocery retailers may require beverage manufacturers to offer a certain share of products in reusable containers in order to get their other products in their assortment. Efficiency wise, seeing that small scale manufacturers may have difficulties to implement reuse systems in their operation as discussed in Chapter 5.1, requiring only bigger breweries to offer their beverages in reusable containers might be an effective way to reach the 10 % target. DE notes that such guidelines, if they come to exist, may not be completely transparent but rather *unwritten rule* from the retailers. PE also recognizes that grocery retailers have influence in the beverage market. RE did not wish to elaborate on the power-dynamics of the market, but rather highlighted that Finnish retailers have strong collaborative relations with their beverage suppliers. They believe that that retailers will collaborate with suppliers to find a mutually advantageous solution to find commercially viable options to reach the reuse targets. RE estimate that the initial 10% target of 20230 is not an insurmountable challenge, illustrated by the following quote when discussing reaching the reuse targets of PPWR:

> “But anyways, whatever it is, it's not it's not difficult. This is quite easy.” (Retail expert, 02.09.2024).

However, a higher reuse target may be more difficult to reach. The PPWR wording that grocery retailers shall *endeavour* that 40 % of beverages are sold in reusable containers leaves room for interpretation of possible future alterations of this target. All interviewees were however fairly confident of the initial 10% target being put in force. The legislative design of the regulation was further discussed with DE, noting that the targets are measured by sales, not requiring the return of the used container to the system. While DE recognizes that collection rates of reusable containers will

be reasonable with the application of the reusable containers to a DRS and offering a credible reuse system with accessible network of collection facilities, DE points out in a humorous manner that measuring the reuse targets by sales instead of return of container may enable deceitful behaviour to reach the targets:

> "… it must be refillable container, but nobody says that they have to be refilled. --- Yeah, we can say that this can be refilled. If I don't get them back, it's not my problem." (DRS expert 28.11.2024)

Despite the possibility of deceitful behaviour, both DE and RE estimate that established economic operators in Finland will act *bona fide* in order to reach the targets.

RE noted that in their business model where individual grocery stores have a degree of independence, not forceful guidance will be given from the chain to individual stores. As long as the right drinks are offered in reusable containers, RE finds that the chain has confidence in stores' ability to reach reuse targets. RE expressed some concern on the level that the reuse targets will be measured. RE finds that measuring sales of reusable containers on an individual store level, the measuring should be on a national level. This would allow flexibility for individual stores while still fulfilling the sustainable objectives of the regulation.

Reuse system is estimated to cause an administrative burden to grocery retailers by increasing their reporting duties (European Commission 2022c). RE, representing an established grocery retailer chain, does not perceive the data submission as a considerable challenge, as is portrayed by the following quote:

> "I think, if we are talking about reuse, I think the data isn't a problem at all, so it will be. It's normal reporting where we can find that data. --- I don't see any problem with that." (Retail expert 02.12.2024).

RE elaborated that the experience gathered by the organization from multiple other reporting duties to authorities decreases the burden of new data submission requirements. RE acknowledges that smaller-scale retailers where IT-systems are not advanced may perceive the data submission as more challenging.

5.4 Business needs or sustainable values as a driver of CE-practices

An emerging topic in the interviews outside the theoretical framework is the question if business needs or sustainable initiative is the main driver of solutions economic operators choose to implement CE practices in action. According to the author's perception, CE literature often concentrates on

environmental efficiency. The commercial viability of CE practices in a competitive market is sometimes addressed but appears to be less significant. The interviewed stakeholders were inquired on what their view is on this matter: is the principal driver of CE solutions business needs or benevolent sustainable values.

PE assesses that business needs is a considerably more significant driver of CE-solutions than sustainable values. PE also perceives that when legislation demands economic operators to act sustainably, it is portrayed as voluntary environmental responsibility:

> "Yes, yes, it is. Everything is addressed with business at the forefront. For many enterprises, it is a shell, a desire to appear sustainable et cetera to the outside but but… At the end of the day, management dictates that it is only costs and money that matters. And when they [enterprises] are forced to do something [CE-practices], it is spun and masked as environmental responsibility." (Packaging expert, 09.12.2024)

PE sees that sustainability regulations should be designed in a way that sets targets and grants economic operators' freedom to find the most efficient way to reach these targets. *The market* produces resource efficient models if the legislation doesn't micromanage practices in too much depth. However, PE recognizes that though centralization of reuse cycle steps could be effective, the business-oriented approach of market stakeholders may inhibit their usage.

DE also finds that inside the legal framework, operations are more driven by business needs than benevolence. This is illustrated by the following quote while discussing the efficiency of centralization against possible competitive decision-making inhibiting it:

> "Business needs, yes, yeah. Because they are the cost factors in the in the whole game. And if somebody sees that, they can reach cost advantages by doing inhouse solutions, they won't let it out, they don't let it out. But then they [in-house solutions] have become a primary business factor then. But if there are considered secondary things that are not that important, they can be kind of fractions of the whole system that they can be put out. Or it can happen that there will be a very wide collaboration, but we don't know yet. We don't know how this will be organized, and what are the operational processes and needs yet. We don't know how business will kind of shape the collaboration. Businesses, businesses are thinking in the total needs."

DE coherently pointed out that the business interest of economic operators will significantly influence all the decisions the economic operators make to solve the challenges set by PPWR. DE supports the view of PE that legislation should leave room for economic operators to find effective solutions to sustainability target. They used the packaging tax used in Finland as an example, which may be avoided by adding the packages in a DRS. Due to this design, economic operators have created co-owned DRS models on their own terms, resulting in leading collection rates of beverage containers.

The design results in clear environmental benefits, despite the primary motivation of companies to participate in DRS is to avoid paying beverage packaging tax on their product. Effective legislation takes the business need -orientation of economic operators into account and design the regulation in a way that makes sustainably effective solutions parallel to economically effective solutions.

In RE's point of view, sustainability as an important value to their stakeholder. However, RE does admit that at the end of the day, they are a for-profit company, in which business interests are a decisive driver of decision making. RE displayed realism when answering with the following quote when asked about the choice of drinks in reusable containers is influenced by both sustainability and business needs:

> "I hope so. I believe that business probably is the most, more important in this case, as it seems that it won't be very efficient system to start with." (Retail expert, 02.12.2024)

Being liable to reach the reuse targets, RE explains that cost effectiveness is a leading contributing factor influencing the decisions final distributors make to reach the targets.

6 Discussion and conclusion

6.1 Answering the research questions

Based on the results of the semi-structured interviews, the theoretical framework on the supply chain impacts of PPWR to the beverage industry (Figure 2) that was based on the literature overview was elaborated to a solution framework (Figure 3). The theoretical framework presented challenges of reuse systems and recycled content requirements set by PPWR and discussed in CE literature with generic solutions found in literature. The solution framework gathers ways to solve the challenges presented in the theoretical framework amended by emerging challenges derived from the interview material. The presented solutions combine measures from the studied literature with insight from the interviewed stakeholders. The key findings are also presented in written form, further specifying the expected challenges set by PPWR to industry stakeholders and the ways in which the challenges are planned to be solved.

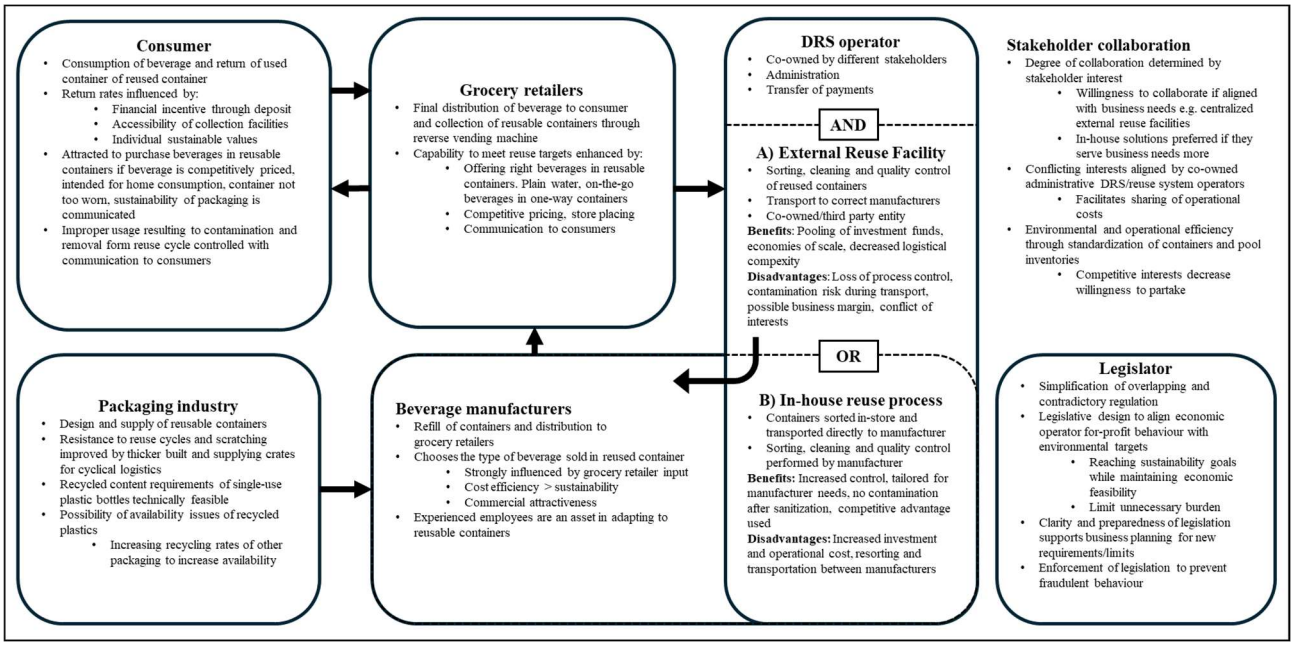

Figure 3 Solution framework of beverage industry stakeholders to PPWR

6.1.1 Supply chain impacts of PPWR

In this section, the first research question (RQ1) of this study will be answered:

RQ1: *How will the Packaging and Packaging Waste Regulation (PPWR) impact supply chains and supply chain management in the beverage industry?*

PPWR will impact the retail sales of ready-to-consume packaged beverages and the industry behind it by setting targets for the proportion of beverages sold in reusable containers and placing recycled content requirements on beverages sold in reusable containers. The requirement to implement a DRS to single-use plastic and metal containers, unless Member States reach a 90 % collection rate for the items, is also a supply chain challenge in Member States without widespread usage of DRS. Seeing that in the studied Finnish market the majority of the concerned beverages are already included in DRS, the supply chain impacts of setting up a novel DRS are not addressed.

Setting up a reuse system for beverage containers in a market where the majority of beverages are sold in recyclable one-way packaging is a considerable effort requiring 1) sizeable investments 2) creation of new processes and altering existing ones to manage backwards logistics and refilling of containers and administration of the system and 3) increased collaboration of supply chain stakeholders

The most significant investments when implementing a reuse system are collection facilities where consumer reusable beverage containers may be returned by consumers, machinery for the sorting, cleaning and quality control of the retuned containers that ensure they are suitable for refilling, the modification of bottling machinery to accommodate the usage of reusable containers and equipment for the production of reusable containers by packaging manufacturers. The investments required for reuse systems are a burden to the involved stakeholders (Morgan et al 2022; Muranko et al. 2021). As industry stakeholders are forced to invest due to PPWR, smaller economic operators may experience a competitive disadvantage due to more limited financial capabilities to invest in efficient machinery.

Reuse systems and DRS increase administrative burden of industry stakeholders (European Commission 2022c). Backwards logistics of used containers from the in-store collection facility to the correct beverage manufacturer for refilling is a complex logistical challenge (Ada et al. 2023; Molina-Besch & Pålsson 2014). The market conditions of Finland, with its thousands of grocery stores across the comparatively large area country, offering a wide array of beverages in limited volumes that are supplied form dozens of suppliers spread in individual bottling facilities adds to the logistical challenge in implementing a successful reuse system. The reuse cycle requires additional careful sorting and transportation planning compared to one-way distribution. Performing these novel necessary actions requires stakeholders to build and adapt new processes in their operation. Stakeholders will have to assess which models and processes to reach reusability targets is in their interest. Implementing a DRS is also a PPWR challenge in markets where such systems are not

commonly used (Visgø 2004; Dace et al. 2012). A DRS requires constant payment transfers and causes administrative burden to involved stakeholders, and finding an efficient manner to adapt this system will be an impact of the PPWR on industry stakeholders. Increased sustainability reporting to authorities may be burdening to the liable economic operator (European Commission 2022c). PPWR requires grocery retailers to report on the proportion of sales of beverages in reusable containers to the correct authorities. Grocery retailers without advanced IT-systems to process sales data and limited existing reporting experience may find this data submission requirement challenging. However, it was found in this study that grocery retailers with adequate IT-systems and prior knowledge of reporting to authorities are not excessively burdened by this task.

In order to implement successful reuse systems in a complex market, collaboration between stakeholders in necessary (Kirchherr et al. 2017**)**. However, supply chain stakeholders may have conflicting interests which decrease the willingness to collaborate in a manner that guarantees the efficiency of the reuse system. In addition to conflicting competitive interests, competition law drastically limits the possibility for horizontal collaboration of competing stakeholders. Horizontal collaboration in reuse systems could enable economies of scales and more effective and sustainable outcomes.

The recycled content requirements for single-use plastic beverage packaging may have some impacts on the availability of recycled plastic, such as rPET. Recycled content requirements concern other types of packaging as well. In Finland, the recycling rate of plastic beverage containers is superior to other types of packaging. If the demand of rPET is increased due to the content requirements in a variety of products without the recycling rates of the other product categories increasing, availability issues of rPET may follow resulting in availability issues of single-use PET-bottles. Some stakeholders in the packaging industry may engage in fraudulent behaviour due to recycled content requirements if the enforcement is estimated to be insufficient. If virgin PET is more available and less costly than rPET, fraudulent stakeholders may attempt to forge and sell virgin PET as rPET.

PPWR will impact supply chains and supply chain management in the beverage industry in various considerable ways. Reuse and DRS requirements will require industry stakeholders to adapt novel processes to their operation. These processes require considerable investments and extensive collaboration between stakeholders in order to be economically and environmentally effective.

6.1.2 Industry solutions to meet PPWR requirements

In this section, the second research question (RQ2) will be answered:

RQ2: *What are the plans of economic operators in the beverage industry to meet the requirements set by the PPWR?*

The plans of industry stakeholders to meet the requirements set by the PPWR may be divided into stakeholder specific solutions and solutions that concern the collaboration of different stakeholders. The focus of this section is on the plans and estimates uncovered in the interview materials amended with some solutions founds in the studied CE literature.

Grocery retailers are liable to meet the reuse requirements set by PPWR. Reaching the initial 2030 target of 10 % of beverages being sold in reusable containers is not considered by interviewed industry experts as overly challenging. Reaching the target does however require some commercial actions so that consumers choose to purchase the beverages offered in reusable containers. Concerning what beverages should be offered in reusable containers and which not, CE literature focuses on environmental efficiency above commercial attractiveness to customer. High volume beverage containers are more environmentally efficient compared smaller ones (Coelho et al 2020). Assuming that the markets continue to make smaller sized beverages available and only a fraction of beverages are offered in reusable containers, the smaller sized beverages should be offered in reusable containers efficiency wise. They occupy limited cargo space more densely, increasing the efficiency of backwards logistics. Morgan et al (2020) and Almeida et al (2017) agree that reusable containers are more sustainable on short distance deliveries. Reusable containers are less sustainable to transport due to their heavier weight and require roughly two times more transportation compared to one-way packaging as the containers need to be transported back to the customers.

As contrast to the CE literature, the interview material indicates that commercial viability appears to be more important than environmental efficiency for industry stakeholders when assessing which beverages to offer in reusable containers. Reusable containers should be used in beverages that are likely to intended for home consumption as opposed to on-the-go consumption. The potential undesired effects on taste by using reused containers is hedged by not using them for water and other lightly flavoured drinks. The interviewees agree with Coelho et al. (2020) that the pricing of the beverages in reusable containers has to competitive in order to be commercially attractive. The contrast between sustainability focused literature and commercial point of view of interviewees reflect that in a free market, the combination of competition between economic operators and the freedom of choice of consumers may not always result in the most environmentally effective solution. Grocery retailers and other stakeholders are more driven find a feasible and cost-effective solution to reach the targets set by regulation. Another finding of this study is that the grocery retailers have

significant influence on what beverages are made available in reusable containers. This is driven by the concentrated nature of the grocery retail trade in Finland and the liability of meeting reuse targets targeted to the grocery retailer.

The existing DRS with a dense and accessible network of reverse vending machines in the majority of grocery retail stores is a factor that strongly facilitates the implementation of a new reuse system from a collection perspective. Linderhof et al. (2019) and Konstantoglou et al. (2023) agree that an accessible network of collection facilities increase collection rates which are naturally important in reuse systems. All interviewees agree that reusable containers should be included in a DRS to promote the collection of the containers. According to DE and RE, the commonly used existing reverse vending machines are capable of some degree of sorting, decreasing the need for manual sorting in store back-rooms. They also collect data that supports the administration of DRS and reuse systems. The planning and implementation of the in-store collection facilities that are required by PPWR will be a considerably bigger effort in member states where DRS with advanced reverse vending machines are not widely used.

Beverage manufacturers and the competitive situation between them will determine the level of centralization of reuse operations and if standardization efforts will be made as an answer to the challenges set by PPWR. It appears that the interviewed stakeholders agree that the bulk of the costs associated with the return and processing of containers for refilling will be covered by beverage manufacturers. Ultimately the costs will be covered by the customers, but the direct costs of transportation, sorting and cleaning will likely be handled by beverage manufacturers. This responsibility offers the manufacturers influence on the solutions they employ. CE literature (Coelho et al. 2020; Circular Economy Portugal 2021; Ada et al. 2023; Muranko et al. 2021; Dace et al 2013) and interviewees agree on the benefits of centralizing sorting and cleaning, with decreased logistical complexity and costs savings due to the possibility for economies of scale cited as the most important advantages. However, estimates of the interviewees that centralization of these processes will take place as a result of PPWR were mixed. Centralization is ultimately dependent on the assessment of beverage manufacturers on what degree of cooperation is in their interest. If beverage manufacturers assess that in-house solutions serve their interests the best, they will not partake in centralized models. Sizeable manufacturers have a better capability to invest in in-houses solutions than smaller ones. This asymmetrical situation may result in competitive measures that inhibit centralized solutions. Manufacturers may also calculate that in-house solutions may be more cost-effective or offer better process control on the reuse cycle which may be desirable. If however, the cost-benefit analysis of manufacturers tilts in the direction of a centralized model, it will be a likely outcome. Due to the

uncertainty regarding this question, the solution framework present both alternatives that depend on beverage manufacturers, communicating the choice between alternatives with *OR*.

Comparably to the degree of reuse process centralization, the standardization of containers is also found to be an efficient solution for reuse systems both by literature (Landi et al. 2019; Morgan et al. 2022; Ko et al. 2012) and interviewees that may be inhibited by competitive measures on the market. Standardization and pool inventories are an economically and environmentally efficient solution that reduce the need for sorting, logistic complexity and costs of inventory management. However, using brand packaging may be competitively attractive and offer brands a possibility to differentiate. Voluntary standardization is subject to commercial opportunism (Dong-hwan 2019). The decision between standardized containers and brand-packaging will be ultimately dependent on the assessment of beverage manufacturers on what choice is in accordance with their interest.

Regardless of the resulting cooperation degree in reuse facilities and package design between stakeholders, all interviewees agreed that a separate DRS operator handling administration, transfers of payment and other matters related to DRS is advantageous. The co-ownership of the operator by industry stakeholders and transparency was identified as leading contributors to neutrality of such an entity. Neutrality is required so that partaking stakeholders may perceive that their interests are considered. Collaborative DRS models facilitate negotiations between stakeholders that often have conflicting interests and may help in finding compromise solutions that align the interests of different parties. For this reason, a separate DRS operator is involved in the solution framework.

The empirical material uncovered some points of interests related to legislative entities. All interviewees agreed that business needs are a more important factor than sustainable values for influencing the solutions economic operators choose in order to answer to sustainability regulation. Effective sustainability regulation should take this business-oriented approach into account and design the regulation accordingly. The level of clarity and preparedness of legislation affects the degree in which affected stakeholders can plan and prepare for it. For example, the vagueness of sanctions for noncompliance and the uncertainty concerning measuring methods for reuse targets inhibit the level of detail with which stakeholders may prepare for the requirements. The empirical results support Chi and Yang (2024) that the credibility of enforcement increases compliance of sustainability regulation.

6.2 Theoretical and practical contribution

The European Unions Packaging and Packaging Waste Regulation will set new requirements for the retail sales of packaged ready to consume beverages and the industry behind it. Though there is a considerable amount of literature on CE practices in beverage containers, research with a supply chain perspective on the impacts and industry solutions for this specific regulation is scarce. This study participates in filling this gap by examining the impacts and solutions holistically, gathering stakeholder specific insights to form an industry-wide outlook on the beverage industry. The results are gathered in a solution-oriented framework that gather points of interests from different industry stakeholders concerning the implementation of a reuse system for beverage containers with supporting insights of DRS and recycled content requirements. The results may be generalized and are applicable in situations where reuse systems and DRS for beverages are implemented. The study provides insight and guidance for economic operators that are facing comparable CE regulation, supporting their planning and decision making to answer to new sustainability requirements in an economically feasible way.

The study may support legislators in designing effective CE regulations that does not burden economic vitality too severely. The studied CE literature is focused on environmental efficiency with limited weight given to the effects of the competitive setting where CE practices are often implemented through legislation. By gathering empirical data by interviewing industry experts that represent economic operators in the beverage industry, this study offers insight on the effects that the for-profit approach of economic operators and resulting competitive behaviour have on the implementation of CE practices required by legislation. This phenomenon may inhibit the adoption of CE solutions that would provide the greatest environmental efficiency. By taking this phenomenon into accounts, legislators may design sustainability regulation in a manner that aligns business interests with environmental interests.

6.3 Limitations and future research suggestions

This study offers estimates on the possible supply chain impacts and challenges of the PPWR on the beverage industry and insight on the solutions industry stakeholders may utilize to answer to them. This research provides theoretical and practical implications but is not without limitations. The study

focuses on the Finnish beverage industry, with its distinctive market conditions, such as low population density and volumes, long transportation distances and the existing widespread usage of a DRS. These market conditions influence results gathered in the empirical analysis. Alternative market conditions may alter the expected impacts and solutions stakeholders choose. The findings may offer insight to the implications and solutions in other member states, but the applicability may not be considered universal. The study uses a limited empirical sample size of three semi-structured interviews. While the interviewees were chosen due to their professional experience in different stakeholders, using a single interviewee per stakeholder retains a risk of subjectivity in the empirical material, especially concerning the stakeholder specific questions. A larger, more diverse sample including multiple interviewees per framework stakeholder would improve the reliability of this study. The limited sample size of the research is a factor to bear in mind when examining the results.

This study examines the market impacts of new CE regulation and the commercially feasible solutions that economic operators may adapt to meet the new requirements. It uncovers beverage industry solutions in set market conditions. Further research could explore how the solutions industry stakeholders will likely choose is influenced by varying market conditions, providing a matrix presenting recommended CE solutions that are dependent on market condition inputs. This type of framework would have considerable practical applicability in assessing impacts and solutions for CE regulation in varying markets.

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Appendices

Appendix 1 Interview Guide

This interview covers topics around the supply chain impacts and solutions to the PPWR in the beverage industry

INTRODUCTION AND BACKGROUND

1. What is your professional experience in the beverage industry and role in your company?
2. How would you describe your company's role in the beverage industry?
3. How has your company planned for the implementation of PPWR on a general level?

STAKEHOLDER SPECIFIC QUESTIONS DERIVED FROM THEORETICAL FRAMEWORK

a) FINNISH DRS OPERATOR

1. What actions and investments are necessary to implement the sorting and cleaning requirements of reuse systems?
    a. How will these investments be funded?
2. What is your perspective on the level of centralization of these processes?
    a. What are the benefits of centralization of these processes?
    b. What are the challenges caused by the centralization of these processes?
    c. What is the alternative to centralization?
3. Do you feel the DRS operator and the stakeholder in charge of of sorting and cleaning services should be separate stakeholders or joined?
4. To what extent do you predict the sorting, cleaning and transportation of reusable containers will be outsourced?

b) PACKAGING MANUFACTURER/ASSOCIATION

1. What challenges are included with the design of reusable containers?
2. How does the business model of packaging manufacturers need to be adjusted in order to include reusable packaging?

3. How would you describe the availability of recycled plastic of sufficient quality for single use beverage containers?
    a. If the availability is not sufficient, how will the markets adjust so that the recycled content requirements are met?

c) BEVERAGE MANUFACTURER

1. What investments need does the PPWR provoke for beverage manufacturers?
2. Is there an added operational load due to the reusability targets?
    a. If yes, what does in consist of?
3. Do you have plans on what type of beverages will be sold in reusable containers?
    a. If yes, what is the reasoning behind this?

d) GROCERY RETAILER

1. What commercial actions are you planning to meet the reuse targets?
2. How do you plan on gathering the necessary data to submit to the correct authorities?
3. What are the challenges you face concerning the requirement to include a collection facility for reusable containers on top of the DRS for containers that are recycled
    a. Does the existence of Recycling system DRS provide synergies?
    b. How do you plan to address these challenges?
4. How will relations with brand suppliers be affected by the requirements?
5. How will relations with private label suppliers be affected by the requirements?

STAKEHOLDER COLLABORATION

4. How do you perceive the collaboration of relevant stakeholders, such as DRS operators, Beverage and packaging manufacturers and grocery retailers concerning the current recycling system including a DRS?
5. How do you perceive the collaboration of stakeholders concerning PPWR?

6. How should the cooperation of stakeholders be arranged to facilitate the design and implementation of a reuse system?
    a. How will the high initial investment costs be divided?
    b. How will operational costs be divided?
    c. How will conflicts of interests be managed?
7. How should the cooperation of stakeholders be arranged to facilitate the design and adoption of reusable containers?
    a. To what extent the harmonization of containers is possible?
    b. What are the advantages and hurdles to a pool inventory of reusable containers?
8. Does competition legislation cause issues regarding necessary collaboration to ensure the efficiency of reuse systems?
9. What type of arrangement is necessary to ensure the compliance to the requirements set by the PPWR concerning reuse targets and recycled content requirements?
10. Is there anything else you would like to add concerning this topic?