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A small deposit for plastic packaging waste could improve sorting habits in rural areas

Muovipakkausjätteiden pieni panttimaksu voisi parantaa lajittelua maaseudulla
Muovijätteiden kierrätysastetta lisätään Euroopan unionissa. Nykyiset toimet eivät ole vielä olleet riittäviä kierrätystavoitteiden saavuttamiseksi. Erityisesti harvaan asuttu maaseutu on tunnistettu haastavaksi alueeksi jätehuollolle, koska kotitalouksien ja kierrätyspisteiden väliset etäisyydet ovat pitkiä. Tämän vuoksi maaseudun asukkaiden jätehuoltomenetelmiin tulisi kiinnittää enemmän huomiota. Taloudelliset kannustimet ovat aikaisemmissa tutkimuksissa tunnistettu tärkeiksi keinoiksi parempien kierrätystapojen saavuttamisessa. Tässä tapaustutkimuksessa selvitettiin muovipakkausten pantillista kierrätysjärjestelmää suomalaisella maaseudulla. Työssä tutkittiin kahta muovipakkausten panttijärjestelmää, jossa pantti perustui palautettuun muovimassan sekä tuotekohtaisiin pantteihin. Tulokset osoittavat, että pieni pantti voi saada kuluttajat parantamaan lajittelua, ja ne kierrättäjät, jotka aiemmin laittoivat muovia sekajätteeseen tai polttivat muovijätettä kotitalouksissa, paransivat kierrätystapojaan. Muovijätteen massaperusteista panttijärjestelmää suosittiin tuotekohtaisiin pantteihin verrattuna. Pantillisten järjestelmien kehittäminen voisi parantaa kuluttajien muovijätteen lajittelua, uudelleenkäyttöä ja puhdistettavuutta sekä voisi edistää muovinkierrätystavoitteiden saavuttamista maaseutualueilla.

Avainsanat: kiertotalous, lajittelu, maaseutu, muovien kierrätys, pantti

Introduction

Plastics production has increased continuously throughout the globe. A significant amount of plastics is used for packaging, and, due to its relatively short service life, discarded packaging ends up polluting the planet (Luijsterburg & Goossens 2014). Thus, plastic pollution has become a serious environmental challenge globally. Plastic waste is a challenge, as it is insufficiently recycled, degrades poorly in nature, and its associated health risks and effects on natural systems are still partially unknown (Hopewell *et al.*

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2009; Rhodes 2018). The current life cycle of plastics is economically wasteful and poses a serious threat to ecosystems, livelihoods, and communities (Xanthos & Walker 2017).

Finding a substitute material that would meet all the requirements is difficult, which is why the recycling and re-use of plastic waste should be considered a priority (Mwanza & Mbohwa 2016). The reuse of plastic offers energy and resource savings (Al-Salem *et al.* 2009) and reduces oil usage and carbon dioxide emissions (Wollny *et al.* 2002; Hopewell *et al.* 2009). Although the attribute of degradability for plastics is longed for (Simon 2019), recycling seems to be the best and most realistic alternative for dealing with the current plastic waste issue. Several countries have considered solutions to deal with the plastic waste issue. For instance, the European Union (EU) launched a strategy for plastics in 2018. The strategy guides the way plastic products are designed, produced, used, and recycled in the EU (European Commission 2018; European strategy for plastics 2018).

Despite the current desire to improve the recycling of plastics, the recycling rate of plastic packaging appears to be quite low in most of the European countries. In the EU, most plastic waste originates from the private consumption of plastic packaging (Littner & Frerejean 2015). Plastics have a major role, *e.g.*, in the food industry because their material properties enhance food safety (The Institute for European Environmental Policy 2018). According to the PlasticEurope – Association of Plastic Manufacturers (2018), the total recycling rate of plastic packaging in the EU was only 40.8 percent. However, the rate varies between countries. Methods of increasing the recycling of plastic packaging are currently being discussed. Meanwhile, new recycling targets have been set for each member state.

To organize plastic recycling, information about demographic characteristics is needed, as demographic variables, such as gender, age and place of residence, affect pro-environmental behavior (Li *et al.* 2019). In Finland, about 750 000 inhabitants live in rural areas (14 % of the total population), and the average distance between home and a plastic recycling point (Rinki Ltd.) is over 20 kilometers. Using average values of plastic recycling per capita in Europe, this accounts for 25 600 tons of plastic packaging waste per year from the Finnish rural areas (European Court of Auditors 2020). About 91 percent of rural people live at a distance of 3 to 50 kilometers from the collection points (Salmenperä *et al.* 2019). In Finland, the current recycling of plastic packaging is based on the producers' responsibility. Finnish Plastics Recycling Ltd is the authorized extended producer responsibility organization in Finland, and companies with a turnover of more than one million euros are subject to extended responsibility. The producer responsibility legislation obliges companies who pack their products or import packed products (see about Waste Act 646/2011 related producer responsibility in Environment.fi [2018]). Finnish Plastic Recycling Ltd. has more than 2 500 contracts with customers to manage the recycling of plastic packages, and it provides 500 bring stations for household packaging, and 30 collection terminals for trade & industry packaging (Finnish Plastic Recycling Ltd. 2022). In Finland, plastic packaging waste is collected from households through various systems, *e.g.*, site-specific collection in urban areas, bring-sites in rural areas, and deposit-refund systems for beverage packaging. The most sparsely populated rural areas are the most challenging environment for site-specific collection. Therefore, households in these areas may have to continue to use regional collection points (Salmenperä *et al.* 2019). Consequently, to achieve higher recycling rates, more attention should be paid to rural inhabitants' motivation to sort their waste. While it can be argued that long transportation distances may reverse the benefits of plastic waste sorting, local plastic recycling could significantly decrease those distances.

Many factors, such as economic, environmental, and social factors, can influence consumers to sort for recycling (Yau 2010; Khan *et al.* 2019). The factors influencing waste sorting by households the most are the degree of easiness, a suitable distance to waste collection points, and the number of public waste collection points (Kokkonen 2020).

Some scholars have suggested the use of economic incentives to improve sorting motivation (Yau 2010). When the economic driver is used, the consumer starts to

see waste as a valuable resource (Mwanza & Mbohwa 2016). In general, the economic incentive could be, *e.g.*, money, groceries, daily goods, or cash coupons, as Yau (2010) has suggested. Recent debates have focused on the plastic recycling technologies of waste management companies, but less on the role of rural consumers. Currently, there are some encouraging examples of the usage of economic incentives in recycling (*e.g.*, Yau 2010; Welfens *et al.* 2016; Palpa 2018). For instance, a deposit-based recycling system for plastic bottles has been in use for several years in some parts of the EU, such as Finland and the other Nordic countries (Hennlock *et al.* 2014; Palpa 2018). The deposit-based recycling system has been efficient, as in Finland the recycling rate has been as high as 90 percent. The deposit is relatively small, usually 10–20 cents per plastic item, but it still significantly increases the recycling rate. The current system has been in use in Finland with plastic bottles since 2008 (Palpa 2018). Ever since, it has become an institutionalized habit of recycling amongst the Finnish consumers. Considering its success, one may wonder why this deposit-based recycling system has not been adopted for other plastic packaging as well. This would most probably impact people's sorting habits, as we have hypothetically assumed in the present study. The deposit-based system might solve further plastic refining issues, such as quality-related questions (personal communication with Marko Mäkinen, Pramia Plastic on Oct 23, 2018, and, *e.g.*, Iacovidou *et al.* 2019; Schneider *et al.* 2021), because it would make it easier to address different plastic types in the source separation phase. Today, packages contain various types of plastics, making sorting and recycling difficult (Civancik-Uslu *et al.* 2019). In fact, the barriers to enhanced plastic waste recycling in the Nordic countries are usually related to the impurities and poor quality of plastic (Milios *et al.* 2018; Eriksen *et al.* 2018). These barriers are suggested to be significantly reduced while using recovery systems with better source-separation and separate collection of hard and soft plastic fractions (Eriksen *et al.* 2018).

There is a limited number of empirical studies on deposit-refund-systems for items other than bottles combined with waste collection solutions for rural people. Consequently, the aim of the present study is to develop and assess the feasibility of the previously mentioned deposit-based system for plastic packaging other than plastic bottles in Finland. Based on consumer interviews and waste sorting habits at the pilot recycling point, we evaluate the motivational aspects of sorting wastes for recycling. This could create potential for developing new business activities around plastic refining.

Methods

Study area and inhabitants

The study area corresponded with a rural municipality called Soini in South Ostrobothnia, Finland (62°52'25"N, 024°12'20"E). The total area of the region is 574 km^2, with a population of 2 114 inhabitants, and population density of 3.7 inhabitants per km^2 (National Land Survey 2017a; Statistics Finland 2017). Most of the population lives in the municipal center. The economy of the region is based on primary production, such as forestry activities. The population age distribution among the groups of 0–14, 15–64, and over 64 year-old people was 16.2, 55.6, and 28.2 percent, respectively, in 2016 (Statistics Finland 2017). The number of households was 940 (Statistics Finland 2018).

Currently, there is one existing plastic waste collection point in the municipal center, owned by Rinki Ltd. and managed by Millespakka Ltd. waste treatment company. The annual amount of collected plastic waste has been on average 26.34 kilograms (standard deviation 2.32) per inhabitant from 2013 to 2016 (I Kekarainen 2018, personal communication, 24 October). Totally, this amounts to ca. 55 700 kilograms of separately collected plastic waste in the study area a year.

Plastic waste deposit scenario

Plastic packaging waste was collected in the study area to test the deposit-based collection system (Figure 1). A separate recycling point was established near the existing collection point, and it was named MuoviSampo (PlasticSampo in English). The Local Association of the Finnish 4H Organization built and organized the recycling point. The collected plastic types were polyethylene terephthalate (PET), polyethylene of high density (PE-HD), polyethylene of low density (PE-LD), polypropylene (PP), and polystyrene (PS) (as classified by Finnish Plastics Recycling Ltd. [2018]). The pilot experiment was established in four campaign events in fall 2018 (October 3–4, October 29–31, November 26–28, 2018), and in winter 2019 (January 7–9, 2019). In total, there were 11 campaign days during the three-month period.

The deposit scenarios were generic a mass-based plastic deposit (1 € per 1 kg of plastic packaging waste) and a piece-based system, based on the number of returned plastic items (pasta packages [Pirkka], yogurt packages [Valio], and minced meat packages [Pirkka] with 2, 5 and 10 cents per item, respectively). We selected these packages, because they were easy to clean by customers after use, and we had an arrangement with the Pirkka and Valio brands to use these items in the experiment. Consumers could return generic mass-based plastic waste and certain deposit-based plastic packaging waste at the same time. It was possible to return packages which had been purchased elsewhere if the consumers were using a mass-based deposit. Piece-based deposit packages were only available in a local grocery store (K-market Kaneli) throughout the pilot, but plastic waste could only be returned to the recycling point during the campaign days. The deposit was a rebate bill, and it could be used as currency in the local grocery store and in a local thrift store (Neliapila) during the experiment. The rebate bill could be reclaimed either by using a paper coupon or a mobile application (downloadable only by a mobile version). The deposit costs were

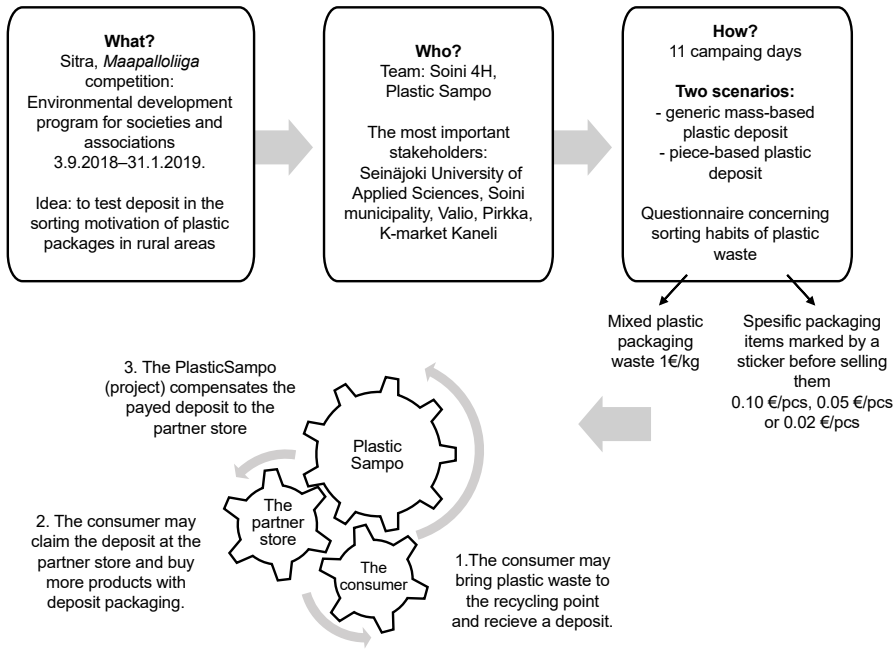

Figure 1. The chart illustrating the PlasticSampo pilot experiment and system.
Kuva 1. MuoviSampo-pilottia ja -järjestelmää kuvaava kaavio.

covered by the project funds, so there were no additional costs for recyclers to purchase the piece-based deposit.

Social media marketing (such as Facebook, Instagram, and YouTube) and articles in local newspapers were published to increase awareness of the experiment amongst the local inhabitants. Also, elementary school classes were invited to participate in a recycling competition. Information and bulletins on how to use the rebate bill were also provided in the local grocery store.

Data collection and analysis

The data was collected face to face, using a questionnaire (the Webropol software, ver. 2.0) while local people were bringing plastic packaging waste to the collection point during the recycling event. People aged 18 or older, usually the adult of the household, were asked about their consumer habits. The local inhabitants who answered the questionnaire were mostly female (59.5 %), with an average age of 37 years. Descriptive statistics are visible in Table 1.

The mass of the collected plastic waste for each return action in the mass-based deposit system was measured with a scale (accuracy of 10 g). The weight data was collected with the Webropol program (ver. 2.0). The questionnaire included questions about the respondents' previous waste sorting habits and their background, such as sex, age, and distance to the collection point from home. The respondents were also asked if the deposit influenced their decision to buy the food product, and what the right price for the deposit should be.

The statistical analyses, including a Pearson Chi-Square Test and Crosstabs, were computed for the results of the questionnaire using the SPSS statistics software (ver. 25). Freeform answers were collected on 74 subjects' own views on how their sorting behavior had changed during the experiment (data available: Laasasenaho & Lauhanen 2019). These results were analyzed qualitatively. Since there was a limited number of replies, we combined the classes for combustion and disposal to mixed waste in the Chi-Square test.

Table 1. Descriptive statistics of the questionnaire.
Taulukko 1. Kyselylomakkeen vastaajia kuvaavat tilastot.

Parameter	N	Min.	Max.	Mean	Std. Deviation
Recycling acts	284				
Age (a)	123	6	87	36.98	25.24
Distance between home and the collection point (km)	102	0.1	45	5.56	7.20
Earlier plastic waste managing habit: Combustion	13				
Earlier plastic waste managing habit: Recycling	78				
Earlier plastic waste managing habit: Disposal to mixed waste	33				

Results

The deposit-based recycling system for plastic packaging waste was tested to find out how the deposit would motivate people to improve their waste sorting habits in the rural study area in Finland. A total of 283 recycling events were carried out during the experiment. The effects of both deposit scenarios on people's waste sorting habits are presented and discussed separately in the following chapters.

Generic mass-based deposit scenario

The generic mass-based deposit scenario (1.0 €/kg) was tested during the campaign days to see how the deposit impacted the waste sorting habits of consumers. The generic mass-based deposit was the most popular way to recycle plastic waste. The generic mass-based deposit was utilized in 278 of the 283 recycling acts. Almost 850 kilograms of generic mass-based plastic waste was collected during the campaign days. The amount of recycled plastic waste per household increased during the pilot, and it was at highest during the fourth campaign event (respectively 1.6, 2.6, 3.4, and 4.1 kg person^{-1} per campaign event). Because the deposit was 1.0 €/kg of plastic waste, the total sum of the distributed deposits was also close to 850 euros.

Deposit-based scenario for certain plastic packages

The deposit-based scenario for certain plastic packages was tested to see how it influences the waste sorting habits of rural inhabitants. The deposit-based products brought to the collection point were calculated and rated.

The returning rate of plastic pasta packages, yoghurt packages and minced meat packages were 3.7, 17.1, and 15.2 percent, respectively. The recycling rates of these packages are presented in Table 2. The total sum of the paid deposits was eventually 24.11 euros.

In the questionnaire, we also asked what the respondents thought was the appropriate amount of a package-specific deposit. The average value-estimate of a suitable deposit was 9.3 cents a plastic package (n = 42), which was calculated from the responses of the respondents who mentioned an exact price.

Table 2. The number and returning rate of plastic packages with a package-specific deposit.
Taulukko 2. Muovipakkausten lukumäärä ja palautusaste tuotekohtaisille panteille.

Parameter	**Yoghurt package**	**Minced meat package**	**Pasta package**
Deposit (€ package^{-1})	0.05	0.1	0.02
Number of sold packages with the deposit	1564	703	108
Returned packages	267	107	3
Returning rate (%)	17.1	15.2	3.7

Crosstabs and Pearson's Chi-Square test

Contingency tables were computed in the study to compare the respondents' previous waste sorting habits with their opinions on how the economic benefit (deposit) improves people's waste sorting habits. 14 percent of the respondents stated that they at least partially disposed plastic packaging by combustion (N= 13/91). Most of the respondents stated that the economic benefit improved their waste sorting habits (Table 3), but it had more significance for men than for women: the gender differences related to the economic incentive on sorting (n=103) (Chi-Square test: $\chi^2 = 5.1$; df = 2; $p = 0.078$). In total, 65 and 75 percent of those who had earlier disposed their plastic packaging as mixed waste or incinerated it said that the economic benefit could improve their waste sorting habits. A clear majority said that an economic incentive would drive them to improve their sorting (Chi-Square test $\chi^2 = 16.29$, $p = 0.00029$). Otherwise, the population size was too small for statistical significance ($p \leq 0.05$) in Crosstabs with the Chi-Square test (Table 3).

Table 3. Previous waste sorting habits and the economic incentive to recycling (n = 85) in crosstab. Chi-Square test: 3.06; df = 2; p = 0.217.
Taulukko 3. Aiemmat lajittelutavat ja kokemus taloudellisen kannustimen käytöstä kierrätyksessä (n = 85) ristiintaulukoituna. Khiin neliö -testi: 3,06; vapausasteet = 2; p-arvo = 0,217.

Previous waste sorting habit	**Does the economic benefit improve your recycling manners?**			**Total**
	Yes	**Maybe**	**No**	
Recycling	29	19	13	61
Combustion or disposal in mixed waste	16	6	2	24
Total	45	25	15	85

People's opinions about the experiment

Opinions about how the respondents' own waste sorting behavior had otherwise changed during this experiment were received from 73 respondents. A total of 49 (67 %) of the respondents stated that the experiment had positively influenced their waste sorting habits (free word in the questionnaire). Twelve said that the campaign had been increasing their plastic sorting. 15 respondents highlighted that the experiment had raised their knowledge of consumption and environmental issues in general, and 16 said that the campaign had improved their sorting habits overall, also regarding other types of waste.

However, 33 percent of the respondents stated that the experiment had not influenced their waste sorting habits. Eight said clearly that they were already good recyclers, so the experiment did not have any effects on their sorting practices. However, the reasons for the respondents to change their previous sorting habits were not clearly indicated.

Discussion

In this study, a deposit-based system was adopted and tested for recycling plastic packaging in the rural case area. The aim was to find new ways to promote the sorting motivation of rural inhabitants. It was possible to return plastic packaging based on a mass-based deposit (1.0 €/kg) or a piece-based deposit (from 2 to 10 cents per item). The results imply that the small compensation encouraged consumers to sort better. A clear majority said that an economic incentive would drive them to improve their sorting. As a suggestive result, the respondents who had previously disposed plastic with mixed waste (to be taken to incineration plants) or combusted plastic waste in domestic fireplaces improved their waste sorting habits during this study. Despite the high returning rate of deposit-based plastic bottles in Finland (over 90 %), the returning rate of the piece-based deposit was relatively low in this study. It is possible that the deposit went unnoticed by some of the customers. Due to the limited duration of the study, some customers may not have had enough time to return the package after the purchase. Moreover, it is easier for the customer to return all the plastic simultaneously and unseparated, which may lead to discarding some items with specific deposits. A product-specific deposit may not drive further separation if there is an optional way to gain the deposit with a mass-based deposit system. However, the average value-estimate of a suitable deposit was close to the current minimum deposit of 0.1 €/item for plastic bottles in Finland (Palpa 2018).

We think that the encouraging results from our experiment merit further discussion. According to Lacovidou *et al.* (2019), the low quality of waste resources prevents their circulation. When the results of the present study are compared to the circulation of Finnish deposit-based plastic bottles, a few issues can be addressed: Finnish deposit-based plastic

bottles are a good example of a well-designed life cycle, as recyclability has already been explicitly designed during manufacturing. In the present study, various plastic packaging types were collected (with different recyclability characteristics), which can make sorting complex for consumers in practice. This experiment suggests that the deposit-based kind of life-cycle planning could be applied to general plastic packaging to support recycling options.

Based on the results, the advantages of the deposit system can be indicated. The deposit system could, for example, contribute to preventing the incineration of plastic waste in rural areas. This could reduce greenhouse gas and other emissions from plastic incineration and improve the plastic recycling rate. However, the introduction of the deposit system may be challenging in urban areas due to a better property-specific collection network. For example, in Finland, in accordance with waste management regulations, plastic packaging collection became mandatory in all residential buildings of at least five apartments in 2021 (Finlex 2021). Thus, the major challenge for the development of the recycling of the deposit system may be the conditions created by the general sorting obligations and the legislation itself. Because there are no regional targets for plastics recycling, it should be reconsidered whether new recycling models would need to be developed based on demographics. Consequently, we suggest that there is a need for regional recycling targets in order to innovate and create regional solutions that are suitable for rural areas.

The study can be useful for municipal-level business developers and for promoting business activity in the field of circular economy. Although a deposit drives people to recycle, it is necessary to discuss what party covers the cost of the deposit. In this study, the total cost of both deposit systems was *ca.* 870 euros. Currently, there is no funding system that would support recycling deposit payments for general plastic waste in Finland. The Finnish plastic bottle deposits are mainly covered by the beverage packaging taxes paid by the producers of beverages. It is important to discuss different options, considering that some plastic waste fractions have economic value as a material resource. When using a deposit, different kinds of plastic packaging can be collected separately, which might increase the value of plastic waste as a resource. Consequently, this could help find solutions for deposit payments. According to the results of the consumer survey, the deposit is also a competitive advantage compared to similar products in the food industry, unless it has effects on the price of the product. The results are in line with Olson (1971) and Yau (2010). Whether the economic incentive permanently impacts the way people sort, requires further research. As Welfens *et al.* (2015) discovered, sorting might not continue after the recycling campaign has ended.

Welfens *et al.* (2015) state that, besides economic incentives, also communication and proper instructions have an important role when adopting sustainable behavior. During the recycling campaign, videos and face-to-face instruction were used to advise people to sort plastic waste correctly. The campaign was visible in the local media and social media. Khan *et al.* (2019) found three constructs that influence the consumer's intention to sort for recycling. Individuals tend to participate in recycling activities if people important to them, such as friends and family, promote recycling and encourage them to sort for recycling. These subjective norms create social pressure to behave in the same manner. Collective recycling habits are important, as people who are sorting for recycling tend to influence and help other people to start sorting, or to recycle more. These interventions are required to change people's habits (Thomas & Sharp 2013). Awareness of consequences, such as of environmental impacts, is a contributing factor in promoting recycling intention. However, the most important predictor of recycling intention was convenience: to increase the recycling rate, sorting for recycling ought to be made easy enough and comfortable (Khan *et al.* 2019). While the economic incentive was effective, many were merely pleased with the chance to gain knowledge about consumption and environmental issues.

This study suggests that the use of a small incentive for plastic packaging improves plastic recycling in rural areas, where transportation distances between home and the

recycling point are usually relatively long. This would lead to better consumer-based sorting, recycling, and refinability of plastic waste and support circular economy targets. Eventually, this practice could have global potential to reduce the amount of harmful plastic waste in nature, as consumers start to see plastic waste as a valuable resource. However, environmental impacts, such as greenhouse gas emissions from plastics collection, were not considered in this study. For example, when estimating greenhouse gas emissions, it must be considered that they depend on various factors, such as the type of vehicle for waste transportation, and consumers' ways of combining waste sorting actions with other housework or leisure activities in rural areas.

The experiment also involved some practical challenges. For example, the collection campaigns required a lot of information and clear guidance, because this was a new system for recyclers. In addition, recyclers often drew false conclusions about what waste and types of plastics could be brought to the collection point. Sometimes, the plastic packaging was dirty. Because of this, during the campaigns, the recycling point always had staff on site to guide consumers in sorting and deposit utilization. Therefore, it would be important to develop the deposit system in the future making the return automated, and the instructions clear. On the other hand, the experiment was short, and it would be interesting to see if consumers' waste sorting habits could change in the long run. In addition, it would be important for plastics recycling to consider the entire production chain, from consumers to refiners and users of recycled plastics. For example, when a deposit refund system was introduced in Scotland, researchers have suggested that it would require a nationwide system similar in function and structure. If consumers' information and opinions about the deposit return system are contradictory, the system and its relevance are questioned (Oke *et al.* 2020). For example, in Finland the deposit refunding system emphasizes the importance of paying attention to the requirements for a deposit, such as the cost of the deposit, how the deposit is financed, and how the disposal of plastic packaging purchased abroad should be treated (see *e.g.*, Saario *et al.* 2014). However, current Finnish packaging waste collection is done in co-operation between producers and municipalities, and any new collection system should comply with that setting.

Future studies could concern automated returning and recycling processes, such as technological solutions for plastic type identification as well as mobile application-based incentives for consumers, which could improve the easiness of the sorting event. We suggest that this could be implemented as part of grocery store bonus systems or other rewarding systems of a similar kind. It would be also interesting to collect only certain plastic types, such as PP or PET, for plastic refiners, and to develop economically feasible and sustainable recycling practices in cooperation with waste companies, refiners, consumers and other stakeholder groups.

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