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Economic–Environmental Performance of Reverse Logistics of Disposable Beverage Packaging

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Abstract: The aim of this article is to provide analysis and description of deposit and recycling system of disposable beverage packaging, which started in the Slovak Republic in 2022. The article provides the review of relevant literature with a focus on circular economy and Deposit Refund System (DRS), where analysis of refund systems was performed for this work. The proposed model involving reverse logistics describes how such deposit and collection system can work in practice, highlighting potential disadvantages, mainly the high investment costs. Therefore, the article also includes a financial analysis exploring potential cost of establishing said deposit and collection system. The number of necessary collection point for Slovakia has been determined and the total investment costs for the vending machines installations and service in Slovakia has been calculated.

Keywords: reverse logistics; deposit refund system; recycling of PET bottles; disposable packaging

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1. Introduction

The subject of the paper is to propose a unified disposal system for plastic PET bottles and aluminium cans in retail stores in Slovakia. The article includes a financial forecast of costs and revenues for the proposed reverse logistics systems. The implementation of reverse logistics system involves transactions that take place between participants in order to properly distribute costs and revenues. The financial transactions include the introduction of a handling fee. This handling fee is paid by the retailer to compensate for costs associated with the collection of used packaging. Additionally, the paper describes the tracking of the material and refunds movement through the system and data recording.

Regarding the plastic waste issue, the annual world plastic production is currently more than 380 million tonnes and increasing at an annual rate of 4%. Consequently, 6300 million tonnes of plastic waste have been generated since 1950. This causes increasing concern regarding the environmental impact of plastic waste and the plastic-related emission of greenhouse gases and motivates the transition towards a circular plastic economy [1]. Specifically, plastic packaging and aluminium cans have been targeted in the European Union with an emphasis on recycling. Especially, polyethylene terephthalate (PET) is the most suitable food-packaging plastic for recycling due to its ability to absorb post-consumer contaminations at lower levels compared to other plastics. Moreover, the subsequent subjection of the recycled PET's to super-clean technologies also removes most of the molecular contaminants [2]. A large proportion of PET plastic bottles is still discarded after first use despite great efforts in recycling. Only about 35% of all PET plastic bottles in Europe are recovered [3]. While the PET packaging market in Europe leads in developing recycling as a sustainable business, many questions remain, with 2019 demonstrating that profitability and cost continue to weigh against the drive to use more recycled plastics in the face of unfavourable economics [4]. Managing the flow of PET plastic bottles and aluminon cans is therefore an integral part of waste management systems. Zielińska [5] describes the level of waste management processes implementation for individual Polish voivodships by utilising a multivariate comparative analysis, effectively creating a ranking that evaluates voivodships according to waste management indicators.

The disposal and effective waste management of PET plastic bottles and aluminium cans is one of the prime examples of the transition to a circular economy. In the current global environmental and social trends, this transition to a circular economy is considered crucial for a sustainable development. The traditional linear business models, where the product was simply discarded at the end of product life circle, are replaced by approaches with focus on re-use of resources. Here, reverse logistics and closed-loop supply chains play integral part for this transition. Lechner [6] presented a case study of an independent company to address an integrated decision making in reverse logistics. It is based on a non-linear optimisation model with interrelated processes for acquisition of used products, establishing grades to determine the product quality and reprocessing disposition. At present, the circular economy is closely linked to reverse logistics, where, according to Hislop, "The circular economy is a development strategy that maximizes resource efficiency and minimizes waste production in the context of sustainable economic and social development" [7]. EU Member States are trying to move social and economic activities towards the "circularity" of reverse logistics, which has conditioned changes in the business model as well as in the labour market. Within the comprehensive action plan of the circular economy, the circular economy is described as an "economic system" where the value of products, materials, and resources is maintained in the economy for as long as possible, and waste generation is minimized.

In the context of this article, reverse logistics is a movement of materials from a typical final consumption in an opposite direction to regain value or to dispose of wastes. Within the system of reverse logistics, the direction of activities takes place from the consumer towards the producer through the implementation of such different processes, including repairs and reuse and recycling. In this context, recycling refers to reprocessing of materials contained in returns during the production process to obtain material to be used along with its original purpose or with another one [7]. Antonyova et al. [8] defined several factors that have a direct impact on the development and successful application of the effective reverse logistics system. Reverse logistics is a movement of materials from a typical final consumption in an opposite direction to regain value or to dispose of wastes. A case study scenario is also used in the paper by Vargas et al. [9], where an application of reverse logistics in solid waste from the construction industry was examined. Therefore, reverse logistics is an alternative for proper management when it is well-planned and -executed. Its objective is to add value to the waste generated or an adequate final disposal. Alkahtani et al. [10] presents the classification methods used in the field of reverse logistics and provides literature review from several fields that are related to either the problem setting or the technical features. Additionally, it provides analysis in the area of reverse logistics and reverse supply chains (Figure 1). Reverse logistics covers initial retrieval or waste, followed by transport to the processing site, where the waste is inspected and sorted. What follows is transport again into individual recovery options: ether reuse, recycling, or safe disposal.

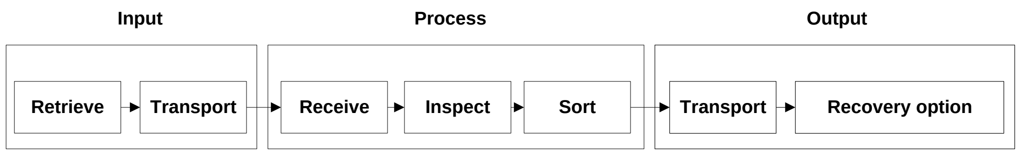

Figure 1. Reverse supply chain collection system [10].

In summary, the reverse logistics is a tool designated to be implemented for waste collection and recycling and suitable in combination with the DRS system, which is discussed next.

The growing population is using increasingly more raw materials and energy to meet its needs [11]. The European Commission is gradually working to put in place measures and requirements to maximize resource efficiency and minimize waste production. These goals include increasing the recycling rate of municipal waste to 60% by 2030 or working towards greener production of plastic bottles by introducing an obligation for manufacturers to use at least 25% recycled plastic in PET beverage bottles from 2025. For this reason, EU countries are required to ensure the rate of separate collection of plastic bottles at the level of 90% by 2029. In practice, the only possible tool to achieve such a high rate of recycling of disposable beverage packaging is to implement a DRS (Deposit Refund System). The concept of DRS was explored in the article of Boros [12], where the implementation of DRS system in Hungary was discussed. The aim, however, was on the popularity of DRS in the general public. The benefits of implementing a DRS model was further discussed by [13], where the implementation in Turkey was discussed considering administration and legislation aspects. Additional case of implementing DRS systems is described in the work of Linderhof [14], who simulated the impacts of DRS implementation on the recycling rate of small electronic appliances and batteries, stating that the DRS is especially effective in cases where current recycling rates are relatively low. Rhein [15] discussed the effects of DRS systems on the overall adverse effectiveness of the circular economy in Germany, stating the increased level of recycling means reduction and reuse on the product level. A case study and economic analysis was performed by [16] on the conditions of the first DRS implementation in Croatia, calculating the overall system costs and identifying the main economic drivers.

2. Methods and Instruments

The DRS was launched in the Slovak Republic from 1 January 2022. Based on the works presented in literature review, the basic proposal to implement PET bottles and beverage cans in Slovakia was analysed, and a model of implementation was discussed. An analysis listing the advantages and disadvantages of effective deposit system was drawn. Whilst the positive environmental benefits of recycling system were not discussed in this article, its biggest disadvantages were discussed, namely the high investment and operating costs. That is why the practical part of this work was devoted to the proposal of a complete backup system for Slovakia, inspired by the most efficient backup systems in Europe. All investment and operating costs, income from the sale of materials, and uncollected advances were quantified. Finally, the amount of the administrative fee for beverage producers and distributors was calculated for each package placed on the Slovak market by modelling the overall balance of the system over a period of 10 years, with an increasing rate of return on packaging in order to repay all investment costs. As the resulting administrative fee, the price of EUR 543.50 per tonne was calculated.

This amount would only be paid by producers for PET bottles, and this amount is even lower than the current rate for plastic packaging: Based on these findings, the proposed back-up beverage packaging system can be considered together with its other environmental benefits to be a suitable and efficient and financially sustainable. The section below wishes to discuss the DRS system concept utilised in this article.

The OECD Glossary of Statistics explains the acronym DRS from the English term deposit refund scheme, that is, a surcharge for the price of potentially polluting products. If pollution is prevented by returning product containers, the surcharge is refunded [17].

The DRS system can be perceived as a combination of tax and subsidy. The implementation of this system consists in the return of used goods (PET bottles or cans) to a designated collection point and payment (advance) as compensation for environmental protection (non-pollution of the environment). The consumer is motivated to keep the bottles and cans out of the environment. This method creates a PULL incentive as the consumer is directed towards "good" behaviour. As payment for subsidies for policy makers would be very costly and would also have negative distributional effects, the refund offer is linked to an advance (deposit) that needs to be paid in advance. The financial deposit is an incentive not to pollute. It is also possible to talk about PUSH incentives because the consumer is encouraged to behave appropriately. A consumer who purchases goods that are subject to a deposit system must pay a deposit above the normal price. The advance paid is the consumer's tax on pollution, according to the "polluter pays" principle [18,19].

There are two ways to establish a DRS system:

- Market-generated DRS system;
- A government-initiated DRS system.

The market-generated DRS system is initiated by manufacturers or retailers. The reasons for starting the system can be divided into two areas:

- Increasing demand for their product;
- A reduction in their production costs by reusing the returned second-hand goods.

Spontaneous beverage packaging DRS systems are not optimal for the whole country; this is the disadvantage of the market-generated DSR system [19]. A better solution is to focus on a backup system that will be initiated by the government. Part of this system is a deposit for disposable packaging, which motivates the return of packaging (after consumption of the beverage) to collection points through a refundable deposit. When buying a drink, consumers pay a deposit, and subsequently, after returning the container to one of the designated collection points, this deposit will be refunded. It is up to the consumer to decide if he does or does not return the empty packaging and lose the deposit. Collection points are located in retail outlets or in centralised places where bulk packaging can be collected. In the case of retail outlets, consumers can return empty beverage containers to the store's cash register or to vending machines, namely a so-called reverse vending machine (RVM). Accumulated empty packaging can be recycled into new packaging and then returned to the beverage industry for filling with new beverages or can be used for other production purposes [20].

Tracking the movement of material and deposits through monitoring and data recording (data flow—blue colour, Figure 2) provides control of transactions that take place between participants to ensure appropriate cost-benefit distribution, for example, in accordance with the contribution of different parties to the system. Financial transactions include a handling fee paid to retailers to compensate for the collection of used packaging.

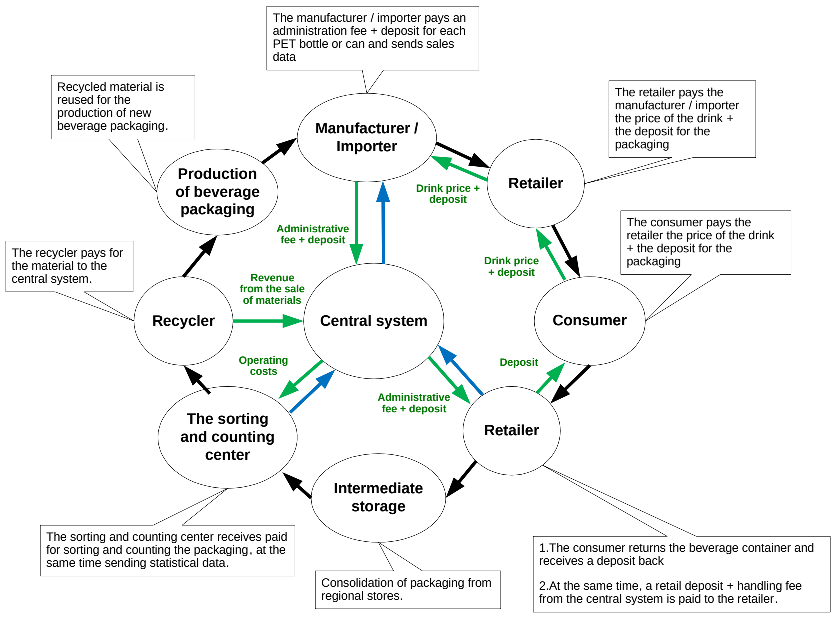

Figure 2. DRS—Deposit Refund Scheme system diagram [21].

Within the scheme of the classic backup system, several actors are involved in this backup return system:

1. Producers, importers of beverages;
2. Retail stores;
3. Carriers;
4. Centralized system;
5. Consumers;
6. Recyclers.

These actors are irreplaceable for the system but, at the same time, complicate this system, as each participant has different interests and needs. The priority of the packaging collection flow is to return the used packaging, so it can be recycled again. The proposed deposit system is important to increase the level of recycling and eliminate the amount of PET bottles and cans in the environment [22]. Within the packaging collection flow, the role of the manufacturer/importer is to pay an administrative fee as well as a deposit for each PET bottle or aluminium can. Subsequently, data are sent to the central system on the sale of individual items. The retailer will make a payment to the manufacturer/importer for the price of the beverage and a deposit for the packaging. Another link in the chain is that the consumer must pay the retailer the price of the drink as well as the deposit for the packaging. Thus, two retail transactions are carried out:

1. The consumer returns the packaging from the drink, after which a deposit is paid;
2. At the same time, the retailer is paid an advance together with a handling fee from the central system.

An intermediate warehouse has been proposed for the purpose of consolidating packaging from regional stores. To monitor the movement of packaging, a sorting and counting centre has been set up, which receives financial payments for sorting and counting of packaging. The task of the sorting and counting centre is to send statistical data to the central system.

From the sorting and counting centre, the packaging is transferred to recyclers, who carry out financial transactions for the material directly to the central system. In the final phase of the waste packaging collection and deposit system, the recycled material is reused to produce new beverage packaging. In the backup system, these new beverage containers are returned to the manufacturer/importer. With the established packaging flow, the deposit system becomes clear and financially sustainable. Achieving the optimal result for the refund system is possible when all parties are economically and/or emotionally motivated to participate in the DRS system [23].

DRS systems can be mandatory or voluntary. In order to increase recycling, the implementation of DRS systems has become mandatory from originally voluntary systems. At the beginning of the implementation, DRS systems were on a voluntary basis due to a decrease in production costs for fresh materials compared to the costs associated with collection and recycling. Mandatory systems for single-use beverage packaging are a trend, and the implementation of mandatory systems presents a higher collection rate compared to systems based on alternative rules [24].

2.1. DRS Objective Specification

The primary goal of the DRS system is to increase the level of recovery of packaging waste. Due to the fact that customers have paid a deposit for the products, it is in their interest to return the empty bottles and cans in order to receive a return of the deposit money. Manufacturers are part of the system, as they are obliged to pay a tax on natural resources for each package generated. If the tax exceeds the cost of participating in the refund system, producers are motivated to meet the DRS objectives. In general, DRS fulfils the following objectives [24–26]:

- Increase the quality of collected materials;
- Reduce littering;

- Increase collection rates;
- Shift the burden of sorting recyclable materials to end users—consumers;
- Increase the involvement of end users in the process, increasing their environmental awareness;
- Collect materials that can be easily recycled;
- Transfer costs associated with waste management activities from municipalities to producers;
- Serve as a tool for product-oriented initiatives such as EPR (Extended Producer Responsibility).

Differences in the scope of targeted products, established rules, stakeholders, deposit rates, actors involved, flexibility, efficiency, and many other characteristics can be seen in the DRS implementation schemes. The main goal of DRS is to ensure a high rate of waste reuse and recycling with a focus on a high level of collected waste. The effectiveness of the system depends on several factors, such as waste policy (at local and national level), the flow (movement) of products that cross national borders, the level of the advance, the flexibility of the system, public awareness, and involvement. All factors need to be considered to increase the usefulness of the implemented system. The disadvantage of the deposit refund scheme (DRS) is the excessive costs. Excessively high costs for DRS lead to a reduction in their attractiveness if there are less-costly alternatives [24–26].

2.2. Deposit Refund Scheme Costs

The implementation of environmental policy aims to create certain benefits for society by stimulating people's behaviour change in the form of waste disposal. Costs play a key role in policy implementation. In some cases, costs are more important than benefits for policy makers, as they have a limited budget. The specific implementation of DRS for disposable beverage packaging is a very costly affair. The reason for the higher start-up costs is how the DRS is organized and coordinated. It is paramount to identify a sufficient number of collection points, as transport costs are part of the return costs. It is necessary to install a vending machine (RVS) for the functional securing of the collection point. The price of the vending machine exceeds the amount of EUR 15,000, and they also have certain fixed costs for operation and maintenance. Subsequently, the collected bottles and cans are transported to a centralized collection point, where they are counted and can be pressed more compactly. At the end of the chain are retailers, who in the form of refunds pay consumers for returned beverage packaging. The total operating costs depend on the rate of return on the backed-up packaging. Due to the fact that the amount of the deposit is several times higher than the price of recycled PET, in a situation where the operating balance is negative, and funds are lacking, these costs are passed on to manufacturers and importers in the form of higher administrative fees. The level of these fees depends on the purchase prices of PET and aluminium, which may fluctuate, and it follows that the price of administrative fees is flexible [27].

2.3. Creation of Collection Points

The area of the Slovak Republic is 49,039 km^2. Approximately 5,464,060 inhabitants live in Slovakia, and the population density is 111.3 inhabitants per km^2. Based on the recommendations of the world manufacturer of collection machines TOMRA, it is necessary to ensure at least one collection point per thousand inhabitants. The recalculation shows that, in the beginning, the Slovak Republic needs to create 5464 collection points. It is essential to find the optimal number of RVMs in order to avoid unnecessary costs and ensure sufficient comfort for consumers. In Europe, the average RVM density in the six main DRS systems is one DRS system per 1900 inhabitants [20]. In comparison with other European countries, Slovakia is the most similar to Denmark in terms of area and population density. Denmark covers an area of 42,933 km^2 and has a population of 5,837,213 and a population density of 13,765 inhabitants per km^2. In Denmark, the DRS back-up system was launched in 2002, and in the last 2 years, the rate of return on backed-up packaging has been 92%, which is very positive. In Denmark, a total of 1.7 billion disposable bottles and cans were transferred in 2020 [28,29].

According to Act no. 302/2019 Coll. on the back-up of disposable packaging for beverages, packaging distributors who sell beverages in backed-up disposable packaging to the end user, with a sales area of at least 300 m^2, are obliged to provide repurchase of backed-up packaging [30]. According to individual institutions, the numbers of retail food stores in Slovakia vary within individual statistics. Of the selected institutions, the most accurate values (numbers) are given in the analysis by the Institute of Environmental Policy, under the heading of the Ministry of the Environment of the Slovak Republic. The analysis included a combination of data from the Statistical Office of the Slovak Republic, the analytical company Nielsen, as well as cooperation in communication with individual franchise networks. At the beginning of the decision, the stores were divided in terms of type and sales area [27].

3. Results and Discussions

From the recalculation, it was found that out of the total number of approximately 8500 retail food stores, 900 stores would fall under the obligation to repurchase (Table 1).

Table 1. Estimated sales of disposable beverage containers [27].

Shop Type	Sales Area (m^2)	Number of Stores	Estimated Sales of 1 Store per Year (pcs)	Estimated Sales of 1 Store per Day (pcs)
Hypermarket	over 2500	133	3,513,300	10,038
Discount	400–1000	131	1,882,300	5378
Supermarket	400–2500	535	582,400	1664
Organized store, large	200–400	568	146,650	419
Organized shop, small	to 200	2488	50,050	143
Unorganized store	-	4617	14,000	40
Total		8472		

Table 1 provides an overview of the repurchase of disposable beverage containers in retail stores. Of the total number of approximately 8500 retail food stores, repurchases should be mandatory for 900. A consortium of beverage manufacturers and retail representatives is responsible for securing and managing the Slovak advance system, with a total of 6500 collection points. The manual purchase of refund packaging would be provided by 5000 establishments, and 1500 establishments would have vending machines. The set number of consumption points is the result of the consortium of the Association of Soft Drinks and Mineral Water Producers in Slovakia (ASDaMWP), the Slovak Beer and Malt Producers Association (SBaMPA), the Slovak Alliance of Modern Trade (SAMT), and the Slovak Trade Union (STU), which would administer the Slovak refund system. The consortium's assumptions are as follows: 5000 establishments would carry out the manual purchase of pre-packages, and 1500 establishments would have vending machines at their disposal [31].

Due to the fact that the year has 365 or 366 days, the number of working days, namely 350 days, is considered to estimate sales of one store per year. Fifteen or sixteen days are public holidays, and the shops are closed, which means that it is not possible to purchase disposable beverage containers. The formula for calculating the estimated sales of one shop per year is as then as follows:

$$Estimated\ sales\ of\ 1\ store = Estimated\ sales\ 1\ store\ per\ day \cdot 350\ days$$

The results of the analysis of the company EKOS PLUS show that Slovakia needs about one vending machine per 2500 inhabitants, which represents approximately 2170 vending machines. In the future, the company expects that up to 90% of returned PET bottles will be collected through vending machines (automation rate will reach 90%), and the other 10% will be secured by manual collection [32].

Analyses of the Institute of Environmental Policy of the Slovak Republic from 2018 present that all stores with an area of over 200 m^2 in cooperation with large, organized stores (26%) will be involved in the system by deploying vending machines. It is possible to assume that larger stores would have two collection machines available.

After recalculation, it would be necessary to create 4325 collection points, and the number of collection machines would be 2150. With the system thus determined, the automation rate is up to 90%, and the expected return rate of beverage packaging is 90%, which represents 1082 million collected packaging annually using vending machines and 118 million packaging using manual repurchase [27].

The form in which the store will buy beverage packaging or if the store will opt for repurchase packing (this applies to stores with an area of less than 300 m^2) depends on the daily sales of beverages in disposable packaging as well as the dimensions of the vending machines (Table 2). Table 2 presents the degree of involvement of stores with manual repurchase as well as stores with automatic repurchase. The beginning of the implementation of the backup system consists in the installation of collection machines only in stores with a sales area of 200 m^2 and more, i.e., categorized as the mentioned organized, large stores, supermarkets, discount stores, and hypermarkets. Later, if appropriate, they would be provided for smaller stores as well. Larger stores would only get one larger vending machine or two smaller ones, which is a more practical alternative, as two customers could return beverage packaging at the same time. The involvement rate of stores with manual repurchase would be 4797 stores, and the involvement of stores through vending machines would be 1367 stores.

Table 2. Form and rate of entry of retail stores into the DRS.

Shop Type	Number of Stores	Involvement Rate by Repurchase	Involvement Rate by Automation	Number of Stores with Manual Repurchase	Number of Stores with Vending Machines
Hypermarket	133	0	100	-	133
Discount	131	0	100	-	131
Supermarket	535	0	100	-	535
Organized store, large	568	0	100	-	568
Organized shop, small	2488	100	0	2488	-
Unorganized store	4617	50	0	2309	-
Total	8472			4797	1367

On the other hand, for small shops (delicacies, parties), this manual purchase will not be advantageous due to insufficient storage capacity for the collected packaging. The financing of vending machines for retail operations is not a problem either, as the costs (depreciation, operation, and maintenance) associated with this financing are transferred to the advance system in the form of a handling fee.

As can be seen in Table 3, the total number of stores involved in the backup system is 6164 stores. The number of stores purchased through vending machines is 1500. Such a division would provide an automation rate of approximately 25% and the total investment costs for all stores, including installation and service contract, are EUR 48,260,000.

Table 3. Investment costs for the purchase of vending machines.

Shop Type	Number of Stores Involved in the System	Number of Machines	Type of Machines	Investment Costs per Store (EUR)	Investment Costs for All Store (EUR)
Hypermarket	133	266	PROLINE 1 PROLINE DUO 2	92,000	12,236,000
Discount	131	131	PROLINE DUO 2	65,000	8,515,000
Supermarket	535	535	PROLINE 1	27,000	14,445,000
Organized store, large	568	568	RVM X2	23,000	13,064,000
Organized shop, small	2488	-	-	-	-
Unorganized store	2309	-	-	-	-
Total	6164	1500		-	48,260,000

3.1. Adjustment of Space in Stores with Manual Collection in Financial Terms

Stores with manual repurchase of disposable beverage packaging will also have to invest in minor changes to their warehouse space. The costs should not exceed EUR 100 per store, and therefore, taking into account all organized small stores and 50% of non-organized stores, the resulting amount is EUR 479,700 [27]. Investments in changes in warehouse areas will also be a forced change for stores with manual repurchase of disposable beverage packaging. For organized, small stores as well as 50% of non-organized stores, the cost would be EUR 100 per store, and the total amount would be EUR 479,700.

3.2. Estimated Funds for the Census and Sorting Center

The transport of backed-up beverage containers from all over Slovakia ends in the centre for sorting and counting [33]. Subsequently, the centre will recalculate the manually collected packaging due to the payment of an adequate amount to retail establishments (stores) and thus prevent frauds. Collected PET bottles from manual collection as well as pressed from vending machines are sorted by colour. For easier handling, sorted PET bottles and cans are bulk pressed into a more compact pallet-sized shape. The packaging thus compressed goes to recycling facilities, and the recycler then pays the quantified amount to the system administrator.

In summary, the operating costs analysis for the proposed deposit system was calculated for this system, consisting of the costs of central administration and retail, and the most considerable item is the cost of transport from retail outlets to intermediate warehouses and then from intermediate warehouses to the counting and sorting centre. The analysis shows that the high transport costs are mainly caused by the condition that the manually collected beverage containers must be transported in an uncompressed form so that they can then be counted in the counting and sorting centre. Only in this way is it possible to prevent potential fraud involving falsely declared quantities. Annual operating costs depend on the rate of return on packaging, which is expected to gradually increase over the years. Revenues from uncollected deposits and revenues from the sale of materials also influence the operating costs. The prices of waste aluminium cans are relatively stable and at a high level, so the income from their sale is subsidized by the costs associated with PET bottles, the price of which in the secondary raw materials market is still marked by low oil prices during the coronavirus pandemic. As the amount of the deposit is already set at 15 cents per package for 2022, it was still necessary to set the amount of the administrative fee paid by the beverage manufacturer or distributor for each package placed on the market.

The greatest potential for reducing the operating costs of the system is the gradual introduction of vending machines in small, organized stores, which, despite the smaller area, collect a relatively large amount of deposited packaging. Manual purchase of used beverage packaging's represents higher labour and transport costs in terms of deposit package price compared to vending machines. Therefore, such a DRS system with effective central administration and implementation can be considered financially sustainable.

4. Conclusions

By analysing the already-established deposit systems in the world and the current size and structure of the Slovak market, a model was designed based on repurchases in retail stores. The proposed model covers all organized stores and 50% of non-organized stores, for a total number of 6164 stores. The model considers that larger stores would be equipped with different types of vending machines depending on their sales of disposable beverage packaging, where smaller and all non-organized stores would purchase packaging manually.

In addition to securing the purchase in retail, it would also be necessary to set up a counting and sorting centre to control the amount of manually collected packaging and their subsequent sorting by colour. Based on the calculation, the total investment costs for the procurement of vending machines, including their installation and servicing, the renovation of premises in manual shops, and the establishment of a counting and sorting centre is at EUR 52,989,700.

Using modelling of the overall balance of the deposit system, to repay all investment costs in 10 years, the amount of the administrative fee was calculated. As the market price for aluminium beverage cans is so high that the revenue from their sales would support and co-finance the collection of PET bottles and the operation of the whole system, the administrative fees for aluminium cans would therefore be zero, which is EUR 250 per tonne less than the current rates. Fees for PET bottles have been calculated at EUR 543.50 per tonne, which is still less than the current rate for plastic packaging.

Further research and studies in this area could focus on implementing similar DRS schemes for other type of waste, such as small electronic appliances or old batteries. Additionally, future study might focus on measuring population satisfaction with the implemented DRS system or evaluating of economical ramification or DRS system implementation.

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