Report

Impact analysis for a potential circular economy strategy for the plastic sector in Estonia

Authors:
Eric Young, Eivind Lekve Bjelle, Anne Gaspers, Helene Øyangen Lindberg, Kristin Pille, Peep Jürmann; Krislin Kukumägi, Kertu Sapelkov

Report No.:
2023:01045 - Open

Client:
Republic of Estonia Environment Agency

SINTEF Ocean AS
Postadresse:
Postboks 4762 Torgarden
7465 Trondheim

Sentralbord: 46415000

Foretaksregister:
NO 937 357 370 MVA

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KEYWORDS
Circular Economy, Estonia

VERSION
1

DATE
2023-09-27

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Eric Young, Eivind Lekve Bjelle, Anne Gaspers, Helene Øyangen Lindberg, Kristin Pille, Peep Jürmann; Krislin Kukumägi, Kertu Sapelkov

CLIENT
Republic of Estonia Environment Agency

CLIENT REFERENCE
Kaili Simberg

PROJECT NO.
902002438

ANTALL SIDER
47

SUMMARY
This report presents the work of SINTEF's collaboration with the Republic of Estonia Environment Agency through the project Enhanced Capacity on Circular Economy, funded by the Iceland, Lichtenstein, Norway Grants.

This report is intended to support the development of Estonia's strategy for circular economy as well as the implementation of the Single-Use Plastics Directive (SUPD). It contains systems definitions, the results of a survey of Estonian municipalities, and the results of an impact analysis.

PREPARED BY Eric Young	SIGNATURE	Eric Young Eric Young (Sep 28, 2023 15:44 GMT+2)
CHECKED BY Vibeke Stærkebye Nørstebø	SIGNATURE	Vibeke S Nørstebø
APPROVED BY Mimmi Throne-Holst	SIGNATURE	Mimmi Throne-Holst Mimmi Throne-Holst (Sep 28, 2023 14:31 GMT+2)

REPORT NO.	ISBN	CLASSIFICATION	CLASSIFICATION THIS PAGE
2023:01045	978-82-14-07865-7	Open	Open

Document History

VERSION	DATE	VERSION DESCRIPTION
1	2023-09-27	Final report

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APPENDICES

1. Introduction

This report presents the work of SINTEF's collaboration with the Republic of Estonia Environment Agency through project Enhanced Capacity on Circular Economy, funded by the Iceland, Lichtenstein, Norway Grants as well as European Economic Area Grants 2014-2021.

The objective of the work is to strengthen the circular economy framework and increase awareness on climate change related actions, with the purpose of contributing in the transition to a low-carbon circular economy in Estonia in a smooth, inclusive and informed manner. This report provides an overview of existing knowledge of how plastic moves through the Estonian society and examines the effects that possible changes aimed at reduced plastic waste will have on the Estonian economy, specifically in terms of plastic packaging waste, employment, and production value. This report, which is for use of the Republic of Estonia Ministry of Climate and the Environment Agency, is intended to support the development of Estonia's strategy for circular economy as well as the implementation of the Single-Use Plastics Directive (SUPD).

1.1. Background on circular economy and the Single-Use Plastics Directive in Estonia

The European Union (EU) is working towards a circular economy, which means that Estonia, as a member state, must also work towards a circular economy. Environmentally sustainable production and consumption must be based on common foundations. Therefore, it is important to agree on both the goal of promoting the circular economy and the principles of the circular economy, which ensure that economic activities support environmental preservation. To support this, the Environment Agency and the Ministry of Climate have created a non-binding white paper on the circular economy, which brings together the vision, fundamental principles, and development directions agreed upon through discussions among ministries and stakeholders. The document supports various stakeholders to ensure that the circular economy becomes a comprehensive framework in planning, consumption, production, policy, lifestyle, culture, and values. The white paper is followed by an action plan for circular economy, which outlines activities and indicators in different sectors. To ensure the effective functioning of the circular economy in Estonia, it is crucial for the separate and collective efforts of various societal members to align with each other, starting from a unified vision. Estonia has set an ambitious goal to establish a well-functioning circular system of production and consumption. Estonia is a leading country in digitization and will also lead the way in transitioning towards a circular economy.

Transitioning to a circular economy in Estonia faces significant challenges, including insufficient collaboration and shared responsibility, limited awareness of environmental and circular economy concepts among the general public, a shortage of experts, the absence of a comprehensive framework for implementing circular practices, and a lack of innovative and sustainable solutions.

The white paper also outlines Estonia's six priority development directions:

1. Resources are used responsibly and based on demand, with well-thought-out resource utilization and minimization of waste generation.
2. Estonian businesses models will be sustainable and circular.
3. The necessary know-how and expertise for implementing the circular economy will be ensured and cooperation between stakeholders and sectors will function well.
4. The circular economy will be well-coordinated at the national level, with a supportive legal and economic environment.
5. Functional digital IT solutions are created to support the circular economy, ensuring high-quality data for monitoring the situation.
6. An environmentally conscious mindset and sustainable behavior will be deeply ingrained in society.

Estonia has not yet adopted a dedicated circular economy strategy. However, Estonia is working on an environmental development plan and, in 2022, a green transition workplan was established. Circular economy topics are present on both documents.

Products made from single-use plastics are a global environmental problem. The EU is committed to reducing the consumption of plastic products and associated waste in the EU Member States. In order to prevent these plastic products from entering the environment, the EU created legislation focusing on the ten most problematic single-use plastic products as well as fishing gear containing plastic.

Adopted by the European Parliament and the Council on 5 June 2019, EU Directive 2019/904 on the reduction of the impact of certain plastic products on the environment (hereafter referred to as the Directive) aims to reduce the environmental impacts of the use of certain plastic products. The aim is to promote a circular economy by replacing single-use products with sustainable and non-toxic reusable products. The Directive introduces measures to reduce the consumption and environmental impact of various plastic products (including reduction of consumption, restrictions on placing on the market, product requirements, labelling requirements, extended producer responsibility, etc.).

Importantly, one of the aims of the Directive is to extend producer responsibility. For example, tobacco producers will have to pay the cost of cleaning the filters of tobacco products from beaches, streets and public bins. Manufacturers of plastic-containing wipes and balloons shall also bear the costs of cleaning up the rubbish generated from the products as well as the costs of transporting and handling. So far, these costs have mostly been borne by the local government.

1.2. Implementation of the Single-Use Plastics Directive in Estonia

In Estonia, the process of transposing the Directive was completed in Spring 2023, and the first changes resulting from the Directive entered into force on 01.05.2023. The additional producer responsibility costs resulting from the Directive will apply from 01.01.2024.

Extended producer responsibility systems must be established for wet wipes, balloons, filters for tobacco products and tobacco products containing plastic, and for fishing gear containing plastic. In addition, the already existing producer responsibility system for packaging must cover the additional costs under the Directive for the following single-use plastic products: food packaging, flexible packaging and packaging materials, beverage containers with a capacity of up to 3 liters, beverage cups, and lightweight plastic carrier bags. Additional requirements relate to the collection of waste from the products concerned, including the infrastructure and its operation, the subsequent transport and treatment of such waste, and litter clean-up costs of waste from the products concerned and their subsequent transport and treatment, which is taken into public collection systems.

Under the Directive, in relation to single-use plastic products for which there are no readily available suitable and more sustainable alternatives, Member States should, in accordance with the 'polluter pays' principle, also introduce extended producer responsibility schemes to cover the costs of waste management and collection, as well as the costs of awareness-raising measures to prevent and reduce such waste. These costs should not exceed the costs necessary for the cost-effective provision of these services and should be determined in a transparent manner between the actors concerned. Pursuant to Article 8(4) of the Directive, the Commission, in consultation with the Member States, shall publish guidelines on the criteria to be applied for the costs of waste collection. These guidelines have not been published, and it is therefore necessary to find solutions at the national level on how the additional costs should be determined. In Estonia, the methodology and procedures for calculating the costs are planned to be laid down in a regulation of the Minister of the Climate, which will involve all relevant actors in the drafting process.

1.2.1. The status of extended producer responsibility in Estonia

Extended producer responsibility is an environmental policy measure that implements the polluter pays principle into a specified financial scheme where costs associated with the waste generated by the sale of a product is paid for by the producer of the product. In extended producer responsibility, the actor responsible for the waste can be the manufacturer or importer of the product, or it can be the entity that makes the final sale to the end user. For packaging, the responsibility for packaging waste often is assigned to the actor that put the product into the product packaging, which might occur at various stages of the value chain.

In Estonia, the extended producer responsibility principle was implemented in waste management in connection with accession to the EU on 1 May 2004 and the adoption of EU legislation in the same year. In Estonia, extended producer responsibility currently applies to the following products:

1) Packaging

2) Tires

3) Electrical and electronic equipment

4) Motor vehicles and their parts

5) Batteries and accumulators

6) Agricultural plastics

As a result of the Directive, extended producer responsibility systems will be added for wet wipes, balloons, filters for tobacco products and tobacco products containing plastic, and for fishing gear containing plastic.

In Estonia, the principle of producer responsibility applies in the packaging sector. Packaging undertakings[1] that place packaged goods on the market must ensure the collection and recovery of packaging and packaging waste placed on the market in such a way that the recovery, including recycling, targets set by the Packaging Act are met. The obligation may be fulfilled by the packaging undertakings themselves or responsibility can be transferred to a recovery organization by written contract.

The obligations of the recovery organization are also laid down in the Packaging Act (2004), and the main obligation is to ensure the collection of packaging waste through the nationwide packaging waste collection network and the re-use and recycling of collected packaging. The recovery organization must ensure that all packaging companies have access to the service and must ensure equal treatment for all companies that have signed contracts. The activities of the recovery organizations are financed by the fees paid by the packaging undertakings placing the packaged goods on the market. The fees are based on the weight of packaging placed on the market.

To be able to operate, a recovery organization must have a license issued by the Minister of Climate. The Packaging Act lays down the requirements that a recovery organization must meet to obtain a license. The license is currently open-ended. No member, partner or shareholder of a recovery organization may hold more than 25 per cent of the votes attached to the membership, shares or stocks (Packaging Act, 2004).

There are four recovery organizations in Estonia, through which more than 4,000 packaging undertakings fulfil their obligations under the Packaging Act. A packaging waste collection network has been set up by the recovery organizations, covering the entire territory of Estonia. Local residents can hand over their

[1] Packaging undertaking means any person who packages, imports or sells packaged goods within their economic or professional activities. (Packaging Act, 2004)

packaging waste free of charge. Estonia has a well-functioning deposit refund system, which was set up in 2006.

2. System definition for plastics in Estonia

A circular economy strategy for plastics in Estonia requires a complete understanding of the life cycles of plastics throughout Estonian society. This means an understanding of the flows of plastic commodities, products, and waste materials, those covered under the SUP Directive and plastics more generally, as well as the various actors involved in trade, production, consumption, and waste management of plastic packaging and products. The systemic interrelations of these actors are important to understand both in terms of the flows of goods between actors as well as the financial flows and incentives that drive behavior of the system.

More specifically to the SUP Directive, to reallocate the costs associated with management of single-use plastics, information is needed on the source of SUP products, the revenues associated with their sales, as well as the destination of the associated waste and the costs associated with managing that waste. To implement a fair cost-sharing system that can incentivize reduction, governments need to know who is putting what kinds of plastics on the market, what happens to those products at the end of their useful life, what the costs are for managing the waste and who bears these costs. A visual system definition, which identifies the various actors and the flows of goods and finances, can generate insights about potential points of intervention and data gaps and needs. This information is important to calculate fair cost-sharing routines as well as to improve the effectiveness of waste management and identify strategies for reducing the burdens associated with single-use plastics. System diagrams have been produced to represent the state of knowledge about the SUP system, to communicate this knowledge to stakeholders, and to identify areas to target with additional knowledge.

The systems diagrams are based loosely on systems theory (Meadows, 2008), and Material Flow Analysis (Brunner & Rechberger, 2016). The diagrams were developed based on literature describing the different plastic use pathways as well as through a workshop with knowledgeable actors in the Republic of Estonia Ministry of Climate and the Environment Agency.

2.1. Findings

Figure 1 shows a simplified diagram of the Estonian plastics system, which is generalized for all plastics products. Plastics move through the Estonian economy between manufacturers, sellers, consumers, and waste management actors. Plastic goods flow between actors in the form of raw materials, products, packaging (new, returned for reuse, returned for recycling), and waste. Monetary flows take the form of direct payment for products, deposits for returnable or reusable packaging, and payments for waste management services, which are paid for by municipalities. Some amount of plastic is mixed in municipal waste imported to Estonia for incineration at a fee to the exporter (World Bank, 2021). Some amount of plastic waste is imported for recycling in Estonia. Some amount of plastic waste is also exported from Estonia for recycling elsewhere. Payment schemes vary according to type of plastic, with only certain types of plastic being covered under extended producer responsibility schemes. For waste products, the payments are dependent on the specific types of waste. For example, in the case of problem products (e.g., batteries), the exporter pays for waste treatment. However, for waste types that have a positive monetary value, the importer buys them, and the exporter earns a profit. The transport costs are mainly paid by the exporter.

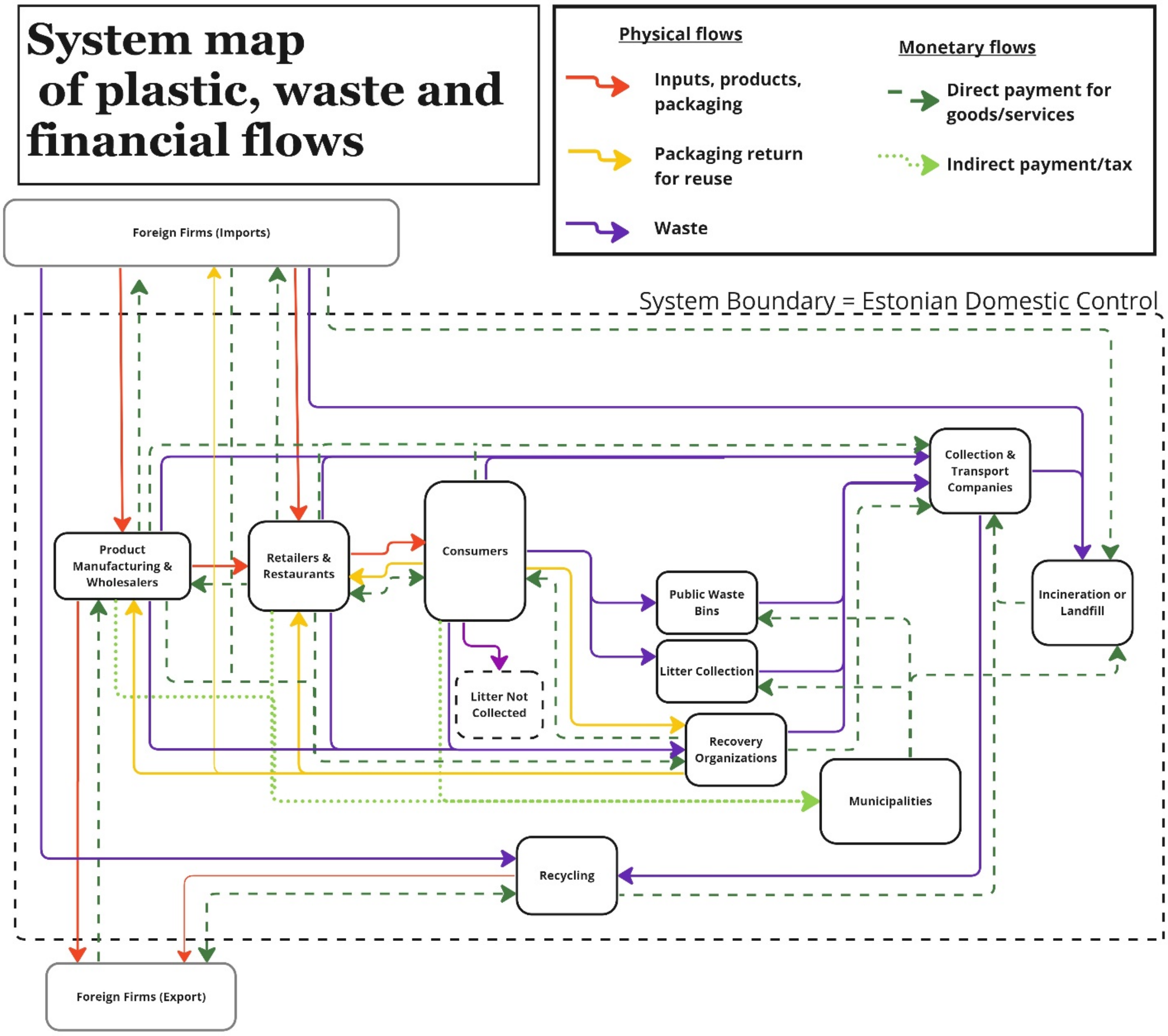

Figure 1: Basic system diagram of (simplified) plastics and payments flows system for plastic products and packaging in Estonia.

Figure 1 shows a lack of incentivizing connection between those who are responsible for products entering the system and those who manage the waste. The product manufacturing, sales, and consumers are linked with direct payments for the goods which are purchased. A change in the number of products supplied will correlate with the amount of money exchanged. Likewise, there is a system of direct payments in the downstream waste collection system; waste collection and transport are paid for by businesses and consumers in proportion to the amount of mixed waste that they produce. Meanwhile, municipalities pay for public waste bins, litter collection, as well as end phase waste handling (incineration). Some of these connections are direct in that the cost to consumers or businesses is in proportion to the amount of waste that is handled by collection and transport companies, which creates some incentive to reduce the amount of waste produced. Though without discriminating between types of waste this incentive does not target any particular type of waste. For waste management services that are the responsibility of municipalities, the connection between the upstream and downstream systems are not direct. The municipal budgets are funded indirectly from the national budget. This means that if any actor in the upstream system would reduce their production of products that become waste, they would reduce the costs of waste management borne by the municipality, but this cost savings will not be passed on to the upstream actor that caused the reduction. This description is merely a way of visualizing the need for an extended producer responsibility scheme. Indeed, the exception to this is seen with the recovery organization process of the diagram, where a direct payment link is made between the upstream and downstream system where actors responsible for putting packaging on the market pay waste management fees in direct proportion to the products they put on the market. Implementation of the SUP Directive requires extending this program to cover the following plastic waste types that are put on the market: wet wipes, balloons and filters for tobacco products and tobacco products, food packaging, flexible packaging and packaging materials, beverage containers with a capacity of up to 3 liters, beverage cups, and lightweight plastic carrier bags.

Figure 1 highlights value of extended producer responsibility in Estonia. For products not under extended producer responsibility schemes, the financial costs from management of problematic plastic waste are not directly connected to the companies putting products on the market, resulting in a lack of incentive for companies to improve their waste generating practices.

This analysis emphasizes the role that product value is playing in the system. For the plastic products in the upstream portion of the system, the products themselves have value and the product and financial flows are parallel, with money flowing upstream as products flow downstream. Once the products cross the use phase, they lose value and become a problem item to be disposed of. In this downstream part of the system, the financial flows are not parallel to the physical flows but instead come from the municipalities to the waste management actors. Importantly, the money in this part of the system is not paying for the waste products but is paying for services to manage the waste products. This causes a loss of information about what products are responsible for which costs.

Good quality data enables policymakers and stakeholders to design tailored extended producer responsibility strategies, monitor progress, and evaluate the impact of these schemes on waste reduction and recycling rates. Furthermore, comprehensive data helps identify areas for improvement, foster transparency and accountability among producers, and facilitate informed decision-making to optimize resource allocation and achieve desired environmental outcomes.

2.1.1. Data system

Implementation of a circular economy strategy and the SUP Directive is a question of implementing systems and routines that manage plastic flows. This requires measuring the flows that need to be managed and making sure that data gets put in the hands of the people in charge of designing the strategies and regulations as well as in the hands of the people who make decisions that influence the behavior of the system.

A focus on good data collection routines and sensible dissemination of collected data is important to ensure that data is available to the people who can use it.

Several organizations play a role in regulating and organizing different aspects of the Estonian plastics and waste sectors. Figure 2 visualizes how data streams reach the Republic of Estonia Ministry of Climate, which is the organization responsible for implementing the Circular Economy Strategy and Single Use Plastics Directive. The data collection activities are discussed, and the various data sets are described and visualized where available in Appendix I.

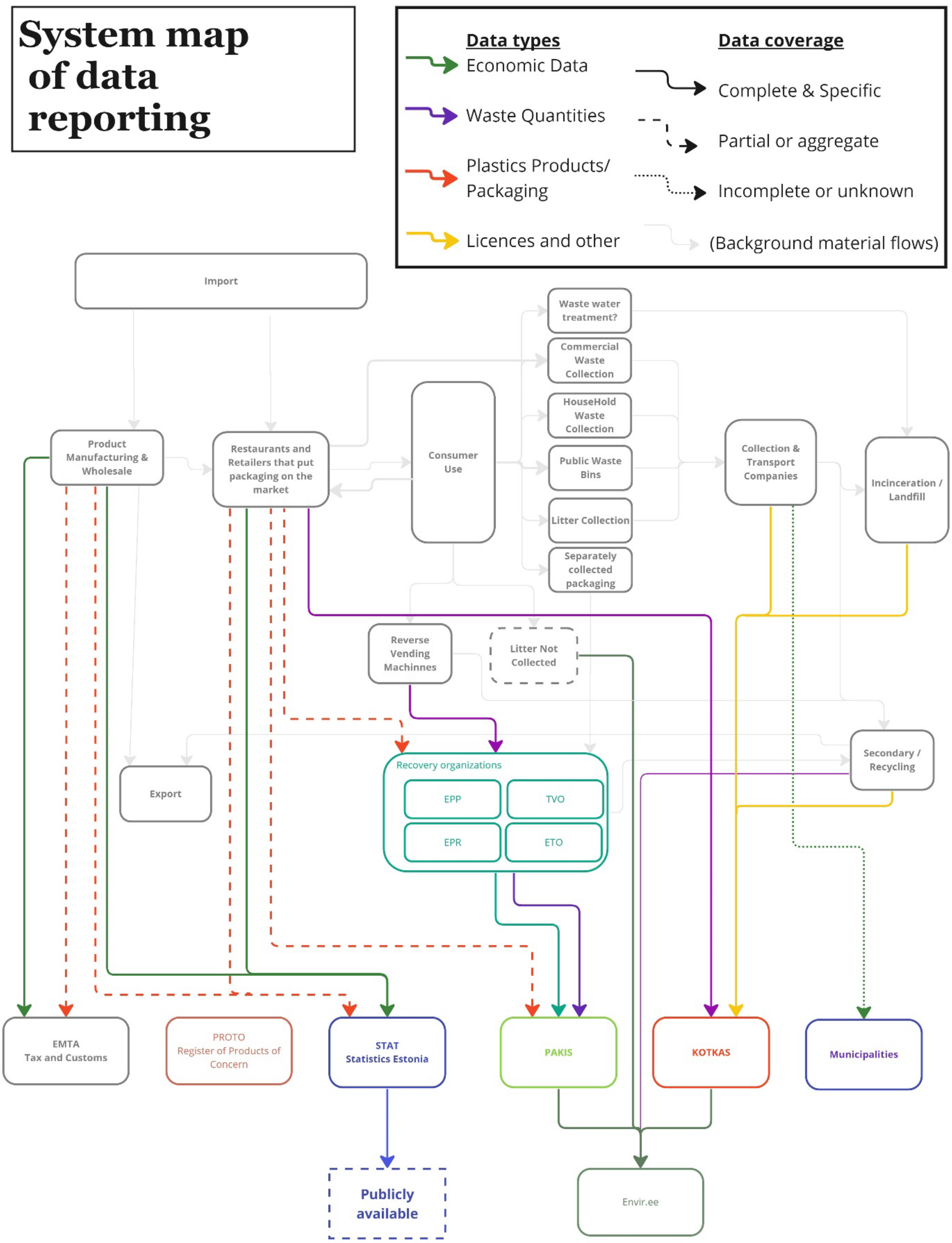

Figure 2: System diagram reproduced showing how data is shared between entities, with links to the actors and bodies that collect information about the plastics economy. The content and quality of the data is shown with reference to the system location of data sets that are available to the Environment Agency. Data content is shown by line color and data quality is represented by the line style. See appendix B for explanation of data streams and organizations.

Additional details on waste data streams relating to recovery and packaging organizations:

- Packaging companies that operate themselves submit their market release data directly to PAKIS.
- Packaging companies that are part of recovery organizations submit their market release data to recovery organizations.
- Recovery organizations submit market-release data of its clients to PAKIS.
- The waste handler submits recycling certificates to PAKIS, which generates the section of waste data for companies and recovery organizations in the report.
- The waste handler also submits waste data to KOTKAS in the waste report.
- Both carriers and recyclers submit this data to both KOTKAS and PAKIS. Landfill operators and incinerators only provide data to KOTKAS.

2.1.2. Data gaps

Existing systems of data collection and management in Estonia are focused on products that have economic value. For example, there are records of economic transactions between sectors of the economy and records of imports and exports and the manufacturing of goods. However, once products lose economic value and become waste, it becomes much more difficult to differentiate between types of waste and little data is recorded on the flows of the waste products themselves and of the costs of managing the waste.

In instances where established extended producer responsibility (EPR) systems are in place and have associated data reporting mechanisms, we can construct a meaningful representation of plastic waste streams. Nevertheless, for waste commodities not encompassed by these systems, the absence of data poses a significant challenge in allocating costs to the relevant producers. Furthermore, this lack of cost attribution hinders the collection of pertinent, informative data. This scenario creates a cyclical dilemma where the lack of an existing EPR scheme makes it difficult to implement an EPR scheme.

Particularly relevant data to the implementation of SUP Directive and specific circular economy strategies is the makeup of the general waste that is collected and dealt with by municipalities and the costs associated with different fractions of that waste. To understand how much knowledge municipalities currently have, a survey was developed and sent to municipal governments in Estonia (discussed in section 3 below).

Enhancing and centralizing data collection can yield valuable insights by making diverse data types comparable. Figure 3 exemplifies this by merging harmonized macroeconomic data from the national accounts on all plastics traded in Estonia with data about packaging from Estonia's packaging registry[2] data, both aligned to EMTAK sector classifications. The figure's left side illustrates the monetary value (in Euros) of purchases from both domestic and international plastics sectors, made by Estonia's top 16 plastics consuming industries. The figure's right side depicts the tracked quantity of plastic packaging (in tons) in the packaging registry. Despite differing units (financial vs. physical) and base years (2015, 2021, and 2022), this combined approach can still provide insightful observations.

First, we see that the plastics sector in Estonia is very international. Not only are the vast majority of plastic products used in the country imported, but the export sales of the Estonian plastics sector are also an order of magnitude larger than domestic sales. The largest Estonian purchasers of plastics of both import and domestic production are the construction sector, the food and beverage sector and the motor vehicles sector. Of these, the food and beverage sector is the only sector which is significantly represented in the

[2] Packaging registry records amount of packaging waste put on the market in Estonia according to certain criteria. Details on data systems such as packaging registry and national accounts given in appendix.

packaging registry data. This emphasizes the importance of taking a wide-boundary perspective when considering solutions to reduce the use of plastics in the Estonian society.

Finally, Figure 3 shows that reusable packaging can play a significant role in reducing plastic use. According to the Packaging Registry for 2022, there is nearly double the amount of plastic packaging being reused (when counted by number of rotations) than single-use plastic being put on the market. However, of the single-use plastic, less than half is currently being recycled.

The main findings from this section highlight the benefits of expanding data streams for implementing a circular economy strategy and the Single-Use Plastics Directive. This includes 1) standardizing data across multiple economic sectors to facilitate comparability and integration of information; 2) considering products with low or negative economic value for a comprehensive coverage of material flows; and 3) a addressing all the main flows of plastic. In Estonia, the construction and motor vehicle sector as well as others should be taken into account.

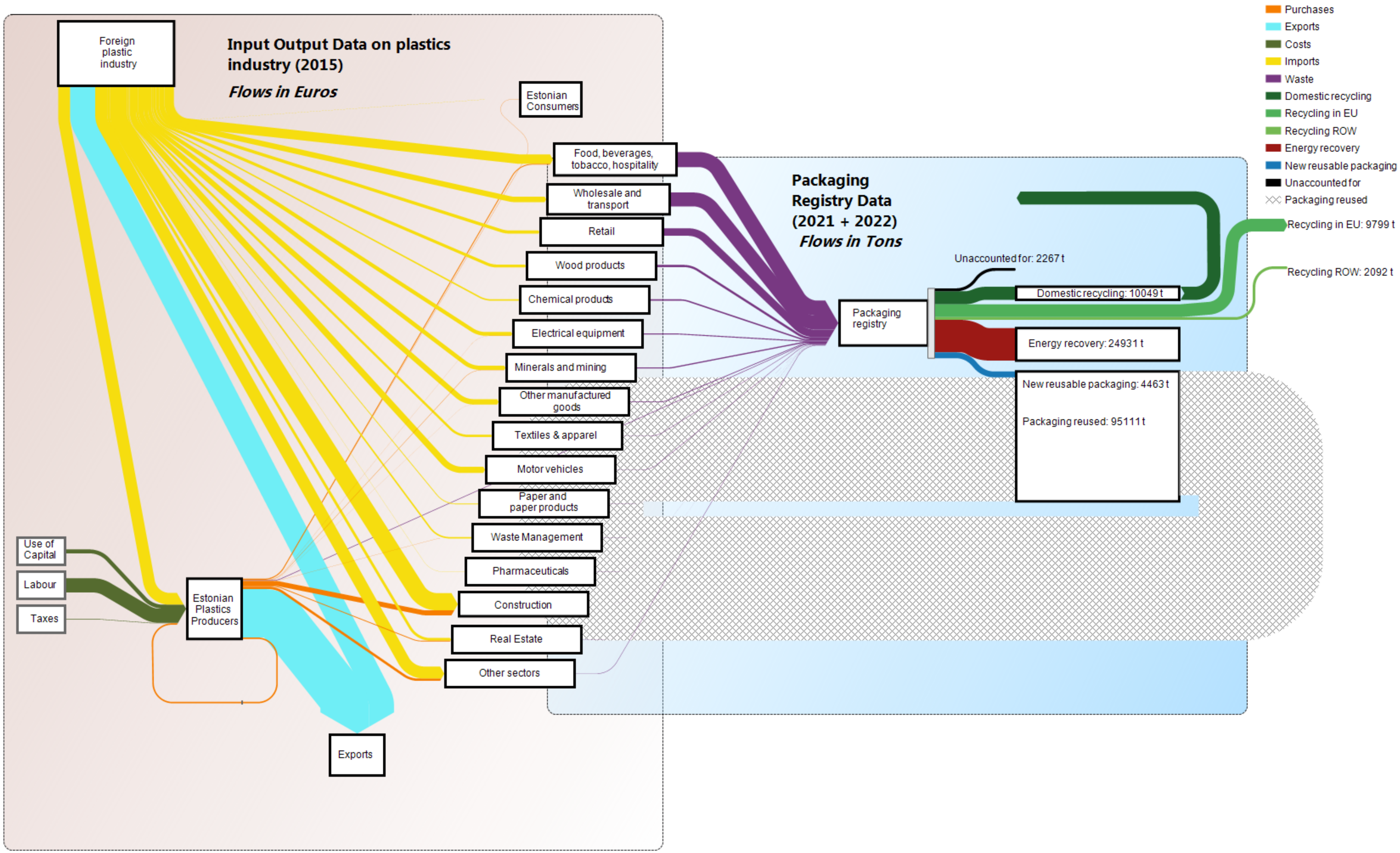

Figure 3 Combination of economic data from input-output tables with waste registry data.

3. Survey

The purpose of the survey was to better understand whether municipalities have an overview of costs in the following areas: waste management (including indirect costs such as awareness raising), emptying trash cans in public spaces, and cleaning up litter. This was important, as highlighted in the previous section, because municipalities have the responsibility of organizing waste management.

3.1. Method

We sent a questionnaire to 79 municipalities on 8 February 2023. It was sent to one person per municipality. It was sent to a person who worked with finance, administration, or environment. The questionnaire was sent via email and programmed in Survey Monkey.

Respondents were initially given two weeks to respond. During this period, the number of respondents was low. Therefore, the deadline was extended by a week. There were 17 questions, which were divided into two types: multiple choice and open answer.

A total of 51 municipalities replied to the questionnaire, and on average each question received between 20 and 25 responses. Thus, not all 51 municipalities were able to answer all the questions.

3.2. Results

The main results of the survey are presented in Table 1, Table 2, Table 3, and Table 4.

Table 1 shows the municipal budget for waste management, emptying trash cans in public spaces, and littering for year 2022.

Table 1: Answers from respondents to the question: How big was the budget (€) in your municipality for: a. waste management, including indirect costs such as awareness raising; b. the costs of emptying trash cans in public spaces; c. the costs of cleaning up littering? (Year = 2022; Dash indicates no data).

Municipality	Waste management (€)	Public bins (€)	Littering (€)	Population
Municipality 1	28 482	-	198	5 776
Municipality 2	107 678	-	-	10 117
Municipality 3	5 981 818	1 306 513	1 306 513	444 999
Municipality 4	443 026	93 557	8 956	94 831
Municipality 5	50 000	30 000	-	5 282
Municipality 6	29 890	13 090	-	7 602
Municipality 7	80 000	37 500	3 500	22 199
Municipality 8	2 207	834	2 882	3 209
Municipality 9	119296	-	-	10 549
Municipality 10	75479	48 117	-	8 814
Municipality 11	26 317	-	-	5 413
Municipality 12	341	346	-	4 617
Municipality 13	82 720	57 720	-	10 646
Municipality 14	75 000	2 400	2 500	8 203

Municipality 15	83 817	4 544	800	4 381
Municipality 16	212 135	5 869	4 281	9 557
Municipality 17	36 801	66 000	5 000	4 659
Municipality 18	173 000	173 000	-	12 878
Municipality 19	53 666	7 561	150	6 172
Municipality 20	30 000	10 000	5 000	16 651
Municipality 21	121 983	2 500	-	11 184
Municipality 22	180 000	51 379	7 500	21 978

Table 2 shows the amount of waste, in tons, collected in the municipality over a period of five years. Respondents did not indicate what type of waste is included in their calculations, whether it is both industrial waste and private/consumer waste.

Table 2: Answers from respondents to the question: How much waste was collected from your municipality (in tons)? (Years 2018-2022). Dash indicates no data.

Municipality	2018	2019	2020	2021	2022
Municipality 1	-	-	54	55	55
Municipality 3	4 433	3 875	3 960	4 333	6 149
Municipality 7	40	38	40	34	42
Municipality 11	2 018	3 026	1 957	2 643	-
Municipality 12	-	-	18 301	56 205	-
Municipality 14	1 794	2 026	2 005	1 700	1 700
Municipality 15	1 000	800	900	1 000	800
Municipality 18	3 393	3 373	3 359	2 432	3 197
Municipality 20	6 738	7 400	7 210	9 842	-
Municipality 22	35 807	24 796	24 806	-	-

Table 3 shows the amount of waste, in tons, collected from public trash cans over a period of five years.

Table 3: Answers from respondents to the question: How much waste was collected from public trash cans in your municipality (in tons)? (Years 2018-2022). Dash indicates no data.

Municipality	2018	2019	2020	2021	2022
Municipality 1	2	3	5	7	7
Municipality 3	1 116	1 150	1 000	1 050	1 750
Municipality 4	68	68	68	87	90
Municipality 7	33	30	34	28	34
Municipality 22	-	-	-	-	80

Table 4 shows the amount of litter (i.e., waste that is not properly discarded in bins, etc.), in tons, collected from the municipality over a period of five years.

Table 4: Answers from respondents to the question: How much litter was collected from your municipality (in tons)? (Years 2018-2022). Dash indicates no data.

Municipality	2018	2019	2020	2021	2022
Municipality 1	7	0,3	7	2	3
Municipality 3	2 231	2 223	2 177	2 253	2 402
Municipality 4	25	33	15	11	15
Municipality 7	7	8	6	6	8
Municipality 9	5	12	10	5	13
Municipality 12	1	1	-	-	-
Municipality 14	-	7	24	1	1
Municipality 15	300	400	500	300	400
Municipality 21	83	46	71	23	18

Municipalities did not know about the composition of the waste.

Municipalities highlighted several reasons for not knowing costs associated with waste management. Municipalities allocate money in different budgeted accounts. For example, the budget for maintenance of a park can be in one account, but the budget for waste collection from public bins in another account. Some municipalities do not know the data because information about the budget is handled in the finance department or by the contracted waste companies. Some respondents also pointed out that the districts do not cooperate in this regard and that the budgets can be different across the districts.

Municipalities highlighted several reasons for not knowing the weight (in tons) of waste, including a) they do not collect data, b) waste companies do not give an overview, and c) the waste is transported directly to the landfill. One municipality stated that the calculation at landfills is laborious, but not impossible.

It was also added that there is a lack of data due to divided responsibility. For instance, in one public area, there are welfare workers, who empty trash cans and pick up trash from the ground. In other areas, the waste companies handle the waste. Along national roads, it is entirely the responsibility of the State (or Transport Agency).

3.3. Summary of results

The results differ between municipalities, which can partially be attributed to the fact that the size of Estonian municipalities varies.

As is shown in Table 1, only 22 municipalities, of the 52 whom responded to the survey, filled in information about their waste management budgets.

The results highlight that:

1. There is a lack of data sharing.
2. Data are collected in different ways, leading to a lack of harmonization.

3. Sometimes data are not collected, and knowing how much municipalities pay is critical for implantation
4. A study of sorting and littering is necessary

4. Impact analysis

An impact analysis was conducted to model potential impacts of different circular economy interventions that might be implemented. The impact analysis enables projections of the growth of the Estonian economy and estimates the effects of various scenarios on indicators such as value-added, employment, imports, and exports for specific Estonian industries. The primary objective of the model is to comprehend the interconnections within an economy. Any sector or business project is intrinsically linked to the broader economic system as it necessitates suppliers and consumers spread across the entire economy.

4.1. Methods

The impact analysis uses input-output based macro-economic modelling based on the method developed by Wassily Leontief (Leontief, 1986). The main data source was the Estonian input-output table made available by statistics Estonia for 2015 (see appendix B for details on the data sources and the system of national accounts). Scenarios are advanced to examine how different circular economy strategies would develop in a mathematical model of the domestic economy.

Input-output tables are a standardized method for recording the monetary interactions of an economy in a structure which maintains the interdependencies between different sectors of the economy in a way that is mathematically consistent and can be used to derive various insights. These tables are compiled based on detailed data and statistical techniques, such as surveys, national accounts, and economic modelling. The table has several standard elements, which are shown in Figure 4.

L: The 'L' matrix represents the Leontief demand coefficients. It quantifies how much each sector of the economy needs of each input to produce one unit of final demand for goods and services. In other words, it reveals the required inputs from various sectors to satisfy a unit of final demand. The 'Z' matrix gives the total monetary flows between industries and together with the final demand compose the basis of the 'L' matrix.

Y: The 'Y' matrix represents the final demand, encompassing consumption, investment, government spending, and net exports for each sector. It defines the final demand for goods and services for each sector in the economy.

x: The 'x' matrix denotes the total production or supply by each sector, revealing the output needed to fulfill both intermediate and final demand.

Extensions ('S'): Other factors which are not monetary can be correlated to the industries in the input-output table and added as extensions ('S' matrix) giving the impact per unit of output. In this study, the IO table was extended with plastic waste and employment data (see section 4.1.1.2 exogenous data below). By dividing the total output ('x') of a sector by the recorded amount of employment or plastic waste needed in production, intensities are calculated and recorded in the 'S' matrix.

Input output Table	Using sectors	Final demand	Total use
Supplying sectors	Z (L)	Y	x
Value added (labour, taxes, etc.)	VA		
Output	x'		

Employment, waste intensities	S

Figure 4: Input output table structure

4.1.1. The macro-economic input-output model

The model is based on the domestic[3] Estonian input-output (IO) tables which show the monetary flows between industrial sectors, state and non-governmental organizations, and private households. The structure of these tables makes it possible to represent how changes in one sector affect interactions throughout the economy. We combine this with exogeneous data on employment and plastic waste to arrive at an IO table with environmental and socioeconomic extensions. The model is based on a demand-driven Leontief IO framework, changes can either take place in the production recipe (L), demand (Y) or on the impact intensity (S). These letters relate to the most fundamental environmentally extended IO function stating that the environmental or socio-economic impacts (e) are a function of S, L and Y.

$$e = SLY$$

In a second stage, the national economy is projected up until 2030 using population and GDP growth projections. For details on the approach and model see Aponte et al. (2021).

The projections up until 2030 can be made both without (baseline scenario) and with (alternative scenarios) exogeneous changes to the IO system. Such changes can be comprised of altering demand such as household consumption or exports, changes in the "production recipe" (the inputs and outputs per sector) or changes in environmental or employment intensities (e.g., amount of plastic waste per monetary unit of production). These changes in the IO structure create ripple effects in other sectors of the economy due to the interlinkages of sectors. It is the comparison between the baseline scenario and the alternative scenarios, as defined below, that forms the main piece of result in this section of the report.

[3] It is important to note that the approach uses a single-region IO table and that we exclude imports from the analysis. While imports make up the majority of plastics sector purchases by Estonian industries (see Figure 3 above), this analysis is focused on the impacts within the Estonian domestic sectors. The reason behind this is that the domestic data is more complete than the import data. Without data on the source of the imports (i.e., in which countries the products/services are produced) we cannot connect the imported impacts to employment, production, and plastic waste results in the country of origin of the imports. In this study we are interested in employment, value creation and waste that occur in Estonia.

4.1.1.1. *Exogeneous projections*

The model is dependent on exogeneous data sources on both historic data and future projections. These are:

- Future population projections from OECD (OECD, 2021)
- Historic population (The World Bank, 2022)
- Historic household expenditure (The World Bank, 2022)
- Historic governmental expenditure (The World Bank, 2022)
- Historic gross fixed capital formation (The World Bank, 2022)
- Historic changes in inventories (The World Bank, 2022)
- Historic imports and exports for Estonia (The World Bank, 2022)
- Historic gross domestic product (The World Bank, 2022)
- Historic value added (The World Bank, 2022)
- Long term GDP growth rate forecasts (to 2060) (OECD, 2018)
- Projection of world GDP growth rate (to 2050) (OECD, 2018)

The projected value added, which is needed as an input in the model, is assumed to increase at the same growth rate as the projected GDP.

4.1.1.2. *Exogeneous data*

Employment data for 2015 from statistics Estonia has been coupled with the IO model. Sector matching was necessary as the employment data is more aggregated on a sectoral level than the IO table (30 and 63 sectors respectively). A concordance matrix between these sector resolutions was developed for this purpose. In practice, this disaggregation means that sectors in the IO table belonging to the same sector in the employment data get the same employment intensity per unit of monetary production (number of employees per million Euros). Employment data was provided by the Republic of Estonia Environment Agency and is not publicly available.

Similarly, plastic packaging waste data was incorporated into the model. This data was taken from the Packaging Registry and classified, first to the 63 sector EMTAK classification (see appendix on data descriptions) then matched to the 63 sectors in the IO table. This allows the model to incorporate the amount of plastic waste that would be produced by each of the different sectors according to the economic developments of the sectors in the different scenarios.

4.1.1.3. *Running the model*

The model is set up to run from 2015, which is the year of the last published Estonian IO table. It then runs in yearly iterations up until 2030. For each yearly iteration there is a convergence criterion between the endogenously calculated household consumption per capita and the exogenously estimated household consumption per capita (based on expected GDP growth) that needs to be met for it to pass on to the next iteration.

Each scenario is run separately and after all runs have completed the results are compared. The only differences between the scenarios are the exogenously given changes as described in 4.1.2. It is possible that the convergence criterion cannot be met or that the exogenous changes can introduce errors, but this was not the case for any of the scenarios.

4.1.2. Scenarios

Four scenarios have been developed.

The following scenarios are hypothetical, and results should only be used for guidance in considering potential options. They describe potential ripple effects in the economy due to changes in one or several sectors of the economy. The scenarios have been based on potential circular economy strategies, which have generally been simplified to align with the resolution of the model.

- **Scenario 0: The baseline scenario** – economic activity projected up until 2030 according to the scenarios of population and GDP growth for Estonia.
- **Scenario 1: The polluter pays scenario –** represents the implementation of extended producer responsibility schemes by shifting the annual cost of SUP collection from municipal expenditure to the food production sector, the retail sector, and the restaurant sector.
  - A gradual increase in operating surplus in the "Public administration and defense; compulsory social security" sector due to lower input needed from the "Sewerage; waste management and remediation services" sector in the period 2016-2025. 5% of the "Sewerage; waste management and remediation services" coefficient is moved to operating surplus per year.
  - An equivalent (5% yearly) gradual decrease in the operating surplus in the "Accommodation and food services" sector due to increased need for input from "Sewerage; waste management and remediation services"
- **Scenario 2: The paper or plastic scenario –** represents policies that incentivize reduced use of plastic packaging in favor of paper-based alternatives**.** The food, restaurants and hotels sectors gradually start decreasing plastic purchases and instead increase paper purchases by an equivalent amount.
  - The input of "Rubber and plastic products" to "Food products, beverages and tobacco products" and "Accommodation and food services" is moved to "Paper and paper products" 10% yearly in the period 2022-2030.
- **Scenario 3: The perennial packaging scenario** – represents policies that facilitate use of reusable packaging alternatives over single use plastics. Rather than using single-use plastics, restaurants and other packaging suppliers shift to using reusable products. In the initial years, research and development increases in the accommodation and food services sector and then inputs of plastics gradually decrease in the following years.
  - 2% yearly in the period 2019-2021 of the operating surplus in the "Accommodation and food services" sector is moved to "Scientific research and development services".
  - In the years 2022-2025, 10% of inputs yearly from "Rubber and plastic products" to "Accommodation and food services" gets moved to operating surplus. In 2026 the remaining part of this coefficient gets moved to operating surplus, representing total phasing out of plastics as input to "Accommodation and food services".
- **Scenario 4: The reduced plastic waste scenario** – represents policies that encourage the largest industries to address their own waste production directly by setting waste reduction targets. Across the five sectors that produce the most plastic packaging waste, there is a gradual reduction in the waste per unit produced of a total of 10% over the period. Together these five sectors produce 85.0% of the plastic packaging waste in the Estonian economy:
  - Wholesale trade, except of motor vehicles and motorcycles
  - Manufacture of food products
  - Retail trade, except of motor vehicles and motorcycles
  - Manufacture of beverages

- Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials

As mentioned in 4.1.1, in a demand-driven Leontief IO framework, changes can either take place in the production recipe (L), demand (Y) or on the impact intensity (S). These letters relate to the most fundamental environmentally extended IO function stating that the environmental or socio-economic impacts (e) are a function of S, L and Y.

$$e = SLY$$

Each of the scenarios involves changes in one or several of these parts (Table 5).

Table 5: Impact analysis scenarios and how they relate to the IO framework.

	Production recipe (L)	Demand (Y)	Impact intensity (S)
Baseline			
Polluter pays	X		
Paper or plastic	X		
Perennial packaging	X		
Reduced plastic waste			X

4.2. Results

4.2.1. Backwards and Forwards linkages

A method for estimating the importance of a specific sector in the economy to the rest of the national economy is the concept of forward and backward linkages. This concept measures how integrated the sector is in the economy, how much the sector depends on input from other sectors, and how much it provides input to other sectors. Backward linkages measure the degree to which an increase in production in a sector leads to demand-driven increases in production in supplying sectors (upstream), forward linkages measure the degree to which other sectors need input from a given sector to produce their own products (downstream) (Miller & Blair, 2009).

These two concepts can be measured in direct and total terms. Direct linkages show the inputs directly to/from the other sectors, while total linkages also include the indirect inputs further down or up the value chains. These combinations of linkages can also be normalized such that linkages that are above average have indices greater than one and those below average are lower than one. We show results for these linkages following the mathematical approach in Chapter 12 of (Miller & Blair, 2009).

By mapping the most important linkages in the Estonian economy, we can gain insight into some of the central industries and most important value-chain relationships in the Estonian economy. The top three industries of each of the normalized linkage metrics are given in Table 6.

Here we see that the most connected sectors in the Estonian economy tend to be raw material sectors: petroleum, wood, and mining as well as services connected to buildings and also services connected to finance and insurance; with waste management being a main sector in terms of backward linkages. Meanwhile, the “rubber- and plastic products” sector ranks relatively low for both forward linkages (direct: 43 and total: 43) and backward linkages (direct: 47 and total: 48). This indicates that this sector is not one of the key sectors for the Estonian economy, but it is relatively more important in terms of sourcing inputs from other sectors (backward) than providing input to other sectors (forward).

In this analysis we are mostly concerned with forward linkages (i.e., which sectors require inputs from the rubber- and plastic products sector).

Table 6: Top three sectors for linkages (normalized) in the Estonian economy.

Rank	**bdN** backward direct linkages normalized	**btN** Backward total linkages normalized	**fdN** forward direct linkages normalized	**ftN** forward total linkages normalized
1	Coke and refined petroleum products	Sewerage; waste management and remediation services	Repair services of computers and personal and household goods	Mining and quarrying
2	Sewerage; waste management and remediation services	Coke and refined petroleum products	Security, investigation; services to buildings and landscape; office and business support services	Services auxiliary to financial services and insurance services
3	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	Mining and quarrying	Security, investigation; services to buildings and landscape; office and business support services

4.2.2. Consumption-based and production-based plastic packaging waste

By incorporating the data in the plastic registry (see appendix B for details on plastics registry) we are able to identify the sectors that contribute the most plastic packaging waste to the Estonian market. As this is examined through a producer-responsibility lens, they are defined as the production-based results (Figure 5).

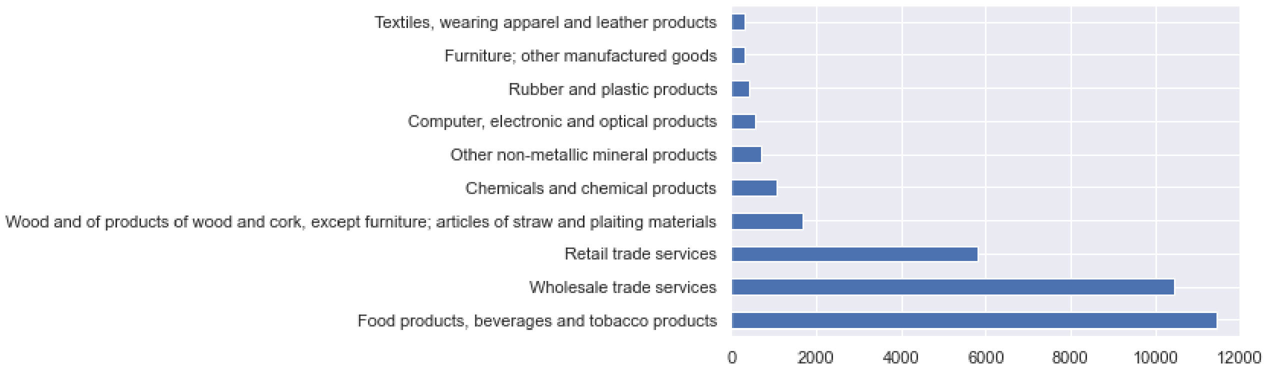

Figure 5: 10 Largest plastic packaging waste sectors (production-based) in tons of plastic waste.

The 10 largest plastic packaging waste-producing sectors make up 32 700 tons (95% of the total) plastic packaging waste in the Estonian economy, showing a high concentration of waste connected to a few key sectors where "food products, beverages and tobacco products", "wholesale trade services", and "retail trade services" alone make up 80% of the total plastic packaging waste produced.

Another way to consider the question of who is 'responsible' for packaging waste is to examine consumption-based results (Miller & Blair, 2009). Here we are rather looking at how much plastic packaging waste consumers are responsible for when buying a product or a service from a sector in the economy. In total, the production-based and consumption-based waste tonnage are the same, but the distribution between sectors changes.

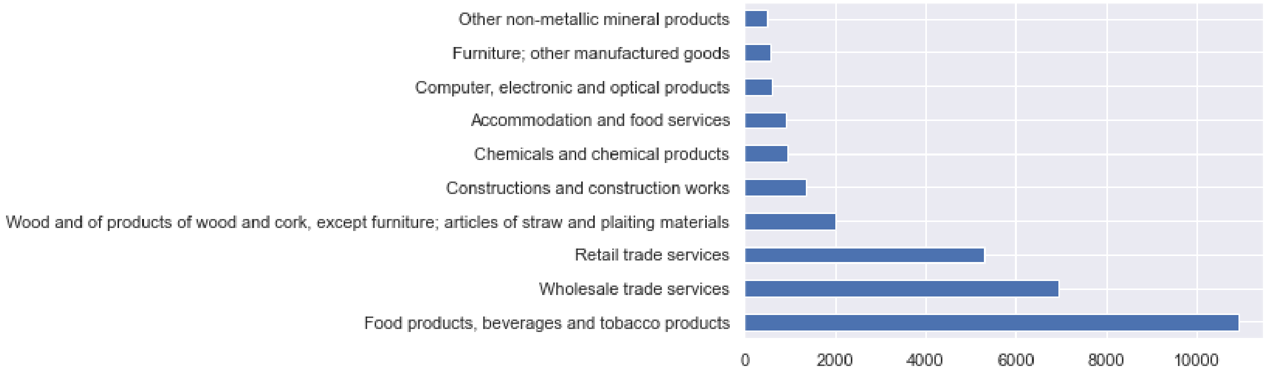

Figure 6: 10 Largest plastic waste sectors (consumption-based) in tons of plastic waste.

Here, the top 10 consumption-based sectors make up 30 000 tons of plastic waste (87%), while the top three sectors (same as production-based) contribute 67% of the total. This still shows a high concentration around key sectors, but less so than for production-based results. In addition, sectors that are more common to think of as consumption sectors, such as "construction and construction works" and "accommodation and food services" are higher on the top 10 list, while "rubber and plastic products" is no longer part of the top 10 as this is a sector whose output is more common for intermediate rather than final demand.

We also compare the differences in allocation between production- to consumption-based results (Figure 7), where we see increases in sectors thought of as typical final demand sectors (sectors that sell directly to end users) and decrease in sectors associated with intermediate demand.

Figure 7: Largest differences in plastic waste (tons) between production- and consumption-based results in tons of plastic waste.

"Construction and construction works" (+1 314 tons) and "accommodation and food services" (+773 tons) increase the most while "wholesale trade services" (-3 507 tons) and "food products, beverages and tobacco products" (-524 tons) decrease the most. While "food products, beverages and tobacco products" is a typical final demand category, it is still logical to see a lower value for consumption-based results than production-based results here. A possible explanation for this is that while the production of food mainly occurs in this sector, the consumers can buy food in different sectors of the economy such as supermarkets or restaurants. The increase in "construction and construction works" is not due to household final demand, but rather a large value in "gross capital fixed capital formation" which refers to investments made by businesses and is considered a final demand category in the IO framework.

4.2.3. Scenario results

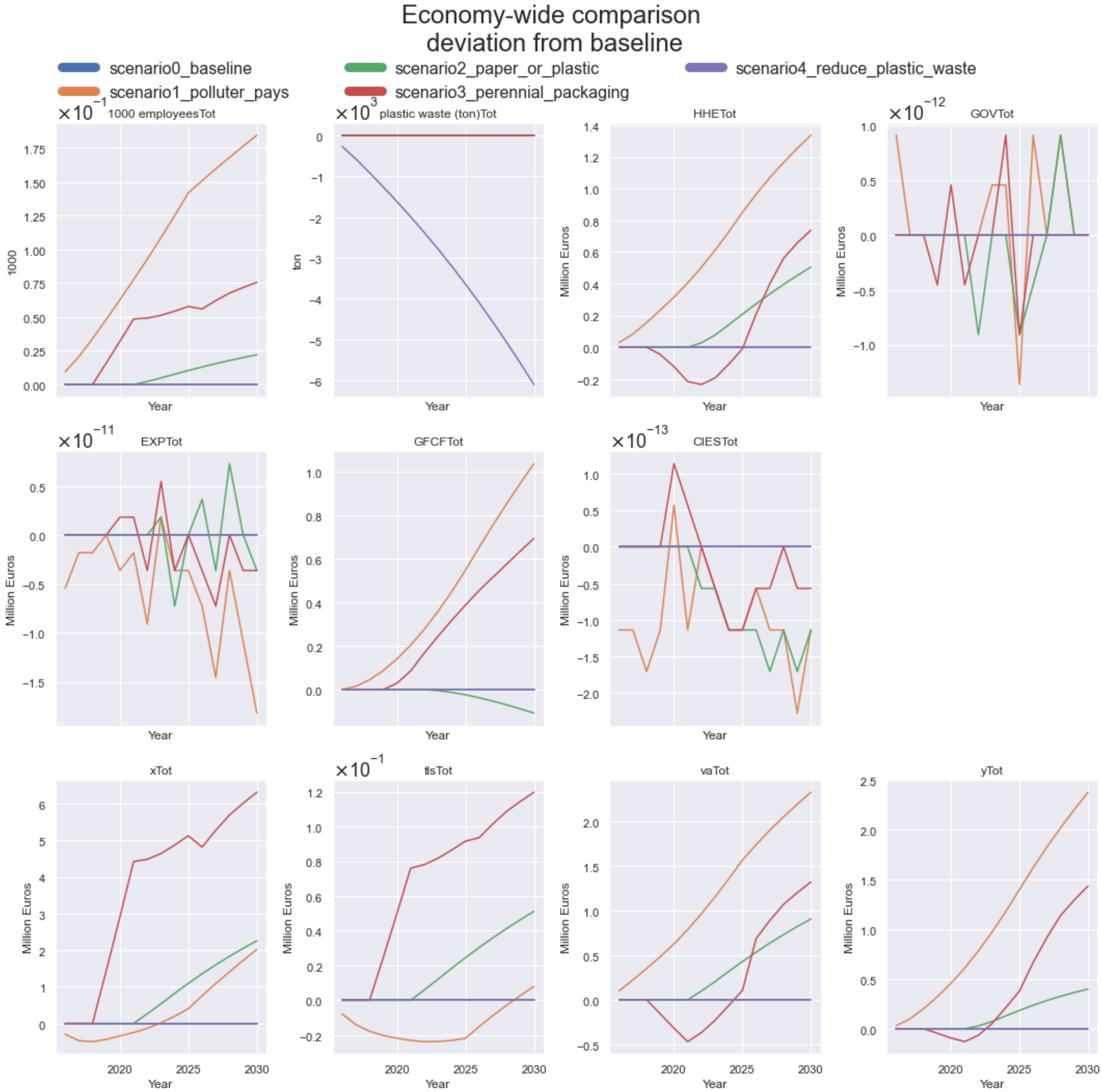

Figure 8: Economy-wide results for different variables relative to the baseline scenario.

xTot – total production value.
hheTot – total household consumption.
expTot – total exports value.
gfcfTot – total gross fixed capital formation.
1000 employees tot – total number of employees in 1000s.
govTot – total governmental consumption.
ciesTot – total changes in inventories.
vaTot – total value added.
tlsTot – total taxes less subsidies.
yTot – total consumption value (HHE+GOV+CIES+GFCF+EXP)
plastic waste Tot – total tonnage of plastic waste.

The input-output model tracks the development of multiple different economic indicator variables across the model time period for each of the different scenarios. These variables include: demand-side economic flows that propel the model economy, including exports, household and government consumption; total value added stands as an analogous concept to the gross domestic product, reflecting the cumulative economic value generated; capital formation and changes in inventory levels, and total taxes less subsidies provide some details into which aspects of the economy are subject to change under the different scenario conditions. Additionally, the exogenous variables relating to employment and plastic packaging waste are also shown by scenario.

Figure 8 gives an overview of how the model variables change for each scenario relative to the baseline scenario. Several of these deviations are direct effects of the scenario inputs. This is the case for HHE, CIES, GFCF, GOV and EXP as these are components of final demand and the model is a demand-driven model. For these components there is a minor (and negligible) difference only in household demand (HHE) and gross fixed capital formation. These are in the order of 1 million Euros, compared to 20 000 million Euros for total HHE and 4 300 for total GFCF. These differences are results of the model dynamics (for example household consumption to some degree depends on value added) and are not important for the overall discussion here.

Employment, plastic waste, production value and value added (Figure 9) are the more interesting result components as these are results of ripple effects in the economy because of the changes introduced in the scenarios.

Overall production value (bottom of Figure 9), which is the sum of all transactions in the economy, including intermediate and final demand, shows an overall improvement over baseline in all scenarios. Production increases the most in scenario 3 (+6 million Euros) corresponding to a 0.01% increase in the total production value in the economy. Figure 10 shows us that most of this increase happens early in the model run and is due to growth in the research and development sector. Scenarios 1 and 2 also have net increases in production value overall though in the polluter pays scenario the adjustments cause a slight decrease in production for the first 7 years of the model run.

Valued added, as opposed to overall production, takes into account the difference between the value of outputs (goods and services) and the value of inputs (intermediate goods and services) used in the production process. Value added in input-output is a close analogue to gross domestic product (GDP). Value added development (Figure 8) has similar patterns to overall production, but here scenario 1 - implementation of extended producer responsibility for packaging waste - has the largest relative increase (+2.3 million Euros) corresponding to an increase of 0.07% in the total economy. The fact that the largest relative impacts for value added are found in scenario 1, while for production value they are found in scenario 3 indicates that the sectors that are most positively affected by the change in scenario 1 have higher value-added unit produced (the accommodation and food services sector) than those in scenario 3 (the research and development sector). Although trends in demand, production and value added are of interest, the two main pieces of results from the impact analysis are employment and plastic waste results, which we will go into more detail on in the following sections. On an overall level (Figure 8) employment increases the most in scenario 1 (+ 185 employees) and scenario 3 (+76 employees). This corresponds to a 0.2% and a 0.08% increase in total nationwide employment respectively. Scenario 2 has a smaller increase, while there is no change in scenario 4 as this scenario only concerns plastic waste which has no ripple effects on employment.

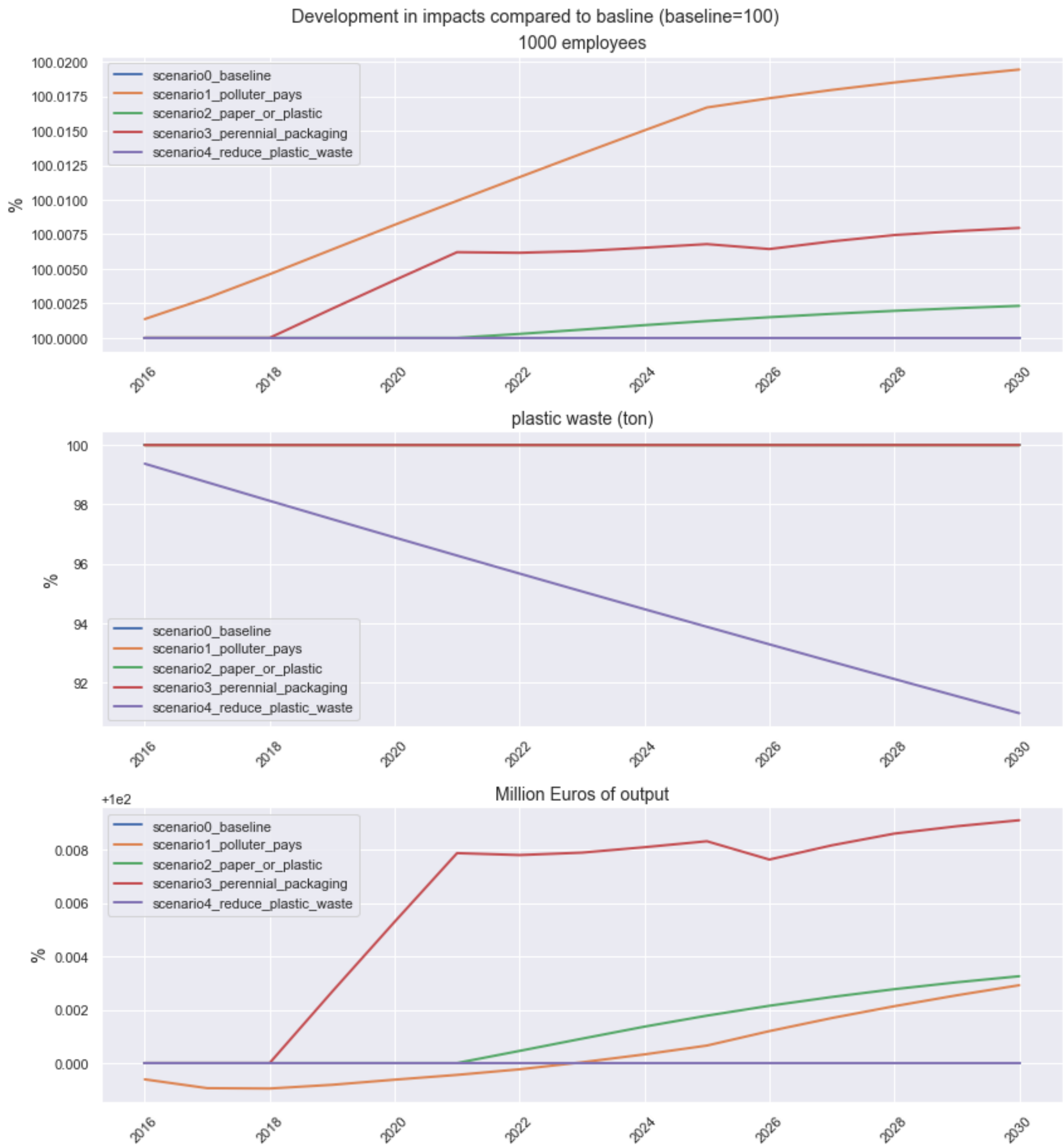

Figure 9: Production value, employment and plastic waste per scenario compared to baseline (=100) for 2015-2030

For plastic waste there is as expected a large decrease of 6 089 tons or 9.0% in scenario 4. In scenario 1 there is a slight increase of 4.0 tons (+0.006%) while there is a slight decrease in scenario 2 of 2.3 tons (-0.003%). Both are barely visible in Figure 9. In scenario 3, the plastic waste is almost unchanged with an increase of 0.2 tons.

The figures above give the overall effects but say nothing about how these effects are distributed among the different economic sectors. We here look at this breakdown by looking at the sectors with the largest changes, first for production value (Figure 10). Numbers are again compared to the baseline scenario.

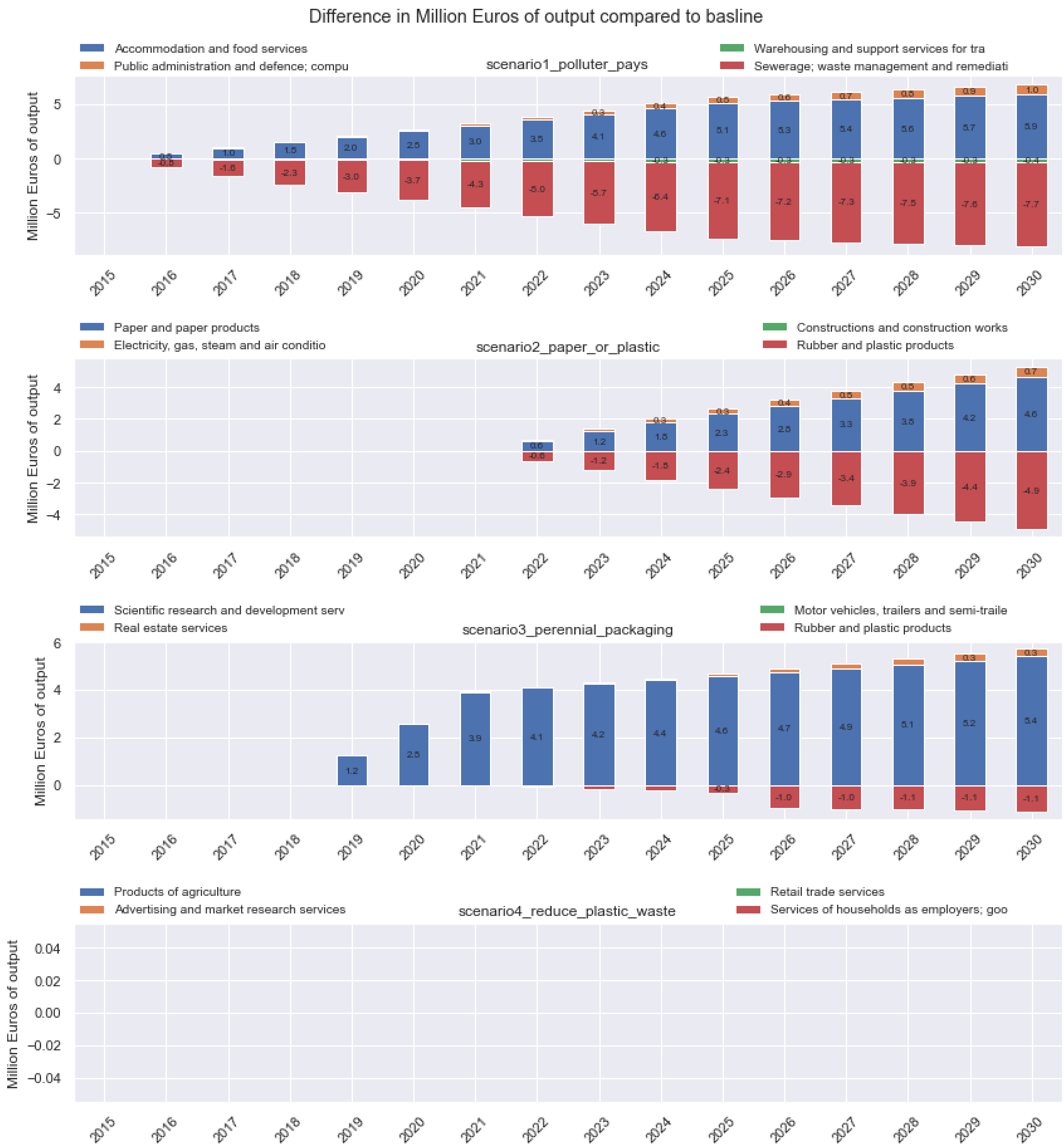

Figure 10: Changes in production value compared to the baseline scenario for the top two and bottom two sectors ranked according to the largest changes.

In scenario 1, polluter pays, there are counteracting trends where "Sewerage; waste management and remediation services" has the largest negative development, and "accommodation and food services" has the largest positive development. Despite the dominating negative development in "Sewerage; waste management and remediation services", the overall production value increases.

There is a negative trend for "Rubber and plastic products" in scenario 2, paper or plastic, but positive development in particularly "paper and paper products" and " Electricity, gas, steam and air conditioning" result in a slight positive overall trend.

Scenario 3, perennial packaging, coming out with the largest positive development, can attribute this to increases in " Scientific research and development services" and partly "Real estate services", while "Rubber and plastic products" has a relatively smaller negative trend.

There is no change in production value in scenario 4, reduce plastic waste, as it concerns only the impact intensity of plastic packaging waste per unit of economic production, but does not affect the economic activity of the sector (S) (Table 5).

While the largest changes for the scenarios typically directly result from the exogeneous changes defined in the scenarios (e.g., “Scientific research and development services” in scenario 3 or "Sewerage; waste management and remediation services" in scenario 1). There are also moderately large indirect effects such as " Electricity, gas, steam and air conditioning" in scenario 2 or " Public administration and defense; compulsory social security" in scenario 1. It is this insight on the ripple effects that is the added benefit of IO analysis.

Employment effects (Figure 11) are calculated as consumption-based, and the interpretation of these results is different than the regular direct employment per sector. Rather, it is employment generated for a given demand, e.g., results for the agricultural sector show employment due to agricultural demand which occur at any point in the economy, and not the amount of employment that takes place in the agricultural sector.

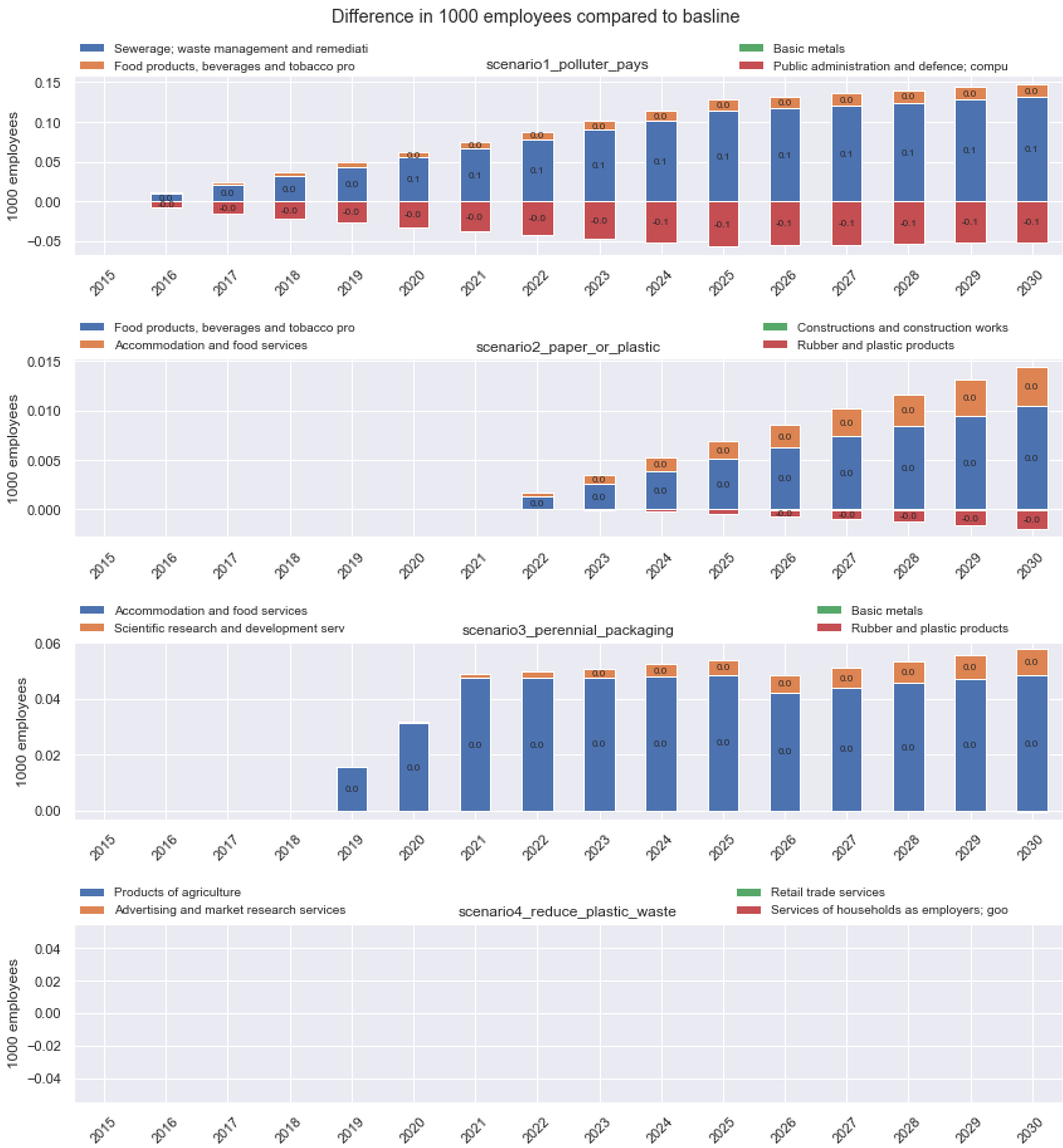

Figure 11: Changes in employment compared to the baseline scenario for the top two and bottom two sectors ranked according to the largest changes.

In scenario 1, demand from "Sewerage; waste management and remediation services" and "Food products, beverages and tobacco products" lead to higher employment than the baseline scenario, while the opposite is true for "Public administration and defense; compulsory social security" – still this is the scenario with the largest positive effects on employment.

The smaller net positive effects (+22 employees) in scenario 2 mainly come from "Food products, beverages and tobacco products" and "Accommodation and food services", while consumption of "Rubber and plastic products" leads to a bit lower employment than in the baseline scenario.

The negative effects in scenario 3 are barely visible, completely dominated by the positive effects in "Accommodation and food services" and "Scientific research and development services" in particular.

As with production value, there is no change in scenario 4 as it concerns only the impact intensity of plastic packaging waste.

The main result of this analysis is arguably the result of the scenario modifications on production of plastic packaging waste (Figure 12). Again, results are consumption-based so they show plastic waste due to demand for different products and services, and not the sector that the waste itself originates in.

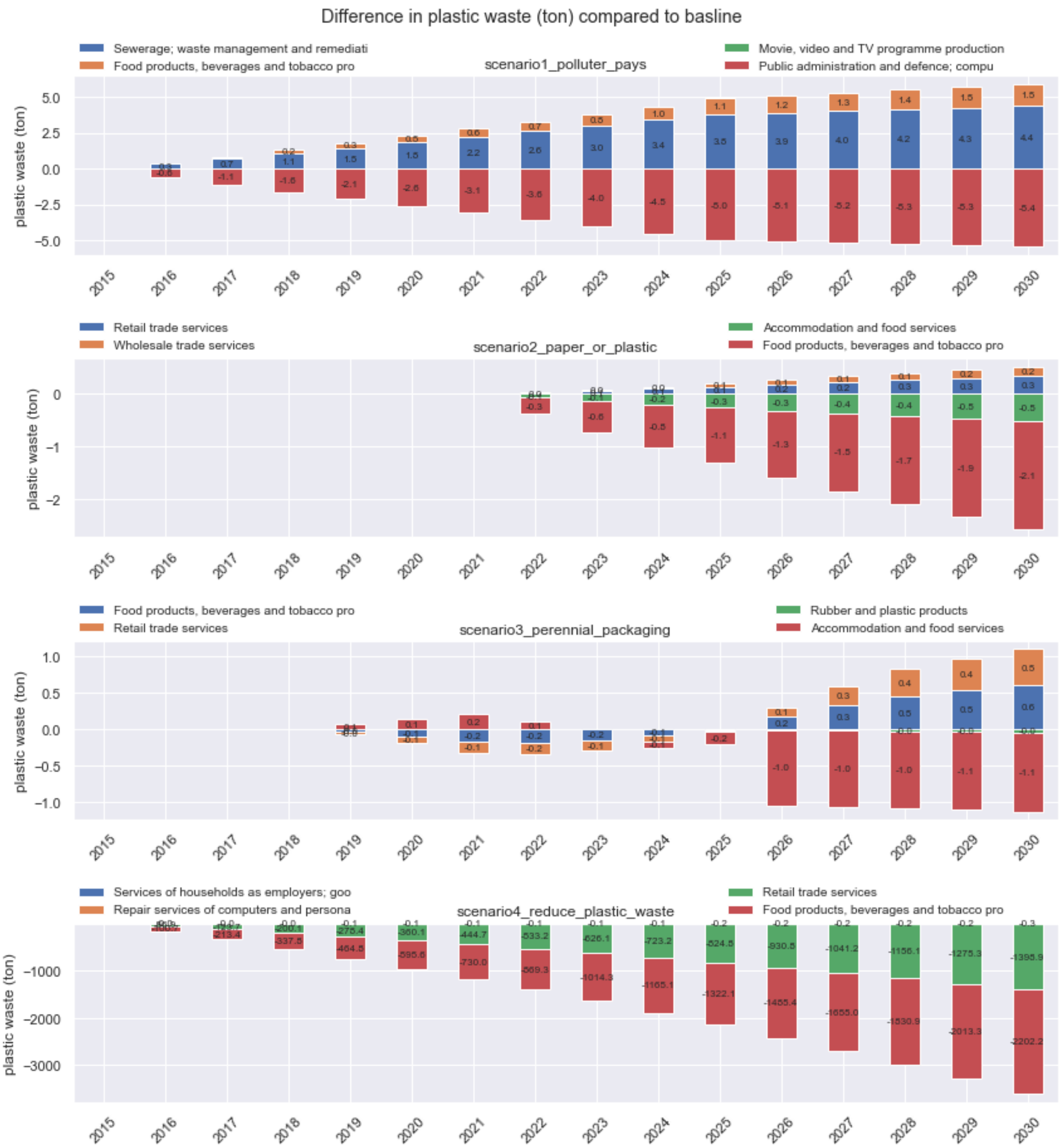

Figure 12: Changes in plastic waste (tons) compared to the baseline scenario for the top two and the bottom two sectors ranked according to the largest changes.

Scenarios 1 through 3 show very little effect on plastic waste production with changes in tons of plastic packaging waste diverging from baseline in the single digits. Meanwhile scenario 4 has an effect 3 factors of magnitude higher.

The slight increase in scenario 1 can be attributed to "Sewerage; waste management and remediation services" and "Food products, beverages and tobacco products". This is partly cancelled out by a decline in plastic waste from consumption of "Public administration and defense; compulsory social security". In scenario 2, the slight decrease is largely attributed to "Food products, beverages and tobacco products" while there is a small increase in plastic waste from consumption of both wholesale and retail trade services. Effects that almost exactly cancel out are found in scenario 3, where a declining development is found in "Accommodation and food services" and increasing waste development in "Retail trade services" and "Food products, beverages and tobacco products". In scenario 4, it is particularly "Food products, beverages and tobacco products" and "Retail trade services" that contribute to the step decrease in plastic waste.

The general trend is that, compared to reducing plastic packaging waste in production in the largest waste-producing sectors (scenario 4), the effects of changing induvial inputs are quite small. However, this analysis only concerns simple examples of changes in the production recipes, and large-scale targeted changes aimed at plastic waste reduction, will likely serve as an important supplement to production-side changes.

A third option we have not investigated here is consumption-side changes where consumers start shifting demand from plastic-intensive products and services to less plastic-intensive ones. This can be achieved through awareness of which types of consumption ultimately lead to the largest amounts of plastic waste. The input-output analysis ability to identify the purchasing sectors which drive the production of the plastic packaging waste (consumption-based approach presented here) can provide the basis for such an awareness and Table 7 provides a comparison of consumption-based and production-based plastic waste intensities of the main consumption based sectors (i.e., plastic waste (ton) per million Euros of consumption and production).

Table 7: Comparison of consumption-based (CB) ad production-based (PB) impact intensities

Sector name	Plastic waste (ton) per M.EUR (CB	Plastic waste (ton) per M.EUR (PB)
Food products, beverages and tobacco products	8.13	7.46682
Wholesale trade services	4.87	4.74461
Retail trade services	4.27	4.19473
Chemicals and chemical products	2.91	2.73394
Other non-metallic mineral products	2.04	1.80997
Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	1.52	0.928722
Rubber and plastic products	1.48	1.27554
Accommodation and food services	1.24	0.155958
Basic pharmaceutical products and pharmaceutical preparations	1.14	1.07013
Sewerage; waste management and remediation services	1.14	0.337251
Products of agriculture	0.95	0.00372358
Furniture; other manufactured goods	0.90	0.488363
Textiles, wearing apparel and leather products	0.88	0.650577
Mining and quarrying	0.85	0.547443
Paper and paper products	0.80	0.544548
Constructions and construction works	0.55	0.0167547
Fabricated metal products, except machinery and equipment	0.55	0.213546
Wholesale and retail trade and repair services of motor vehicles and motorcycles	0.52	0.42876
Electrical equipment	0.43	0.314101
Coke and refined petroleum products	0.43	8.24E-06
Computer, electronic and optical products	0.41	0.388419
Other transport equipment	0.38	0.0463893
Machinery and equipment n.e.c.	0.35	0.0502175
Residential care services; social work services without accommodation	0.34	0
Products of forestry	0.34	0
Fish and other fishing products; aquaculture products	0.33	0
Other personal services	0.32	0.0874644
Electricity, gas, steam and air conditioning	0.29	0.00101596
Printing and recording services	0.27	0
Other professional, scientific and technical services; veterinary services	0.26	0.018692
Repair services of computers and personal and household goods	0.26	0.0035082
Repair and installation services of machinery and equipment	0.25	0.0141697
Sporting services and amusement and recreation services	0.22	0.00118059
Advertising and market research services	0.22	0.00019307
Motor vehicles, trailers and semi-trailers	0.22	0.0998133
Warehousing and support services for transportation	0.21	0.0827958
Publishing services	0.20	0.032394
Services furnished by membership organisations	0.18	0
Security, investigation; services to buildings and landscape; office and business support services	0.18	0.000412462
Creative, arts and entertainment services; library, museum, cultural services; gambling services	0.18	0.00650274
Postal and courier services	0.17	0.0732981
Rental and leasing services	0.17	0.0552313
Education services	0.17	0.000446535
Air transport services	0.17	0
Human health services	0.16	0.00570209
Public administration and defence; compulsory social security	0.16	0.0542993
Land transport services	0.16	0.0046683
Architectural and engineering services; technical testing and analysis services	0.14	0.00379137
Natural water; water treatment and supply services	0.12	0.0198461
Real estate services	0.12	0.000223963
Legal and accounting services; services of head offices; management consulting services	0.10	0.000109578
Movie, video and TV programme production; sound recording and music publishing; broadcasting	0.10	0.0158851
Travel agency, tour operator and other reservation services and related services	0.10	0
Basic metals	0.09	0.0516539
Telecommunications services	0.08	0.0419047
Computer programming, consultancy and related services; information services	0.08	0.0108246
Water transport services	0.07	0
Scientific research and development services	0.07	0.00152504
Services auxiliary to financial services and insurance services	0.06	0
Insurance, reinsurance and pension funding services	0.05	0
Employment services	0.04	0
Financial services	0.03	4.35E-05
Services of households as employers; goods and services produced by private households for own use	0.00	0

We see that the order of the top five sectors does not change, although the numbers change to some degree. Most notably the "Food products, beverages and tobacco products" intensity increases, highlighting the need for targeting this sector to achieve plastic waste reduction. Also worth noting, is that "Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials", "Accommodation and food services" and "Products of agriculture" have much higher consumption-based intensities. As this is due to the value chain effects (and not the first-order production effects), these are good examples of important insight that cannot be obtained without the consumption-based approach.

A successful reduction or elimination of plastic waste will need to involve all components of the value chain – from production impact mitigation, through production recipes and to consumption changes.

4.3. Scenario Summary

In scenario 1 – polluter pays – an extended producer responsibility scheme is modeled by shifting some public administration expenditure on waste management to the restaurant and retail sector. The model shows that this policy results in positive outcomes in economic production, employment, and plastic packaging waste. The model indicates increases in economic activity for the food and accommodation sector, and a decrease in the waste management sector. Meanwhile, activity in the waste management sector drives a significant increase in employment over the baseline which more than compensates for decrease in employment attributable to the public administration sector.

In scenario 2 – paper or plastic – a modelled shift in both the food production sector and the hospitality sector away from plastic packaging and toward paper packaging shows steady improvements in economic production and employment numbers. Possibly because the paper sector is more strongly linked to other important sectors in the domestic Estonian economy.

In scenario 3 –perennial packaging – the hospitality sector's attempts to replace single use plastic packaging with reusable solutions requires expenditures in research and development. The model shows that the increase in expenditure results in an initial increase in economic activity and employment driven by the R&D sector although positive effects on the value added appear to be delayed by several years, becoming a net positive on GDP near the end of the model run.

These three scenarios involved alterations in the production recipe of the sectors related to plastic packaging waste. That is, they essentially changed the structure of transactions between different sectors. These changes lead to changes in the amount of plastic packaging waste in the model only indirectly by shifting economic activity from one sector to another and relying on the differences in waste intensity (amount of waste produced per Euro of economic activity) between the sectors to lead to a decrease in waste production. In reality, some of these changes would also change the intensity of waste production of the individual sectors, meaning that they would produce less plastic packaging waste while not reducing their economic activity levels. The amount of change in intensity that results from each scenario change would be too great an assumption to include in the scenarios, however. For this reason, scenario 4 – reduce plastic waste – models the reduction in plastic packaging waste intensity of the five sectors that produce the most, separate from any changes in the economics of these sectors. By a targeted reduction of intensity of plastic packaging waste in these sectors alone we see a substantial decrease in plastic packaging waste nationwide.

4.4. Discussion, limitations, and recommendations of further analysis

The scenarios chosen here are a selection of a multitude of "what if" scenarios, and it is important to note that the scenario set is not comprehensive.

In combination, the results from the four scenarios paint an optimistic picture of the ability to address plastic packaging waste through policy interventions. The net economic impacts of three different modeled interventions were prudently positive both across aggregate economic measures and employment impacts. The fourth scenario supports that targeting certain important sectors can have sizable results for waste reduction. The consumption-based analysis indicates that in addition to the sectors that directly produce the most plastic packaging waste, it is important to include measures directed at the hospitality and agriculture sectors as these sectors appear to drive the purchase of more plastic packaging waste products than can be seen from the packaging registry.

An IO table is quite aggregated on the product/sector level (the Estonian IO table contains 63 product groups). Consequently, we are not able to distinguish types of plastic or rubber products from the product group in the IO table ("Rubber and plastic products"). Rather, we are modelling the "average" product that this sector manufactures. We consider this the best option since we do not have detailed data on the input and output structures of specific products in the sector, such as single-use plastics. It is likely that attempting to model such specific products with incomplete background data introduces high levels of uncertainty and subsequent uncertain results. When interpreting the results, it is important to remember this aggregation, although we believe the approach here represents the best option available. More detailed IO tables to distinguish specific products such as single-use plastic is an important area of future work to reduce uncertainty. This can be achieved through specific and detailed data gathering on monetary flows for a sub-sector such as single-use plastics, although this can often be a substantial task.

Price mechanisms such as increasing the price faced by consumers to study how it alters consumer preferences is highly relevant in the case of single-use plastics. However, with IO analysis a change in prices on the demand side simply translates to a change in quantity demanded, as IO tables are given in monetary terms. To be able to model price changes, the IO model would need to be extended by a price model that e.g., shows how consumer preferences respond to price changes. Such an extension of the IO model is beyond the scope of this study.

Another type of analysis we have not included is looking at investments in existing or “yet-to-be-established” sectors. In IO tables, an amplified investment in a specific sector can appear to come out of nowhere and have positive effects in all sections of the economy and the IO system, while in reality, this increased investment often means reductions in other parts of the economy, such as the operating surplus of a sector. As we do not have background data to support such analyses they are outside the scope of this study. Worth noting however is that such investments (if not taken from other parts of the economy) would have positive effects on all results shown in this chapter as this translates to an increased demand. An exception to the positive effects is plastic waste, which would increase.

Imports are not included in the analysis and results are only for the domestic Estonian economy. The role of imports or bilateral trade in general is expanding in several Estonian economic sectors, as is the case in most countries of the world. This expansion opens more strategic choices for specific policies aimed at e.g., reducing plastic waste. These strategies can include importing from countries and industries known for having good plastic waste management and generating minimal plastic waste in production. With a multiregional input-output table with global coverage and plastic waste extensions, further analyses could be made on for example setting up an optimization routine that sets goals for plastic waste reduction and optimizes import patterns based on this, and possibly other relevant restrictions or goals that could be economic (e.g., value added) or environmental (e.g., greenhouse gas emissions).

Yearly efficiency improvements due to, for example, the introduction of new technology is for most sectors a natural development and will appear as reduced factor inputs per unit produced in the IO table. However, in the scenarios used here, these efficiency improvements are excluded, except those exogenously defined in scenario 4. The reference scenario (scenario 0) is for this reason not the "most realistic future", but a scenario that includes the expected increase in demand, but not the expected technology improvements. In addition, as household income changes from year to year, so will household preferences for different products and services. As people become more affluent, demand typically shifts from necessities to luxury goods. In the period studied here, such a shift is likely for Estonian households. In addition, household awareness of the harmful effects of single-use-plastics will hopefully help shift demand towards goods and services associated with less single-use-plastics. Although such demand effects are not included here (see Table 5), a package containing changes in all three components (demand, production recipe, and impact intensities) is needed to mitigate and potentially eliminate plastic waste.

5. Conclusion

The purpose of this report has been to gather an overview of existing knowledge of how plastic moves through the Estonian society and to examine the effects that possible changes aimed at reduced plastic waste will have on the Estonian economy, specifically in terms of plastic packaging waste, employment, and production value. Background investigation of available data sources was conducted, including a survey to identify system knowledge at municipal levels of government.

The systemic analysis identified a general decrease in the quality of record keeping for products which do not have financial value. The existing system of extended producer responsibility for packaging has extended knowledge of those waste types which are currently covered under it. Comparison between various data sources shows that while the Estonian system has strong coverage over a significant amount of plastic packaging, other significant plastic sources, particularly imports to the construction sector and the vehicle manufacturing sector were identified.

The survey highlighted deficiencies in data sharing among municipalities, which impedes comprehensive understanding and collaboration within the field. Furthermore, the varied methodologies employed for data collection have resulted in a lack of harmonization, making it difficult to draw accurate and consistent conclusions across regions. The absence of data in certain instances, particularly related to municipal expenditures, and the composition of waste are the most significant gaps that were found to be necessary to recommend an approach to implementation of the Single Use Plastics Directive.

Four different scenarios were developed and compared against a hypothetical baseline scenario in the period 2015-2030. A consumption-based analysis using input-output methodology quantified the value chain effects on plastic packaging waste, employment, and production value under the different scenarios.

The Baseline scenario includes no technological changes and only follow expected population and demand increase. The four alternative scenarios in total make out possible ways of reducing plastic packaging waste where the concepts are the plastic polluter paying (scenario 1), a shift from the use of paper instead of plastic in sectors using single-use-plastics (scenario 2), a shift towards reusable products in the accommodation and food service sectors (scenario 3) and a reduction in plastic packaging waste in production in key sectors (scenario 4).

The largest effects on plastic packaging waste reduction were found when reducing the waste from production of the goods and services in the sectors that in total produce most plastic packaging waste (scenario 4). Small, but positive employment and production value effects were found for the other three scenarios. In these three scenarios, the effects on plastic packaging waste varied with slight increase in scenario 1, a slight decrease in scenario 2 and a flat development in scenario 3.

The analysis suggests that measures targeted at reducing the waste production of industries can have larger effects on waste reduction than individual changes in the structure of the industries modelled in these scenarios. Meanwhile, measures adapting the operation of individual industries to reduce plastic waste can result in positive impacts on employment and value production.

While results here highly depend on the choices made in the scenario implementation (deviations compared to the baseline development), they highlight the need for considering actions on both the demand side, production side and technological development aimed at reducing plastic waste.

To significantly reduce or even eliminate plastic waste requires a large and targeted effort where significant and coordinated changes in all three components (demand, production recipe, and impact intensities) are needed.

We also highlight the importance of including the consumption-based approach, particularly to understand demand-side mitigation potentials such as reduced or changed consumption. When comparing the production-based and consumption-based impact intensities, they change substantially for certain sectors such as accommodation and food services whose impact intensity increases by a factor of 8 when going from a production-based to a consumption-based approach.

Lastly, future research and model expansion are needed to specifically be able to distinguish single-use-plastic as a sub-sector and to understand the role of price changes and consumer preferences in reducing plastic waste. The analysis would also benefit from the inclusion of imports into the model as Estonia appears to incorporate a significant amount of import of plastic and plastic packaging.

6. Recommendations

Good data is crucial to implementing the Single Use Plastics Directive. The survey results (section 3) show that there is a need for better data collection and sharing practices, and the systems definitions (section 2) highlight the need for standardizing data across multiple economic sectors to facilitate comparability and integration of information.

An improved system of data collection and data sharing that enables more precision from future impact analysis. Specifically, we recommend:

- Harmonization in data collection across different entities that are engaged in waste management
- A sorting study of waste composition
- Recording of physical waste quantities where possible
- Recording of waste management budget according to specific activities and waste types
- Extension of waste reduction schemes, such as extended producer responsibility to include the most significant plastic flows

The systems definitions (section 2) highlight the need to consider products with low or negative economic value for a comprehensive coverage of material flows. In Estonia, the construction and motor vehicle sectors as well as others should be taken into account.

Based on the impact analysis we recommend:

- Focus on reducing plastic waste in production of the key sectors identified.
- Changes in the input-output structure aimed at reduced plastic use can provide small, but important supplements to plastic waste reduction in production without harming employment and production value or value added.
- Consumption-side actions, such as changed or reduced consumption, can further boost positive impacts on reduced plastic use and waste. This is an area we recommend that further research should focus on.

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A Appendix – Explanation of data sources

This section provides details of the different data sources that were visualized in section 2.

The Estonian Tax and Customs Board (EMTA) is responsible for the administration of state taxes, customs, and other national revenue. EMTA manages data related to tax collection, customs duties, and other financial transactions. EMTA is the collection node for data on imports and exports of plastics goods and waste products. This data is reported to statistics Estonia where it is compiled, and some portion is made available to the public. Additionally, some data on imports and exports of waste is reported directly to the Estonian Environmental Agency.

Statistics Estonia (SSB) serves as the primary national statistical office of the country, responsible for producing and disseminating official statistics on key aspects such as population, economy, and national finances. The organization compiles data related to various indicators, including GDP, employment, and population growth, providing valuable insights into Estonia's socio-economic landscape. Statistics Estonia makes available national accounts data, as well as some production data, to inform decision-making and support the understanding of the country's progress and development. Relevant data sources from SSB include reporting on the system of national accounts, manufacturing and production data, and imports and exports.

The System of National Accounts (SNA) (Statistics Estonia, 2018) [4] is a comprehensive framework that provides a consistent and flexible set of macroeconomic accounts for analyzing and evaluating the performance of an economy. SNA 2008 is the latest version, and it is followed by most countries, including Estonia, to ensure international comparability of their national accounts data (Vereinte Nationen, 2009). The SNA provides input-output tables and supply-and-use tables for the Estonian economy detailing the economic value of purchases between industrial sectors, value of purchases by end users, and value of inputs to production such as labor costs taxes and investments. This data set shows, at a high level, which industries and end users are the biggest purchasers from the plastics sector, but it does not show what products or services are being purchased.

TO71: Manufacturing Production, 2015 by TTL code and name of product. [5]

In Estonia, the List of Estonian Products (TTL) is used, which is based on the PRODCOM List (8-digit codes) used in the EU for the collection and dissemination of statistics of industrial goods[6]. The TTL is a more detailed version of the PRODCOM List due to the nature of the Estonian economy, and it uses 11-digit codes. The List of Estonian Products is available on the website of Statistics Estonia.

VKK34: EXPORTS AND IMPORTS OF GOODS[7] by flow, commodity, country, indicator, and year.

Statistics Estonia has different tables about foreign trade in goods. Goods are categorized by standard international trade classification (SITC) codes and values are given in both financial and physical flows though the physical data is less complete. It is possible to look at information about different waste types. The table is available updated for years 2004-to current. Figure A-1 visualizes of import and export data filtered by commodities with plastic in the title for 2015. The data is not complete or comprehensive, but it captures one of the main characteristics of the Estonian plastic sector which is that the international trade in plastics is a much larger sector larger than domestic production and use of plastics.

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[4] https://andmed.stat.ee/en/stat/majandus__rahvamajanduse-arvepidamine__sisend-valjundraamistik
[5] https://andmed.stat.ee/en/statsql/majandus__valiskaubandushttps://andmed.stat.ee/en/stat/Lepetatud_tabelid__Majandus.%20Arhiiv__Toostus.%20Arhiiv/TO71/table/tableViewLayout2
[6] https://ec.europa.eu/eurostat/cache/metadata/EN/prom_esms_ee.htm
[7] https://andmed.stat.ee/en/statsql/majandus__valiskaubandus__kaupade_vk/VKK34

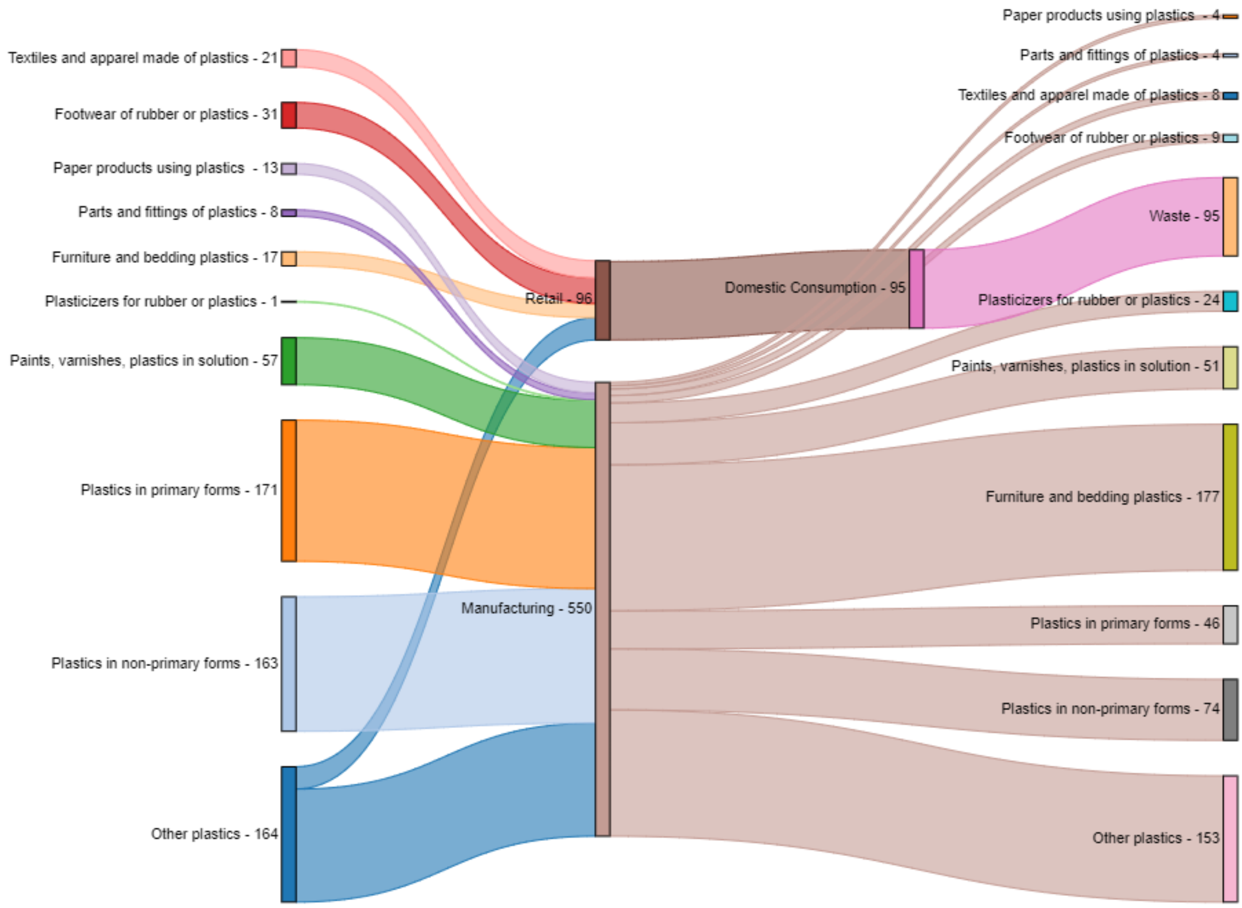

Figure A-1 Flow diagram of import and export values (million euros) of select plastic commodities 2015.

The Register of Products of Concern (PROTO) is a database that contains information about products that may pose a risk to human health, safety, or the environment. The register is used by various stakeholders, such as regulators, manufacturers, and importers, to track and manage these potentially hazardous products. Data management in PROTO involves collecting, storing, and processing information about the products, their potential risks, and any measures taken to mitigate those risks. The primary role of PROTO is to ensure that stakeholders have access to accurate and up-to-date information about products of concern to support informed decision-making and risk management. While no PROTO relevant data sets were included in this report, the organization is shown as an existent and active component of the regulatory ecosystem.

Packaging Registry (PAKIS)[8] is the national waste information system of Estonia. It is used to collect and manage data on waste generation, management, and disposal in Estonia. The system is used by waste management companies, local authorities, and other stakeholders to report on their waste-related activities. PAKIS allows for the tracking of packaging waste from its generation to its final disposal, providing transparency and accountability in the waste management process.

In previous years, companies which put more than 1 ton of plastic on the market were required to register the mass of each type of packaging placed on the market. As of 2023, the threshold was removed so that going forward all plastic packaging put on the market should be captured in this register. This register

[8] https://pakis.envir.ee/pakis/main/welcome)

provides some insight into which sectors of the economy produce the largest quantities of plastic packaging as shown in figure Table A1. However, the register does not record plastic packaging according to the categories relevant to the SUP directive and suffers from the possibility of misreporting or intentional underreporting, as noted in (Nõmmela et al., 2020).

Table A 1 Main sources of single single-sue use packaging put on market according to 2021 data from the packaging Packaging registry Registry

EMTAK sector classification	Tons plastic packaging in waste registry
Wholesale trade, except of motor vehicles and motorcycles	10452
Manufacture of food products	7886
Retail trade, except of motor vehicles and motorcycles	5819
Manufacture of beverages	3562
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1674
Manufacture of chemicals and chemical products	1049
Manufacture of other non–metallic mineral products	713
Other	608
Manufacture of computer, electronic and optical products	553
Manufacture of rubber and plastic products	407
Manufacture of furniture	316
Wholesale and retail trade and repair of motor vehicles and motorcycles	261
Manufacture of textiles	228
Manufacture of fabricated metal products, except machinery and equipment	217
Mining and quarrying n.e.c.	215
Manufacture of electrical equipment	190
Warehousing and support activities for transportation	181
Food and beverage service activities	120
Manufacture of paper and paper products	115

Recovery organizations

Producers of packaging are responsible for collecting packaging and waste but can transfer these duties to a state-accredited recovery organization. Since July 2011, the Ministry of Climate has accredited four such organizations: Tootjavastutusorganisatsioon OÜ (TVO), Eesti Taaskasutusorganisatsioon (ETO), and Eesti Pakendiringlus (EPR), which handle packaging material collection, and OÜ Eesti Pandipakend (EPP), which manages the deposit refund system for beverage containers, including the collection of empty beverage containers, the management of the deposit account system, and the payment of deposits to consumers who return their empty beverage containers. EPP finances its operations through unclaimed deposits and service fees. All packaging organizations, operated by producers and retailers, must be non-profit, with any profits reinvested into the company.

Companies that have entered into a cooperation agreement with a recovery organization do not have to submit a packaging report to the register, as the recovery organization does this for them. The packaging report needs to include information on the number of packages placed into the market in one calendar year. The sale, exchange or own use of goods packaged, purchased and imported from another member state by the manufacturer is considered to be placed on the market. The quantities of plastic, paper and cardboard, wood, and black and non-ferrous metal packaging (which has to be divided into groups and transport packaging and sales packaging) need to be reported. In addition, records are kept of thin plastic carrier bags. The classification and quantities of single-use packaging and re-used packaging are also required. The fee collected from the producers goes to the recovery organization, which depends on the amount of packaging used by the packaging company. The same packaging fees apply to all packaging undertakings.

KOTKAS[9] is the national environmental monitoring system of Estonia. It is used to collect and manage data on the state of the environment in Estonia. The system is used by environmental authorities, researchers, and other stakeholders to monitor and analyze environmental trends and to inform policy decisions. KOTKAS includes data on air quality, water quality, soil quality, biodiversity, and other environmental indicators.

Hazardous waste consignment notes information system (OJS)[10]

This is for digital consignment notes for monitoring hazardous waste movements. A hazardous waste consignment note is a document containing information on the type, composition, quantity and essential characteristics of hazardous waste transferred for handling. The consignment note shall set out the information concerning the producer, transferor, carrier and receiver of the waste for handling. A consignment note shall be drawn up for each dangerous waste shipment before the shipment takes place. The aim is to monitor and control the movement of hazardous waste within the country.

Local Municipalities are responsible for ensuring that waste is collected, transported, and disposed of in an environmentally sound manner. They are also responsible for providing waste management services to residents and businesses within their jurisdiction. Municipalities can choose to provide waste management services themselves or to contract with private waste management companies. In addition, municipalities are responsible for enforcing waste management regulations and for promoting waste reduction and recycling within their communities. These municipalities do not report data onwards about the waste management activities or the associated costs.

Information System about waste types 2020-2021[11]

From 2020, the Estonian Environmental Agency issues a dataset about waste types. In this system, it is possible to see how different types of waste are managed at the national, county and municipal level. It is possible to distinguish waste by main group, subgroup, type of waste, name, material name, code and country of import or export. You can then view how much waste was in stock from the beginning and end of the year, accumulation of the waste, how much was imported, exported, reused and put on the landfill.

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[9] https://kotkas.envir.ee/)

[10] https://ojs.envir.ee/ojsweb/auth/login?request_locale=et

[11] https://public.tableau.com/app/profile/keskkonnaagentuur/viz/Jtmeliigid2020-2021/Riigitasand