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epa Research

Packaging Waste Statistics, Producer Motivations and Consumer Behaviour

Authors: Craig H. Bullock, Nicolai Thorball, Celia Somlai and John Gallagher

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Rialtas na hÉireann
Government of Ireland

Environmental Protection Agency

The EPA is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: Implementing regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.

Knowledge: Providing high quality, targeted and timely environmental data, information and assessment to inform decision making.

Advocacy: Working with others to advocate for a clean, productive and well protected environment and for sustainable environmental practices.

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- Urban waste water discharges;
- The contained use and controlled release of Genetically Modified Organisms;
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- Promote environmental awareness including supporting behaviours for resource efficiency and climate transition;
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The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

1. Office of Environmental Sustainability
2. Office of Environmental Enforcement
3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

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Identifying pressures

The production of plastic packaging for food and other products has increased substantially over the past 50 years. Plastic packaging has many desirable properties: it is inexpensive, lightweight, mouldable and impervious to air and water, making it an excellent material for keeping food fresh and reducing food waste. Unfortunately, plastics are derived from fossil fuels and do not decompose easily, often accumulating in the environment as litter with significant environmental impacts for our oceans. Many types of plastic packaging are also challenging to recycle. Changes are needed if Europe is to achieve a circular economy that minimises waste and preserves resources. Ambitious targets for plastic recycling have been set at the EU level, but recycling rates in Ireland have stalled in recent years.

The ReWrapped project investigated why Ireland's production of plastic packaging waste appears to be higher than that of other EU Member States. The project also undertook a survey of producers to help understand what drives their use of different types of plastic and the extent to which sustainability considerations influence their decision-making.

Informing policy

The methodologies used by different EU Member States to compile waste statistics are examined, particularly the waste analysis approach used by Ireland and the placed-on-the-market approach used by most other Member States. Both approaches are subject to flaws due to sampling costs or varying national coverage or guidance, but under-reporting, online sales and differences in moisture content are among the main reasons why the placed-on-the-market approach often underestimates packaging waste quantities. On this basis, the per-capita plastic packaging waste generation in Ireland would appear to be higher than in many other countries, albeit not exceptionally so.

Responses from the producer survey indicated that many food producers use an increasingly wide variety of plastic packaging for reasons that range from maintaining freshness to marketing. Some of these packaging types are difficult to recycle. Many producers are now examining ways to make their packaging more recyclable or compostable. Producers are also conscious of new EU directives which will require packaging to be more recyclable and use recycled content. They expressed a need for more specific information and guidelines. Interestingly, much of the pressure regarding sustainability to date appears to have come from major retailers rather than government.

Developing solutions

The project also surveyed consumers to discover their opinions about different types of packaging and sustainability labelling. The survey included an experiment to determine consumer preferences for recyclability, compostability and recycled content. It found that there is widespread awareness of recycling, and that consumers are willing to pay modest amounts more for sustainable packaging. However, current sustainability labelling creates confusion for consumers. There also appears to be low awareness among consumers of the virtue of recycled content.

Communication should be improved and awareness raised to maintain pressure on retailers and producers to improve packaging sustainability. Although a move to sustainable product packaging can be challenging, it is evident that producers often have the capacity to respond to market and policy pressures given relevant information, guidance and a mix of incentives and penalties, as well as sufficient lead time. Regular data from waste composition analysis can inform this process, but more consistent and harmonised reporting methods need to be implemented that combine waste-based and placed-on-the-market data.

EPA RESEARCH PROGRAMME 2021–2030

Packaging Waste Statistics, Producer Motivations and Consumer Behaviour

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EPA Research Report

Prepared for the Environmental Protection Agency

by

University College Dublin and Trinity College Dublin

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This report is based on research carried out/data from September 2019 to December 2021. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

Packaging waste in the EU includes 35% municipal waste; plastic packaging accounts for over 19% of this and is the second most common waste material, after paper and cardboard. The EU's Plastics Strategy and the Single Use Plastics Directive (Directive (EU) 2019/904) underpin the objectives of a circular economy by aiming to significantly reduce the amount of plastic packaging intended for single use. However, the amount of all packaging waste has continued to increase across the EU, reaching a record 178 kg per capita in 2019. The amount of plastic packaging waste generated in the EU has increased even more sharply, to 15.4 million tonnes, corresponding to an average of 34.5 kg per capita.

The EU's revised Packaging and Packaging Waste Directive (Directive (EU) 2018/852) requires that 65% of packaging waste and 50% of plastic packaging waste is recycled by 2025, with these proportions rising to 70% and 55%, respectively, by 2030. Ireland has so far performed well in meeting its targets. Over 62% of packaging waste is already recycled as of 2019, exceeding the current EU target, while plastic packaging recycling, at 28%, is also above the current target of 22.5%. However, Ireland would appear to generate high levels of plastic packaging waste relative to other Member States. Indeed, the amount of plastic packaging used in Ireland is 65 kg per capita, almost double the EU average.

Accurate statistical estimates are essential for determining national recycling rates and for managing waste performance to meet packaging targets. The ReWrapped project examined the various methods used across the EU to estimate packaging and plastic packaging waste generation. The project supports the view that a contributory factor in Ireland's relatively high reported levels of packaging and plastic packaging waste is the choice of methodologies adopted by different Member States to calculate these estimates.

As a relatively small country which imports many consumer products, Ireland relies largely on the "waste analysis" method. This method requires regular and thorough sampling that can provide accurate measures of the composition of the actual material which ends up as waste.

Most other countries use the "placed-on-the-market" approach, which relies mainly on producers reporting the volume of packaging, either voluntarily or through producer responsibility schemes. The approach has the capacity to provide accurate data, but it is vulnerable to various incentives to under report; the risk of incomplete data; errors in the data on net imports and exports; cross-border trade by small businesses or private individuals; free-riding and online sales; and assumptions made for smaller companies, which are exempt from reporting requirements.

It appears likely that many countries using the placed-on-the-market approach may be underestimating their packaging waste generation. It also appears possible that Ireland uses more plastic packaging than some other countries. However, Ireland's presumed position as an outlier can be contested.

Nevertheless, there is still much to do to change both producer and consumer behaviour regarding packaging. From a practical perspective, plastic is an inexpensive but versatile commodity with positive properties in terms of resource use, weight, strength, and ability to protect contents from contamination through air or moisture (barrier qualities). Without it, energy and transportation costs could be higher and food waste even more of a problem.

The ReWrapped project therefore undertook a survey of producers and found that many are experimenting with new types of packaging to deliver greater sustainability and recyclability. This report finds that a policy stimulus and innovation are needed to meet the challenge of reducing plastic packaging or to deliver packaging which is more recyclable.

A survey of consumers was also undertaken, which found a widespread awareness of food packaging issues and a willingness to purchase recyclable packaging if the price premium is modest. A choice experiment was applied and revealed that recyclability is favoured as a characteristic and is preferable to, or more familiar than, compostability. The experiment

also found low preference for (or awareness of) the reuse of plastic for packaging. In addition, the consumer survey revealed a poor understanding of recycling or sustainability labelling.

Both consumers and producers seem to desire more targeted information and more persuasive measures to induce changes in motives or behaviour.

1 Introduction

1.1 Objectives

The ReWrapped project set out to examine the production, consumption, management and reporting of packaging waste, specifically plastic. Its objectives were to:

- critically examine alternative methodologies used across the European Union (EU) for the compilation of packaging waste statistics, including their reliability and comparability;
- undertake an integrated analysis of packaging from production through the distribution chain to the consumer;
- investigate the factors influencing the behaviour of both producers and consumers, and the role of various forms of plastic packaging, including different polymers, and recycling opportunities.

1.2 European Waste and Packaging Waste Policy

European waste policy goes back 40 years, but recent years have seen increased attention given to packaging as a major component of household and commercial waste, particularly plastics and plastic packaging, given their abundance, their limited capacity to degrade in the environment and the impact that plastic litter has on the terrestrial environment and marine ecosystems. The original Waste Framework Directive (WFD) dates back to 1975, but it is the more recent WFD, Directive 2008/98/EC (EU, 2008), and subsequent revisions that provide much of the overall legislative base for current European waste policy and have established the relevant concepts and criteria, including the definitions of waste, waste reduction, recycling and recovery. The WFD stipulates the measures to be taken by Member States at all stages of waste management. At its heart is a five-tier “waste hierarchy” to encourage waste minimisation, beginning with (1) prevention/reduction in use, and followed by (2) reuse, (3) recycling or reprocessing of constituent materials, (4) recovery of embedded energy and, finally, (5) appropriate disposal.

A guiding principle of European waste policy is the Polluter Pays Principle, which seeks to ensure that those who produce waste are also responsible for the cost of its management. In this respect, Article 8 and 8(a) of the WFD outlines the role of extended producer responsibility (EPR) schemes, whereby packaging producers are made aware of the downstream costs associated with product disposal and encouraged to fund collection and recycling operations.

The EU has since committed itself further to creating a more circular and resource-efficient economy that decouples waste generation from economic growth and moves instead towards materials recovery (EC, 2014). These principles were first set out in the Circular Economy Action Plan of 2015 and then revised in 2020 as a core element of the European Green Deal (EC, 2020a). The principal objective of this new strategy is to retain the value of products, materials and resources within the economy, as it is argued that this will provide competitive advantage by protecting European industry against future resource scarcity and the price volatility associated with raw materials. The second objective is to provide a direct public good by minimising waste generation, reducing water and marine pollution, and moving towards the more sustainable use of materials and energy.

Plastics have been a particular focus of this approach, given that hydrocarbons are the raw material of plastics and the need to address the CO_2 emissions which arise from their manufacture and use. Ambitious targets have been introduced to reduce the use of plastics and increase the uptake of recycled materials, including that 55% of plastic packaging be either reusable or capable of being recycled cost-effectively by 2030 (see Table 1.1) (EC, 2018). The revision of the Packaging and Packaging Waste Directive in 2018 (Directive (EU) 2018/852) also provided a mandate for the European Commission to require improvements in packaging design to encourage reuse or recycling (EU, 2018).

By its nature, almost all single-use packaging becomes waste, including throwaway items such as carrier bags, food packaging, wrappers and drinks containers. To measure progress towards targets, the EU Packaging and Packaging Waste Directive (Directive 2008/98/EC) requires Member States to

Table 1.1. Current and future EU recycling targets

Packaging waste targets	Current	2025	2030
Packaging waste recovered or incinerated with energy recovery	60%	–	–
Packaging waste recycled	55%	65%	70%
Glass recycled	60%	70%	75%
Paper and cardboard recycled	60%	75%	85%
Metal recycled	50%	70%	80%
Aluminium recycled	–	50%	60%
Wood recycled	15%	25%	30%
Plastic recycled[a]	22.5%	50%	55%

[a] **Exclusively plastic material recycled back into plastic.**

work towards having harmonised reporting systems for reducing packaging waste and increasing its collection and segregation. The Directive refers to "essential requirements" for the manufacturing and composition of packaging, including the potential of that packaging to be reused or recovered.

The abstract nature of the essential requirements has, however, been identified as having undermined enforcement. Indeed, the European Commission itself has raised questions (EC, 2020b) in regard to the lack of discrimination in the requirements between end-of-life costs and environmental impacts of different packaging and the fact that a diverse range of packaging types and of materials are often used in the same packaging. Recommendations to improve the essential requirements include those listed below; these are expected to be addressed in a revision of the Packaging and Packaging Waste Directive in 2022:

- a reflection of the waste hierarchy in packaging design;
- clarity on packaging design;
- more strictly defined requirements and fewer derogations;
- alignment on the role of compostable packaging to reflect its use and value;
- support for the supply and demand of high-quality material; and
- well-defined enforcement to replace a presumption of compliance.

A priority has been to address the issue of unrecyclable packaging and the use of labelling to raise consumer awareness. A second priority has been to design products with ease of recycling in mind, ensuring that the recyclability of packaging is maximised the first time a product is placed on the market.

1.3 Plastic Packaging

Plastic has increasingly become a major component of packaging, and in Ireland it is second only to paper and cardboard in its contribution to packaging waste (EPA, 2021). Plastic has many desirable properties. It is low-cost, strong, durable, lightweight, easily mouldable, water resistant (hydrophobic) and bio-inert. It has also made a remarkable contribution to the reduction of food waste by extending the lifetime of products, although this also causes households to often dispose of products that are still in their packaging once their sell-by date has been exceeded. The major problem, however, is the negative impact of plastic on the environment when it is not, or cannot be, recycled or disposed of properly. In particular, plastic pollution of the oceans has become one of the greatest environmental challenges of our time (Nielsen *et al*., 2019), and the production and use of plastic contribute to global CO_2 emissions.

These negative impacts are compounded by plastic's abundance. The use of plastic in packaging has accelerated due to its versatility, along with a shift from cardboard or metal containers to convenient single-use plastic (SUP) products. In 2015, it was estimated that 6300 million tonnes (Mt) of virgin plastic had been manufactured since the material first became available. Of this total, it is thought that only around 9% has been recycled and 12% has been incinerated, while 79% has accumulated in landfill or in the natural environment as litter (Geyer *et al*., 2017). A least 150 Mt of plastic has accumulated in the oceans (Ocean Conservancy, 2015).

Plastic, therefore, is precisely the type of material whose use must be addressed by EU waste and recycling policy. Although it has an adverse environmental impact, plastic is a potentially valuable recycled material, given the embedded energy arising from its manufacture. The European Plastics Strategy, adopted in January 2018, proposes that plastic material be more recyclable and demand for this recycled plastic increase (EC, 2018). Furthermore, the EU Circular Economy Action Plan (CEAP) (EC, 2020a) includes the need to address potentially hazardous additives and the practicalities of biodegradability. It aims to extend producers' responsibility by ensuring greater harmonisation and reliability, including a clearer definition of responsibilities and common definitions of what constitutes packaging and recyclability. It will extend producers' responsibility to the costs of clean-up, including of litter, and apply differentiated costs to the production of packaging depending on its recyclability.

However, trends in plastic use have remained on an upwards course. There has, for example, been a 4.2% annual global increase in food and drink packaging placed on the market since 2010 (Ketelsen *et al*., 2020). In Europe, packaging waste reached a record of 178 kg per capita in 2019 (Eurostat, 2022a). At 19.4%, plastic is the second most common packaging waste material, after paper and cardboard (40.6%). The volume of plastic waste generated in the EU-27 increased by 9.6% between 2008 and 2019, to 15.4 Mt, corresponding to an average of 34.5 kg per capita. The same trends have been seen internationally.

The Single Use Plastics Directive (Directive (EU) 2019/904) (EU, 2019) and the new 2020 updated CEAP (part of the European Green Deal) can, therefore, be seen as a response to these negative trends. In the first instance, the strategy forecasts that 90% of plastic bottles will be recycled by 2025, supported by producer responsibility schemes, and that plastic bottles of capacity up to 3 litres will be required to contain a minimum of 30% recycled plastic. The CEAP forecasts that by 2030 all packaging will be recyclable.

To maintain this momentum, a Plastic Own Resource calculation was introduced in January 2021 (Council Regulation (EU) 2021/770) (EU, 2021). Member States are now required to demonstrate their commitment to a circular economy by making a contribution to the EU budget based on the amount of non-recycled plastic packaging they produce. The measure has been likened to a plastic tax, and a rate of €0.80/kg has been set, although Member States are free to draw on any source of revenue for this purpose. This national contribution is part of a set of levies on energy and carbon emissions introduced as part of the European Green Deal to reduce resource use.

1.4 Plastic Packaging Generation in Ireland

The WFD introduced the concept of the "waste hierarchy", whereby prevention and reuse are prioritised ahead of recycling and energy recovery, with landfill to be considered as a last resort. This accords with the principles of resource efficiency and of fostering a more coordinated approach to waste management. A national waste strategy was set out in *A Waste Action Plan for a Circular Economy*, published in September 2020, and followed by a Circular Economy Strategy a year later (DECC, 2021). The plan included proposals for the establishment of a deposit-and-return scheme (DRS) for plastic bottles and aluminium cans, along with plans to ban certain SUP items accounting for more than 70% of marine litter, in line with the Single Use Plastics Directive (Directive (EU) 2019/904). Small items, such as sachets, bottle tops and collars, are especially evident in marine litter; such items constitute 10% of the packaging market but are prone to leakage into the environment. These products include plastic cotton bud sticks and plastic straws and cutlery. Oxo-degradable products were also included in the ban due to concerns that they might not be fully degradable in an outdoor environment and could still add to litter and microplastic pollution. Other targets for the SUP Directive, relating to the attachment of lids to bottles and the amount of recycled plastic content in polyethylene terephthalate (PET) bottles, are due to be set in 2024 and 2025. Under the plan, companies that produce or use packaging, either primary packaging (packaging that is in direct contact with the product) or secondary and tertiary packaging (packaging used in the distribution of products between companies or from producer to retailer), will be required to join Repak, which is the producer responsibility organisation (PRO) for EPR in Ireland. Previously, companies had the option of self-declaring their amounts of packaging. Repak charges fees to members to cover the cost

of collection and recovery. Eco-modulation has been introduced to account for end-of-life management options including the costs of recycling different types of materials.[1] Repak member fees were raised in 2021 from €114.32 per tonne for both recyclable and non-recyclable plastics to €175 per tonne for the latter to accommodate a higher subsidy to cover treatment costs (collection, sorting and recycling) faced by waste processors. Fees are due to be increased in 2022 to €214 per tonne and are currently under review for 2023 to ensure that the total estimated costs of processing non-recyclable plastic packaging are covered.

However, the most recent figures available for Ireland mirror wider international trends by revealing that the level of packaging waste continues to increase, from 1.012 Mt in 2018 to 1.125 Mt in 2019 (EPA, 2021). Table 1.2 shows that over 62% of packaging waste was recycled in 2019, exceeding the current EU target of 55%. However, the rate of recycling has declined in recent years at a time when the targets of the Packaging and Packaging Waste Directive are due to be raised to 65% in 2025 and 70% in 2030. Furthermore, only 16% of Ireland's total packaging waste is recycled in the country, with the remainder sent abroad. In Ireland, as seen in EU statistics, plastic is the second most common type of waste generated (Figure 1.1). However, of the 319,082 tonnes produced, only 28% was recycled. While this again exceeds the current EU target of 22.5%, new targets of 50% and 55% will apply by 2025 and 2030, respectively. Moreover, two and a half times more plastic packaging waste was sent for energy recovery through incineration than was recycled, with the proportion having risen to 69% in 2019, from 44% in 2017. The level of recycling for plastic is far below that achieved for other materials (Table 1.2), despite plastic's much greater environmental impact. Higher recycling rates for glass (84%), paper and cardboard (79%), wood (79%) and metal (69%) (EPA, 2021) demonstrate that there are fundamental difficulties with the recycling of plastics.

In addition, interviews undertaken with waste collection/processing companies as part of the project confirm the high levels of contamination in residual waste of 22–28% reported in characterisation studies undertaken for the EPA. Among the recyclable proportion, aluminium and steel are the most valuable materials, but paper reached €130–140 per tonne on the open market in 2020 due to a shortage at the time (usual prices are between €50 and €100). Plastic prices are linked to that of oil as the raw material alternative, but clear plastic fetched €80–120 per tonne. EPA studies reveal that brown bins also contain a lot of plastic waste, mostly food packaging, all of which is presumed to be non-recoverable and only 50% of which is capable of degrading in the industrial composting process.

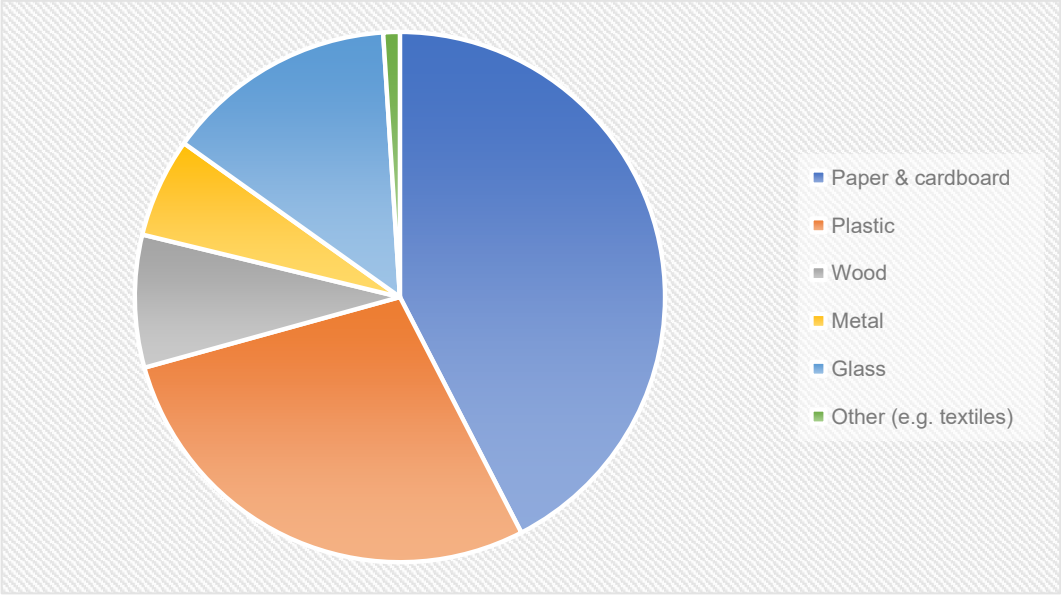

Figure 1.1. Percentages of materials in the packaging waste stream (EPA, 2021).

1 Article 8a(4)(c) of the WFD (EU, 2008).

Table 1.2. Key packaging statistics for 2019

Packaging type	Packaging (tonnes)	Packaging per capita (kg)	Recycling rate 2019	Current target	Packaging and Packaging Waste Directive target 2030
All packaging	1,124,917	229	62%	55%	70%
Plastic	319,082	65	28%	22.5%	55%
Paper and cardboard	473,459	96	79%	60%	85%
Ferrous metals	40,432	8	78%	n/a	80%
Aluminium	25,328	5	54%	n/a	60%
Glass	161,114	33	84%	60%	75%
Wood	92,763	19	79%	15%	30%

Source: EPA (2021).

2 Packaging Waste Statistics

For Europe's policy ambitions to be realised, a clear understanding is needed of the amount and type of waste generated, including packaging, and in particular, plastic packaging. This requires a framework that permits the analysis and comparison of different streams and types of packaging, particularly taking into account the complexity of plastic packaging (Matthews *et al*., 2021), including the contribution made by different polymers, flexible/rigid plastic containers, mixed plastics, and composite plastic/cardboard/foil packaging. Reliable and comprehensive waste data assist with the setting of future targets and are vital for implementing the Single Use Plastics Directive (Sahimaa *et al*., 2015). These data are also essential for the subsequent monitoring of performance against national and EU targets for waste management, including waste collection, reuse, recycling, recovery and landfilling (Yu and MacLaren, 1995; Brunner and Rechberger, 2016).

The Packaging and Packaging Waste Directive obliges Member States to report their packaging waste data, including data on generation and treatment. New guidance on reporting has recently been prepared by Eurostat, the statistical unit of the European Commission (Eurostat, 2022b), and a revised format adopted in April 2019 to apply to reporting from a new reference year of 2020. Information on the different types of packaging, i.e. plastic, glass, paper and cardboard, and the total amount of metal, wood and other types of materials, is required, along with now mandatory cross-checking between the two main methods, the "placed-on-the-market" (PoM) and "waste [or waste composition] analysis" (WA) methods, for reporting packaging waste. National authorities are responsible for submitting these data to Eurostat electronically no later than 18 months after the end of the reference year.

However, recent studies by Robaina *et al*. (2020) and Cimpan *et al*. (2021) have highlighted the complexity of plastic waste data analysis, and the methods used to collect and compare these data between Member States are inconsistent. Official data indicate that, in 2019, Ireland's total packaging waste per capita amounted to 228 kg and that Ireland also reported the largest amount of plastic packaging waste in the EU, at 65 kg, a figure that is 87% higher than the EU average (Eurostat, 2022a) and compares with a reported 39 kg per capita in Germany (Figure 2.1). However, the amount of plastic bottles and plastic packaging that Repak members reported in 2019 as a proportion of

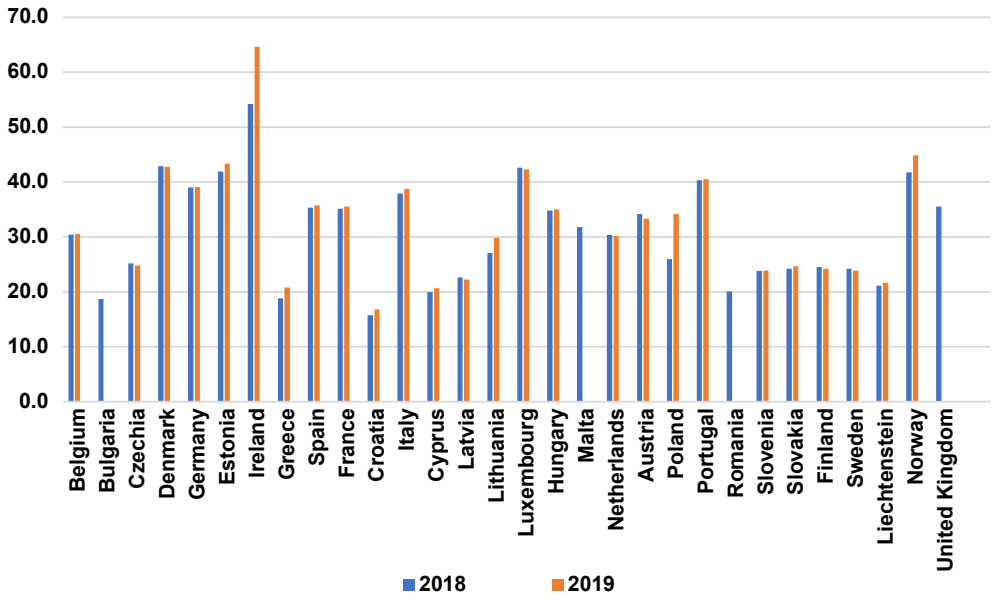

Figure 2.1. Plastic packaging waste generation across the EU (kg per capita). Source: Eurostat (2022b).

the total packaging waste was lower, at 24%, than the national figure of 28.4% would suggest.

Across the EU, Croatia reported the lowest amount of plastic packaging waste in 2019, at 16.8 kg per capita. Although there is a sizable difference in economic development, and therefore in personal consumption, between countries, Ireland generates almost four times more plastic packaging than Greece, Bulgaria or Croatia.

A key assumption underlining the interpretation of national statistics is Article 2(2) of the European Commission Decision (2005/270/EC of 22 March 2005) relating to Directive 94/62/EC (EU, 2005), which states that "Packaging waste generated in a Member State may be deemed to be *equal to* the amount of packaging placed on the market in the same year within the Member State". This statement signals acceptance by the EU of the two main aforementioned methods, the PoM and WA methods (see Table 2.1), for estimating the quantity of packaging waste generated.

The need for accuracy has been strengthened by the introduction of the Plastic Own Resource budgetary contribution, which is based on figures submitted by Member States to Eurostat on non-recycled plastic waste. However, the reliability of both the PoM and WA approaches is dependent on the quality of the data collected or the sampling undertaken. Eurostat guidelines (2022a) propose that PoM data be collected directly from producers, or as submitted to national or regional authorities, independent consulting companies or PROs that represent manufacturers and retailers and are responsible for EPR. Meanwhile, WA should involve numerous samples of equal weight or volume, broken down into different waste categories, across different times of the year, bearing in mind factors such as settlement structure, household characteristics, socio-economic factors, and the waste services or charging schemes in operation. The merits and disadvantages of these two approaches are summarised in Table 2.1.

In practice, it is challenging to obtain information on the precise implementation of the particular methodology used by different Member States. Although Member States are now obliged to submit annual "quality reports" to Eurostat that describe how data are collected and estimates calculated, the degree of detail needed in these reports has not been specified. Consequently, there is a lack of transparency. Different Member States use different methodologies, typically based on historical approaches, including estimates based on trade statistics, waste management statistics and/or a combination of both. Recent guidance from Eurostat (2022b) requires that Member States now report on the cross-checking undertaken and address the possible reasons for inaccuracies identified above or the reasons for different estimates from the PoM and WA methods where both methods are used to one degree or another.

Table 2.1. Overview of applications, advantages, disadvantages and relative costs of WA and PoM approaches

Category	WA approach	PoM approach
Applications	Determination of waste composition Spatial, temporal, socio-economic variations Evaluation of waste management system Assessment of recycling potential	Assessment of single materials Assessment of relative importance of different sources
Advantages	Comprehensive, as accounts for all packaging Detects spatial, seasonal and other variations	Inexpensive No field sampling and analyses
Disadvantages	Labour and time intensive Unidentified fraction Vulnerable to sampling methods and estimates of moisture, and contamination	Dependence on data supplied by "economic actors" – incentive to underreport Vulnerable to estimation of net imports and exports, free-riders and estimates of exempted producers
Relative costs	High	Low

Sources: Brunner and Ernst (1986), Eurostat (2022b).

2.1 Alternative Methodological Approaches and their Limitations

2.1.1 Placed-on-the-market approach

The PoM approach is the more prevalent across the EU. Data are collected by PROs operating EPR schemes on behalf of their members or are based on calculations of manufactured packaging net of imports and exports. PoM assumes that packaging is used within a short time frame. Various adjustments are then applied to account for imports, exports and cross-border sales (Brunner and Ernst, 1986; Brunner and Rechberger, 2016). Data collection varies among Member States depending on the extent of their relative dependence on EPR, statistical offices' estimation of production data, industry declarations and cross-border movement, as described below.

Data from producers

Twenty-five of the 27 Member States have EPR schemes in place (IEEP, 2017) in which manufacturers and retailers report how much packaging they produce or sell. EPR can be looked on as the main source of data, supported by the other three sources listed below. Currently, only a few schemes have more advanced eco-modulation of fees (such that no fee is applied to reusable packaging and higher fees are applied to non-sortable, non-recyclable or composite packaging). EPR schemes need to be more harmonised and transparent so that data quality is improved (Leal Filho *et al*., 2019).

Production statistics

At least five Member States use these data to estimate the amount of associated packaging placed on the market based on standard coefficients for different product types. The calculations are based on a range of assumptions about composition and packaging for many different product groups. For example, the Danish system relies on assumptions about the composition and amount of packaging used for almost 9000 different products. Although the frameworks can be sophisticated, uncertainty is inevitable when assumptions are associated with many different products.

Industry declarations

Self-declarations are used in around 13 Member States, while questionnaires or other means of verification are used in at least another 13. Information may also be based on studies by consulting companies or regional authorities, including of taxation returns. In Ireland, businesses will soon be required to join Repak, but self-declaring companies have accounted for an estimated 36% of packaging waste reported to date. By comparison, the plastic packaging placed on the market by Repak members amounts to 132,000 (Repak, 2018) of the total 319,000 tonnes of plastic packaging waste estimated by WA (EPA, 2021).

Adjustment for imports and exports

Member States must make adjustments for packaging which has been PoM in one Member State but collected in another. This could occur through cross-border trade, including online sales and direct purchases by consumers in other countries.

2.1.2 Limitations of the placed-on-the-market approach

In practice, hybrid systems are often used, which rely on a range of sources, but these vary by Member State. The variety of methodologies, data sources and level of validation for the PoM method is problematic. Inaccuracies can arise in the following ways:

- irregular or incomplete reporting, for example where there is a reliance on occasional data collection;
- double-counting due to uncertainty over who in the production chain is responsible for reporting;
- incomplete industry data, for example when sample sizes are not representative or incorrect calculation has been applied;
- declaration of the predominant packaging material to the exclusion of other components such as plastic lids or bottle tops;
- free-riding and non-compliance with reporting;
- underreporting of online sales, including between countries;
- use of *de minimis* thresholds whereby small companies are not required to report the packaging they produce, which is estimated by the reporting authorities instead;

- lack of comprehensive import and export data, including estimates for third parties (e.g. traders) and consumers;
- reliance on self-declarations by traders, although their accuracy is uncertain as declarations are rarely verified;
- private purchases and sales of packaged goods from abroad and across borders.

Extended producer responsibility

Across the EU, EPR implementation lacks harmonisation and transparency, and there is no common approach to the collection of data (OECD, 2014; Zero Waste Europe, 2015). The characteristics of PROs vary considerably. Member States have chosen to adopt either collective or individual (company) producer responsibility reporting. Different schemes can apply to different types of waste, and some countries' schemes focus on household and commercial waste but exclude industrial packaging.

Some PROs assume simple financial responsibility for the management of packaging, while others have adopted partial or full responsibility for this. For example, in the Netherlands, the Afvalfonds Verpakkingen PRO exercises responsibility through reimbursement contracts with municipalities and sorting plants. The nature of the financing, including its monitoring or oversight, inevitably affects the figures which are reported to the European Commission on the amounts managed.

As at 2020, 12 Member States (41%) had one EPR scheme, whereas nine others (33%), including Portugal, have competing schemes. In addition, despite Eurostat guidelines, there is currently no clear information on how different Member States define packaging waste in practice or how this waste is related to its source.

In all schemes, there is an inherent incentive for companies to report lower quantities of packaging to minimise the fees they are obliged to pay. This incentive is exacerbated by the commercial status of some PROs, including where PROs are competing with one another. In fact, all players, including local authorities, waste management companies and EPR schemes, have an incentive to report the lowest possible plastic packaging waste generation and the highest possible recycling rate.

Schemes that allow packaging and recycling rates to be self-declared are subject to inaccuracy and abuse, the most extreme example of which is free-riding. Free-riders place plastic packaging on the market but do not report data or pay for collection and treatment of packaging waste . A recent study by the OECD (2018) identified online sales platforms as a major contributor to the free-riding of EPR schemes. In the electrical sector, packaging placed on the market by free-riding producers could amount to between 3% and 9% of all EEE (electrical and electronic equipment) sales in the EU. In addition, e-commerce generally has been growing by over 5% year-on-year, and overpackaging by these companies has been identified as a distinct issue (EC, 2020b). Cross-border trade also exacerbates free-riding, as some items are purchased in one country, but their packaging is disposed of in another (Eunomia, 2018).

Among the 19 Member States using PoM-based EPR data, it is believed that only a minority include estimates of packaging arising from free-riders, private imports and exports or internet trade. Where members do account for these, there appears to be a lack of information on the estimation process itself.

De minimis *thresholds*

De minimis applies to smaller producers who are not obligated to provide data. Instead, national reporting authorities estimate the quantities below the threshold, but with varying accuracy. Moreover, the threshold itself varies across Member States. In Ireland, many smaller companies are members of Repak, but the *de minimis* threshold means that they are requested to report only turnover (turnover is recommended by Eurostat, as it tends to be a more accurate measurement than packaging weight). The new Eurostat guidelines (Eurostat, 2022b) require waste reporting even by small producers who fall below the *de minimis* for EPR schemes. Table 2.2 provides examples of the *de minimis* thresholds used by various Member States. As an example of the significance of these thresholds, in the Netherlands only 3% of companies fall below the threshold, although these account for 93% of the market (Eurostat, 2022b).

It is thought that only a minority of Member States which use PoM, based on EPR data, include estimates for the part of the market not covered by the EPR

Table 2.2. Examples of countries applying different *de minimis* thresholds for obligatory declaration of plastic packaging placed on the market

Country	Plastic packaging (kg)	Turnover
Latvia[a]	300 (total)	NA
Germany[b]	30,000	NA
Austria[c]	100	EUR 730,000
Czechia[d]	300	CZK 4,500,000
Netherlands[e]	50,000 (total)	NA
UK[f]	50,000 (total)	GBP 2,000,000
Portugal[g]	Not in place	Not in place
Ireland[h]	10,000	EUR 1,000,000

[a]https://likumi.lv/ta/id/219851-noteikumi-par-izlietota-iepakojuma-regeneracijas-procentualo-apjomu-registresanas-un-zinojumu-sniegsanas-kartibu-un-iepakojuma (accessed 22 November 2022).

[b]https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl117s2234.pdf (accessed 22 November 2022).

[c]https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20008902 (accessed 22 November 2022).

[d]https://www.mzp.cz/C125750E003B698B/en/packaging_legislation/$FILE/OODP-Act_on_Packaging_No_477_2001-20110111.pdf (accessed 22 November 2022).

[e]https://zoek.officielebekendmakingen.nl/stcrt-2017-75133.html (accessed 22 November 2022).

[f]https://consult.defra.gov.uk/extended-producer-responsibility/extended-producer-responsibility-for-packaging/supporting_documents/23.03.21%20EPR%20Consultation.pdf (accessed 22 November 2022).

[g]Email confirmation from the Portuguese Environmental Protection Agency.

[h]https://www.irishstatutebook.ie/eli/2014/si/282/made/en/print (accessed 22 November 2022).

scheme (i.e. small companies below the *de minimis* thresholds of their EPR scheme).

2.1.3 Waste analysis approach

WA is used primarily by small countries that import many products from abroad, including Ireland, Estonia, Luxembourg and Austria, but partly also as a secondary check in Portugal and Hungary. WA provides information about the amounts and types of materials in the waste stream and uses samples at point of generation (i.e. household, business or drop-off centres) or at a waste processing facility. In principle, WA should provide the more accurate measure of packaging waste generated, as it captures data that might not be reported using the PoM approach, including the packaging generated by companies below the *de minimis*, from online sales and from free-riders. Ireland is presented in Eurostat's guidance (Eurostat, 2022b) as a best practice example of WA. Data are collected on recycled and non-recycled packaging. Data on the former are collected from waste processors and surveys by local authorities, while data on the latter are collected from waste collectors and checked against data from the National Waste Collection Permit Office (NWCPO), the National Transfrontier Shipment Office (for waste exports and imports) and Repak compliance reports. A characterisation of waste material composition is undertaken and typically consists of four phases: (1) planning and design of analyses, (2) sampling of waste, (3) sorting of waste into component categories (e.g. paper, plastic, organics, combustibles) and (4) evaluation and interpretation of data.

2.1.4 Limitations of waste analysis approach

Sampling

The sampling procedure used in WA has a notable effect on the estimates of the proportion and type of packaging. To ensure accurate compositional sampling, it is necessary to take frequent and consistent samples of adequate size (Sahimaa *et al*., 2015). Moreover, capturing all packaging in municipal solid waste (MSW) necessitates an analysis of separately collected recyclates and other packaging that ends up as litter or large bulky refuse; in drop-off facilities and street bins; or is disposed of privately (Christiaens, 2015).

Different views on sample size are given in the literature (Nordtest, 1995). As a rule of thumb, a minimum of 10 samples are required for characterisation if the sample size is 100 kg or larger (Dahlen and Lagerkvist, 2008). The most crucial choices are then stratification (i.e. the choice of a relevant number of waste sources and types), sampling procedure, sample size, and the type and number of waste component categories. It is essential to stratify by type of waste (household and other waste), but other important strata include urban/rural, residential structure (e.g. single-family houses, apartment complexes), separation at source (e.g. number of bin types), season, socio-economic differences and availability of recycling centres (EC, 2004, Edjabou *et al*., 2015; Sahimaa *et al*., 2015).

Furthermore, assuming a 20% random sampling error (as is quite possible given the difficulty of achieving a representative sample for waste) and an overestimate of the amounts generated, the estimated per-capita plastic packaging waste could be reduced to 46 kg, marginally above the levels in Estonia and Luxembourg. If a 35% sampling error were present, this would reduce the amount to 38 kg per capita, around the same level as in France, Austria and Spain (Zero Waste Scotland, 2015).

For these reasons, the Solid Waste Analysis tool was developed to provide a European standard for the sampling of MSW.[2] However, there are a lack of standardised rules for sampling and data collection, and the guidelines that do exist are complex and costly to apply. In practice, different methods continue to be used throughout Europe (Dahlen and Lagerkvist, 2008, Edjabou *et al*., 2015, Sahimaa *et al*., 2015).

Moreover, specific breakdowns of packaging by source or sector are few, including the ratios of food and beverage packaging to non-food packaging (estimated to be 2:1) (TMR, 2018). According to Plastics Europe (2018), 20.5 of the 51.2 Mt of plastic manufactured is represented by packaging, of which 8.2 Mt is food packaging and 12.3 Mt is "other". One report (Schweitzer *et al*., 2018) notes that data on the amount of plastic packaging used for food are difficult to obtain, although Muncke (2009) has estimated this at 41%. This uncertainty makes resolving issues of unsustainable packaging at source more difficult. Composite packaging is also becoming more common, in part due to the growing demand for SUP beverage cups that combine cardboard and plastic waterproofing. The use of composites has also resulted from producer efforts to reduce the amount of plastic by using lighter packaging.[3] However, the constituent materials of such packaging can be challenging to determine, as they are often laminated together, and so they are difficult to recycle.

Contamination and moisture

Another issue arises from the degree of contamination or moisture. Packaging placed on the market is dry and free of extraneous material or contaminants. However, once this packaging becomes waste, moisture generally has added significant weight. Light materials such as paper and plastics can also be heavily contaminated by labels, glues and inks (also food residue). The use of these materials appears also to have increased (EC, 2020b). Extrapolation for WA therefore requires a correction factor that accounts for moisture, residue and other contaminants.

For example, a study by WRAP (2015) estimated that non-target materials account for 10% by weight of MSW. It is therefore essential that correction factors are applied to account for differences in weight due to contamination. Studies have reported as much as 65% contamination depending on the material, including 39% for drinks cartons and 41% for plastic bags and film (CTC, 2018). Ireland applies various correction factors for household plastic packaging waste (see Table 2.3). Eunomia (2018) recommends 25%, but

Table 2.3. Correction factors applied in Ireland to account for contamination of packaging

Material	Correction factor
PET	15.9%
PE	19.8%
PP	29.1%
Plastic bags and film	32.7%

Source: CTC (2018).

2 https://cordis.europa.eu/project/id/EVK4-CT-2000-00030 (accessed January 2020).

3 Plastic bottles have become 53% lighter since 1970 (www.spadel.com, 2018; accessed March 2022).

correction factors vary between Member States. Furthermore, the actual variation is considerable, making it difficult to arrive at reliable comparisons.

2.2 Comparing Data Between Member States

Even allowing for variation in the statistics derived from both methods, it is unclear why estimates should vary even among those Member States which use WA. The extent of variation is apparent in Figure 2.2. There are a multitude of reasons for this discrepancy, which could be determined only through a like-for-like and detailed evaluation of the precise application of WA by other countries rather than through an evaluation of the method in principle or of reporting by Ireland alone. For example, until recently, Estonia did not account for moisture at all.

While data quality will increase with sample size, sampling frequency and number of strata, so too will the cost and labour required in sampling. Data are challenging to compare over time and between regions in larger countries where consumer behaviour and waste management vary from region to region. In practice, the expense of thorough sampling means that Member States relying on WA can be tempted to sample infrequently, which can lead to further discrepancies between Member States in annual estimates of plastic packaging waste generation.

While Member States are encouraged to use either the WA or PoM method, none applies both methods equally. In addition, several Member States use a combination of approaches, largely for verification. In Germany, for example, the Association of Packaging Market Research – GVM (Gesellschaft für Verpackungsmarktforschung mbH) – uses data from trade statistics, industrial declarations and numerous individual studies or samples, together with data from household sales and packaging composition databases.

As a check on the approximate validity of the two methods, we can compare the packaging and plastic packaging waste generated as a proportion of MSW (see Table 2.4) and MSW per capita (see Figure 2.3). A ratio of MSW generated to packaging waste estimated from WA involves a comparison of related waste streams and is likely to be more accurate than a comparison with the PoM method.

Table 2.4 shows that Ireland's packaging and plastic packaging as a proportion of MSW is indeed high relative to other Member States. In 2019, MSW in Ireland was roughly split 50/50 between household and commercial waste.[4] Ireland's total packaging can be seen to be at a similar level to that of the UK, which mostly relies on the PoM method. However, Ireland's level of plastic packaging is second (only) to Estonia, while other EU Member States using the "WA" approach, for example Austria and Luxembourg, have much lower levels.

Figure 2.3 further indicates that Ireland ranks highly for MSW generation per capita, although, in this graph, its level is below those of some countries which are ranked lower in Table 2.4.

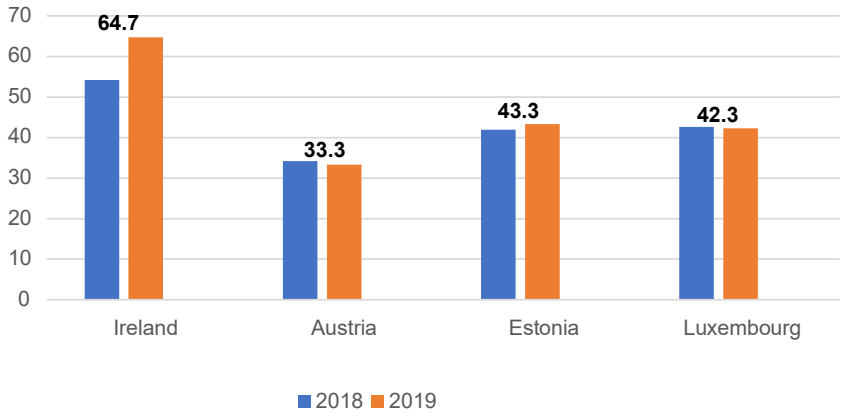

Figure 2.2. Plastic packaging waste in EU Member States that use the WA method (kg per capita).

4 In 2019, 52% of MSW was collected from households and 48% from commercial sources.

Table 2.4. Packaging and plastic packaging as proportion of MSW, 2019

Country	Packaging	Plastic packaging
Estonia	58.9%	11.7%
Poland	49.3%	10.2%
Hungary	43.3%	9.0%
Ireland[a]	38.1%	10.8%
UK[a]	36.7%	7.7%
Spain	36.2%	7.5%
Belgium	35.3%	7.4%
Portugal	35.0%	7.9%
Italy	34.2%	7.7%
Slovakia	31.9%	5.9%
France	31.2%	6.5%
Norway	29.3%	5.8%
Germany	29.2%	6.4%
Lithuania	29.0%	6.3%
Romania[a]	28.7%	7.2%
Sweden	28.0%	5.3%
Netherlands	27.9%	5.9%
Austria	27.5%	5.7%
Czechia	26.9%	5.0%
Denmark	25.5%	5.1%
Latvia	23.9%	5.1%
Luxembourg	23.7%	5.3%
Slovenia	23.3%	4.7%
Finland	23.2%	4.3%
Malta	22.7%	4.6%
Bulgaria[a]	18.2%	4.6%
Greece	17.6%	4.0%
Croatia	15.9%	3.8%
Cyprus	12.6%	3.2%

[a]Data for 2018.

There is no reason to presume that Ireland might have an unusually high level of packaging waste based on its total MSW generated. For example, Luxembourg also uses the WA approach and reports a relatively high level of plastic packaging generation, at over 40 kg per person, but its MSW is high and above that of Ireland. While Ireland reports a still higher quantity of plastic packaging, its waste generation places it seventh in the rankings and is similar to that of countries such as Austria and France, while not being too far off the EU-27 average.

Typically, there is a partially positive correlation between household income and waste production. Ireland, Luxembourg and Austria have similar per-capita GDP, although, based on Eurostat statistics on adjusted gross disposable household income per capita (2019), Luxembourg (€35,102) and Austria (€28,098) have much higher levels than Ireland (€21,877), which, in turn, has a higher level than Estonia (€17,513), which also relies on the WA approach and generates significantly less waste.

A possible reason for the difference between Luxembourg and Ireland is that the former applies a higher correction factor (35%) to mixed waste for contamination. Without doubt, contamination varies considerably by packaging product type and can be as much as 35%. Street litter, for example, typically has a high level of moisture and food waste contamination. As noted previously, waste processors in Ireland report typical contamination levels of 22–28%, while the EPA applies estimates that may be more specific than Luxembourg's, as discussed in section 2.1. This could imply that Luxembourg's higher estimates of contamination accounts for some, but not all, of the difference in the relative reporting of plastic packaging waste between the two Member States.

Therefore, the evidence from which to draw conclusions on the accuracy of WA is mixed. Allowing for the difference in methods, it does seem possible that countries using the WA approach report higher figures than countries using the PoM method for plastic packaging waste generated. It is just as likely that some other Member States that use the PoM method and report low levels of plastic packaging waste generation could be underestimating this, particularly due to the effect of free-riding. However, it is less clear why Ireland would appear to produce a much higher level of plastic packaging waste than Luxembourg or Austria.

Aside from packaging data, market research on retail sales does indicate a high usage of some plastic packaging in Ireland.[5] For example, pouches, which are commonly used for soup, breakfast cereal and pet food, account for 34% of sales of packaged food. Ireland also uses more high-density polyethylene (HDPE) bottles than other Member States, equal to 7% of sales, and has the second highest use of plastic

5 GlobalData. Available by subscription online: https://www.globaldata.com/

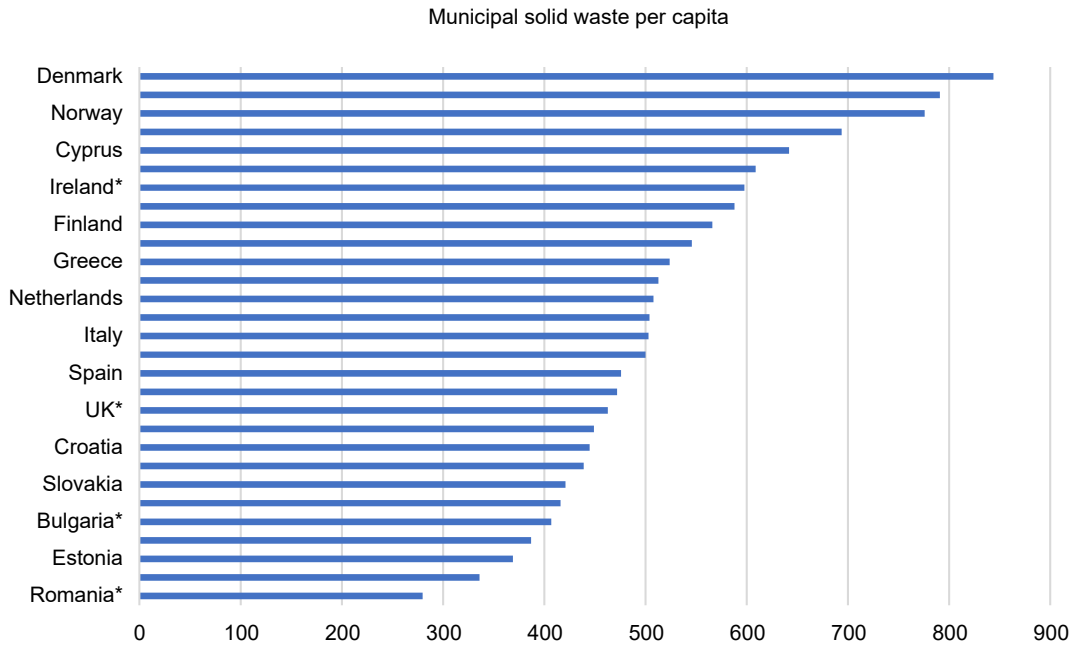

Figure 2.3. MSW generated (kg per capita) in 2019. Source: Eurostat, 2021 (Member States using WA (Estonia, Luxembourg, Austria, Portugal and Hungary)). *Data for 2018.

film in primary packaging in the EU, at 13%. However, Ireland's consumption of plastic trays and PET bottles is comparatively low. Milk sales would explain the high levels of use of HDPE bottles, as Ireland is among the world's biggest consumers of milk, with per-capita consumption of 138 litres per year. Continental European countries tend to package milk in tetrapack containers, but HDPE is highly recyclable compared with other plastics (aside from PET). If large numbers of these bottles were recycled, it would matter less from a target perspective if Ireland used more plastic milk bottles. However, in 2016, only 20% of PET bottles, 12% of HDPE bottles and 6% of pots, tubs and trays were recycled (EPA, 2018).

2.3 Summary

The transition to a circular economy presents challenges to policy and planning which require reliable, comprehensive and comparable data on waste generation and composition. A first step is to ensure good-quality data on packaging waste generation and harmonise the measurement of packaging waste generation and recovery.

The predominant PoM approach commonly underestimates the amount of packaging waste generated. Some of the less developed EU Member States declare levels of packaging that constitute a small proportion of the MSW they produce. However, the high degree of inconsistency extends to all Member States that rely on data from EPR schemes, even though Eurostat recently provided clearer guidelines on how data should be collected. There is also a high likelihood of non-estimation or underestimation of free-riders and online sales, and of variations in *de minimis* reporting.

By comparison, the WA approach includes used material that has a higher moisture content and is often contaminated by food waste or other residues. WA also demands thorough and frequent sampling, but this is usually deterred by the high costs, such that formal composition analysis is undertaken in occasional years only.

In conclusion, the study highlights a lack of harmonisation in the methods adopted for reporting. It indicates that the apparently high level of packaging waste in Ireland is likely to be an output of the statistical method used, although there are also reasons to think that Ireland may be at the upper end of the scale due to its high dependence on heavily packaged imported products. Shared circular economy goals cannot be achieved without first understanding the magnitude of the challenge and addressing this with stricter guidance.

2.3.1 Very lightweight plastic bags

As part of the terms of reference for the ReWrapped project, a survey was undertaken on the use of very lightweight plastic bags (bags with a thickness of < 15 microns). One tonne of plastic would be sufficient to produce 260,000 vest-type carrier bags or many more smaller bags of the type routinely provided by greengrocers, butchers and other small shops such as discount retailers and newsagents. The lightness of these bags means that they contribute to litter, even though soft plastics can now be recycled. Contamination is an issue when the bags have been used for meat. At present, Directive 94/62/EC aims to reduce the consumption of lightweight plastic bags. Very lightweight plastic bags are currently excluded from this Directive, but Member States are asked by the Commission to report on the numbers or weight of these bags.

The best way to collect data on the number of very lightweight plastic bags placed on the market would be directly from manufacturers or importers. However, although assistance was received from three suppliers (whose help we gratefully acknowledge), other companies chose not to respond. Based on the figures received, we estimate that Ireland's seven main supermarket chains are responsible for providing 145 million units per year to customers. This figure would be equivalent to 2.3 very lightweight plastic bags per household per week, but it is likely to be a considerable underestimate given that they are so commonly used by independent greengrocers, butchers and other smaller retailers.

3 Producer Behaviour

Ireland's own National Waste Policy 2020–2030 underpins its commitment to the EU Waste Action Plan and the European Green Deal (EC, 2019). The goals of the policy include moving to carbon neutrality by 2050 and decoupling economic growth from single-use resource dependence. The Circular Economy Action Plan (CEAP) for Europe identifies seven key value chains, one of which is packaging.

Ireland's Waste Action Plan for a Circular Economy contains the key objectives "to shift the focus back up the product life cycle, to remove or design out harmful waste, to extend the life of the products and goods we use, and to prevent waste arising in the first place – consistent with the concept of a zero-waste future" (DECC, 2020). These objectives place an onus on producers to contribute to the realisation of a circular economy. Key measures will include:

- introducing targets for specific packaging formats, e.g. beverage and food;
- making EPR mandatory before 2024, including eco-modulation of fees based on packaging type;
- ensuring that all packaging is reusable or recyclable in an economically viable way by 2030;
- making proposals for mandatory recycled content in packaging materials, including introducing a virgin-plastic levy;
- producers being responsible for a minimum of 80% of the costs associated with the management of the packaging they place on the market;
- reducing the complexity of packaging, including the number of materials and polymers used;
- collaborating with the Food Safety Authority of Ireland (FSAI) on food-contact packaging for reuse while conforming to health and safety requirements;
- continuing the development of mywaste.ie as a principal communication tool;
- introducing a DRS for plastic bottles and aluminium cans.

There are numerous challenges to be overcome in realising these objectives. Producers' adherence to the use of plastic in packaging arises from the primary attention they give to containment, protection, convenience and communication. Inadequate containment or protection will cause a product to leak or be damaged, contaminated or degraded. Convenience allows the product to be more easily handled for transport, presentation and customer use. Communication is a tool for brand marketing but also for providing information on use, cooking, nutritional content and disposal (Marsh and Bugusu, 2007; Robertson, 2012). Plastic packaging fulfils each of these needs depending on the nature of the product and has the added advantage of being inexpensive. Furthermore, highly recyclable alternatives are not free of environmental costs. The production of paper and cardboard, for example, requires large volumes of water, and metal cans require much energy in production, as does glass, which also has high transportation costs (Geijer, 2019). The benefits of plastic's positive characteristics, especially in enhancing the preservation of food, must also be offset against the costs of its negative environmental impact. Where packaging is used simply for single-use convenience, for marketing, for multi-packs, to permit remote sourcing or simply to "sell air", the balance of its properties can be questioned.[6] There have been few life cycle assessment studies of plastic packaging and insufficient analysis of consumer behaviour with regard to storing packaged foods. Plastic may be good for preserving food, but much of the content of green and brown bins is food still in its packaging (Gali and Brunori, 2013).

Repak's Plastic Packaging Recycling Strategy (2018) sets out methods for improved packaging design to increase reuse and recycling and encourage sustainability. The PRO has been instrumental in attempting to direct producers towards the choice of more sustainable packaging. Its guidance document *Packaging and Design for the Circular Economy (Version 2)* (Repak, 2021) acknowledges the need to reduce the material complexity of packaging and provides producers with a range of recommendations

6 For example, Heinz manufactures 11 billion single-serve sachets of ketchup each year.

that can be used to increase the potential for reuse or recyclability. In terms of plastic packaging, it recommends avoiding materials with different densities, or at least making them easily separable. In terms of paper packaging, it recommends reducing plastic laminates to 5% or less, avoiding PVC, or coating on one side and making plastic windows easily peelable or removable. Numerous proposals are presented with regard to films, non-PE layers, additives, colours and labelling. In response, many companies have signed a Repak Members' Plastic Pledge (Repak, 2019) to prevent waste, support the circular economy, simplify polymers, use recycled materials and avoid food waste wherever possible. This may involve terminating SUP lines, increasing the recyclability of packaging, reducing plastics through redesign, moving away from composite materials to mono-materials, or reducing the use of polymers in laminating boards.

Repak has recently introduced eco-modulation, whereby EPR fees are set according to the recyclability of packaging. It is hoped that this will incentivise businesses to move towards improved packaging design (eco-design). It is acknowledged, however, that the lack of currently available information on the actual level of recyclability by polymer type makes it challenging to refine eco-modulation to reflect the precise costs of recycling (Repak, 2018).

Decisions to reduce packaging, improve packaging recyclability or include more recycled content must first address producer needs. However, food producers have the added constraint of food safety regulations. For example, Regulation (EC) No 1935/2004 (EU, 2004) sets out the general principles of safety and inertness for all food-contact materials. This restricts the use of recycled plastics unless the recycling process has been assessed for safety by the European Food Safety Authority (EFSA) and authorised by the European Commission. As recycled plastic contains a mix of plastics whose origin cannot be verified, its quality as food packaging cannot be guaranteed. For the material to be recycled into food packaging, it should be demonstrated that 95% of it was previously used for food packaging. At present, this can be achieved only by recycled PET, which consequently has a high price and is collected separately (Geijer, 2019).

Plastic packaging comes in various forms with associated degrees of recyclability. Plastic can be categorised as rigid, flexible or semi-flexible. Its chemical composition is defined by its Resin Identification Code (RIC) (see Table 3.1), which is also recognised by the European Commission under the Packaging and Packaging Waste Directive (94/62/EC (EU, 1994).

The relative use of these polymers has remained fairly constant over time, except for small reductions in PVC and HDPE and an increase in LDPE. However, this reduction in use does not necessarily equate to a reduction in the number of items, given simultaneous efforts by producers to reduce the thickness or weight of packaging. On a unit basis, the weight of items fell by 32% between 1990 and 2015 (EC, 2020b).

It is important also to distinguish between different levels of packaging (Robertson, 2012):

- Primary packaging is in direct contact with the product. It works as the initial and often primary protective barrier. Examples include metal cans, paperboard cartons, glass bottles and plastic pouches. This is usually the first packaging that the consumer sees.
- Secondary packaging often contains multiple primary packages. It is the physical distribution carrier and is often designed for use by retailers, including shelf-ready secondary packaging such as corrugated cases and boxes.
- Tertiary packaging is used for distributing secondary packages from producer to retailer. This often consists of stretch-plastic-wrapped pallets of corrugated cases.
- Quaternary packaging is used for transporting tertiary packages and is used more often in global trade. This is generally in the form of metal containers, and in certain cases the internal environment of these can be regulated (e.g. humidity, temperature and gas atmosphere).

3.1 Producer Study

Various businesses are represented in the supply chain, from materials suppliers, packaging producers, fillers and co-packers to retailers and waste processers. Ireland's five dominant supermarkets are Dunnes Stores, Supervalu, Tesco, Aldi and Lidl, which together account for 90.8% of grocery business in the country (Statista, 2022) compared with continental Europe, where large retailers account for closer to 50% of the market share. Retailers rely heavily on

Table 3.1. The seven RICs, materials and plastic demand distribution across all industries in 2019

RIC	Application	Demand
1. PET (polyethylene terephthalate)	Plastic bottles for soft drinks, water, juice, sports drinks, beer, condiments Food jars for peanut butter, jelly, jam and pickles Oven-tolerant film Microwavable food trays	8.4%
2. HDPE (high-density polyethylene)	Milk bottles Grocery bags Cereal box liners	12.9%
3. PVC (polyvinyl chloride)	Blister packs Shrink wrap for deli and meat wrapping	9.6%
4. LDPE (low-density polyethylene)	Bags for bread, frozen foods and fresh produce Food packaging film Shrink wrap and stretch film Coatings for paper milk cartons and hot and cold beverage cups Container lids	17.4%
5. PP (polypropylene)	Containers for yoghurt, margarine, takeout meals and deli foods Sweet and snack wrappers Bottle caps and closures Bottles for condiments and syrup	19.8%
6. PS (polystyrene)	Food service items, cups, plates, bowls, cutlery, hinged takeout containers Meat, fish and poultry trays Rigid food containers	2.9%
7. Other	Not frequently used for food packaging	29%

Sources: ACC and Trucost (2016), Plastic Europe (2021).

marketing (including the use of packaging for this purpose) and have a high degree of interaction with consumers (Schweitzer *et al*, 2018). Most retailers, however, do not disclose their waste flow data (SumOfUs, 2016).

Repak membership fee data give a reasonable estimate of packaging placed on the market in Ireland. Except for a lower proportion of plastics, Repak's estimated volumes by material are comparable to the national packaging waste figures issued by the EPA, allowing for the volumes produced by self-declaring companies and others placing plastic on the market (see Figure 3.1). More than one-third of fees, 35%, are received from retailers, and 32.1% are from the food/drink/tobacco sector. When related categories are summed, retailers are responsible for 85% of the final packaging placed on the market, followed by grocery wholesalers, at 11.2%. The data show that food/drink/tobacco products account for 70% of packaging, followed by pharmaceuticals and healthcare products (9%) and chemical products (8.2%).

3.2 Methodology

To examine producer decision-making in relation to packaging and the factors that influence this, ReWrapped undertook a series of semi-structured interviews with stakeholders in the winter of 2020/21. These were followed by a survey of food producers and retailers in the summer of 2021. Food and beverage packaging accounts for two-thirds of the market value of European packaging (EC, 2020b).

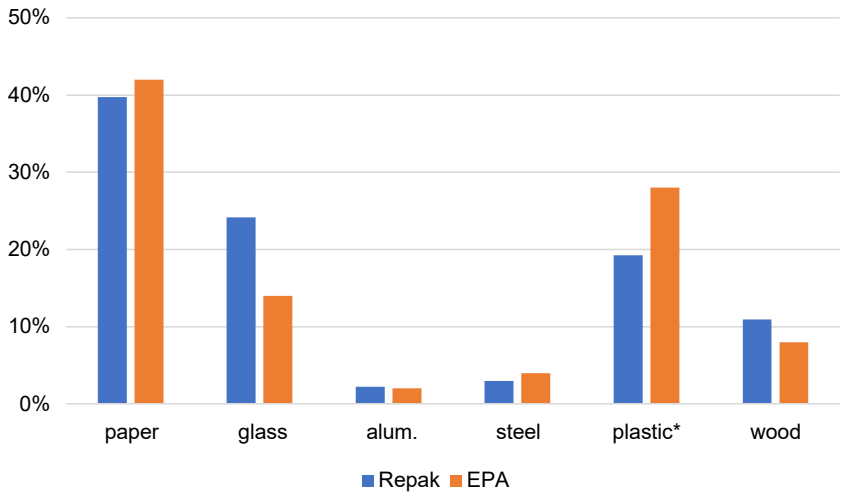

Figure 3.1. Proportional volumes of Repak members' packaging placed on the market and national EPA packaging waste data. *Repak plastic (bottles = 6%).

More details on the approach and results are available in the ReWrapped research report *The Irish Packaging Life-Cycle and Factors Influencing Non-consumer Stakeholders.*[7]

Key issues explored in both the interviews and the survey were priorities for packaging; the use of packaging types, especially plastic; the decision-making process; the influence of external organisations, overseas head offices and consumers; the role of policy; moves towards sustainability; barriers; and perceptions of solutions.

3.2.1 Stakeholder interviews and findings

Interviews were held with food producers, retailers, packaging companies and waste handlers and processors. The composition of the food producer group is given in Table 3.2.

The semi-structured interview was based around 28 questions, which can be viewed in the ReWrapped producer report.[8] Questions were divided into five sections, namely an introduction, the role of packaging producers, the role of packaging producers' clients, the role of policy and the role of sustainability. Data were analysed using NVivo 12 software using the 16 nodes listed in Table 3.3.

A total of 15 stakeholders were interviewed: nine were from the food sector, two were retailers, one was from a packaging solutions company and three were waste processors. Many of the findings have been combined under the relevant headings from the larger producer survey. However, the main findings are discussed below.

Producer choice of materials

Packaging solution companies are responsible for many of the key proposals on materials and format, with input from the producer as the client. Recommendations for packaging materials appear to be made by a technical team quite early in the process of introducing a new product, although other benchmarks must be achieved before the packaging is approved, including cost and sustainability. The materials and packaging will also be subject to rigorous stress testing. Protection of the product is the key consideration, and products need to withstand transportation and changes in ambient conditions, including for export, even with the additional protection of secondary or tertiary packaging. Depending on the properties required, packaging materials and combinations of materials are selected from the different types of polymers listed in Table 3.1. Producers interviewed argued that more recyclable materials, including more widely used mono-materials, may not always be able to withstand the same stress tests.

7 Available from the authors or https://rewrapped.ucd.ie (accessed 22 November 2022).

8 Available from the authors.

Table 3.2. Food producers interviewed

Interviewee number	Industry	Main products	Brand	Main packaging materials
1	Beverage, non-alcoholic	Soft drinks, water	Own brand Other brand	PET bottles, aluminium cans, glass bottles
2	Meat	Fresh meat, frozen meat, processed meat	Own brand Retailer brand	PET trays, plastic film, cardboard, card sleeves, film packaging
3	Dairy	Butter, cheese, milk powder	Own brand Retailer brand	Aluminium foil, HDPE tubs, plastic packaging, cans
4	Fruit and vegetables	A large variety of fruit and vegetables	Retailer brand	PET trays, cardboard trays, film, bags, PP labels, water-soluble glue
5	Snacks	Confectionery	Own brand Retailer	Wax paper, cans, shrink plastic, cardboard, OPP plastic
9	Meat	Fresh meat	Retailer brand	Vacuum packs, vacuum pack trays, MAP (modified atmosphere packaging)
10	Meat; catering	Fresh meat, cold cuts	Own brand Retailer	PET PE tray with top film, paper
11	Beverage, alcoholic	Spirits, wine	Own brand Other brand	Paper, cardboard, glass, bottle labels, carton dividers
12	Snacks, dry goods, cans/jars		Own brand	Cardboard, metal, glass, plastic

Table 3.3. Nodes used to identify semi-structured interviews

Node	Definition
Attributes	Main industry and brand relationship
Packaging materials	Main packaging materials they use
Packaging system	The infrastructure they use to produce their packaging
Packaging design	Design processes for new packaging or revising existing packaging and factors taken into account
Secondary packaging	Their secondary packaging system
Argumentation for choice of material	The reasons for using current materials for packaging
Communication with recycling facilities	The collaboration they have with recycling facilities and waste processors
Communication with retailers	The collaboration they have with retailers
Communication with consumers	The interactions they have with consumers
Sustainable solutions	Approaches taken to minimise their packaging and sustainable development of packaging
Challenges for sustainability and circularity	Barriers preventing packaging from being more sustainable and circular
Recycling of packaging	The recyclability of their packaging, and barriers and incentives for designing recyclable packaging
Reuse of packaging	The reusability of their packaging, and barriers and incentives for designing reusable packaging
Deposit-and-return scheme	Advantages and challenges of setting up deposit-and-return scheme in Ireland
Adaption to policy	The actions they have taken to adapt to policies, and the polices they are preparing to adapt to
Repak	Comments related to Repak's role and impact

Retailer influence

Retailer approval is vital and was argued to have been behind much of producers' recent efforts to ensure that packaging is sustainable. Decisions and pledges on recyclability have been made at corporate level by many of the larger retailers, but these can place large demands on producers, especially when products are of lower unit value. In addition, factors such as shelf-life are of considerable importance to retailers

and can take precedence over recyclability. However, producers have been requested to change from PVDC films to ethylene vinyl alcohol (eVOH) films, which are less impermeable to moisture and extend shelf-life. Retailers may also seek exclusivity for new or innovative products or packaging. These arrangements may restrict producers' options and incentives to sell to alternative outlets. They may also want to trial the new packaging with their brands, reinforcing exclusive relationships. Consumer acceptability is paramount. However, the point was made that better sustainability or recyclability does not necessarily result in higher sales and, indeed, could compromise these. For example, the replacement of black plastic trays for meat with transparent ones has not been welcomed by consumers, who associate black trays with high quality. There have been reversals on the use of some more sustainable packaging, such as for bacon products, because consumers did not like the packaging or associated plastic packaging with good quality (Cochoy and Grandclement-Chaffy, 2005).

Recyclability

A widely made comment was the need for a coordinated across-the-table drive towards recyclability led by government. Producers said that little practical advice had come from government, although they were aware of prospective changes in policy. It was stated that efforts were needed to encourage greater recyclability in product design but that these needed to be mirrored by support for the reuse of recycled materials. Consumer awareness and waste processing were also seen as part of this process. Markets exist for all recyclable materials, including low-value composites. PET is acknowledged to be one of the most valuable recycled materials. However, even in an undeveloped marketplace, demand often exceeds supply because of difficulty in minimising contamination and food safety rules, which prevent the use of even recycled PET (rPET) for many products. Nevertheless, rPET is in high demand for products such as fruit or vegetable trays, and the price of rPET increased from €600 per tonne in 2009 to €900 per tonne in 2019, largely because food-grade materials are required to have a 95% purity rate. In addition, an absence of contaminants such as added colour dyes is also essential for bottled water given the need for purity and transparency. Such contaminants can cause bottles to fracture but can be tolerated to a degree in the bottling of soft drinks.

Reuse

The reuse of packaging presents its own problems. Producers said that this was often limited to office water coolers and glass bottles from the bar trade. They also commented that reusable plastic packaging needs to be sturdy to sustain multiple uses and so it often has to be thicker, which requires more plastic and, therefore, more resources. However, this does not contradict the benefits of reuse where this can be achieved. The proposed DRS would provide for reuse and be capable of delivering a purer flow of materials, as much of what would be returned would be PET. A risk of potential fraud was raised, as it was argued that cheaper products without a levy could be purchased from Northern Ireland to cash in on the deposit available in the Republic. This risk has been discussed before in relation to the proposed Scottish DRS. Waste processors have argued that a DRS could divert profitable recyclates such as PET away from the waste stream and reduce the value of the materials that remain.

Waste processing

The waste processors interviewed said that there was minimal communication between them and producers about packaging material choices. Slightly more communication occurred with retailers. Waste processors argued that producers fail to communicate with them over what is, and is not, recyclable. Some waste processors said that, on occasion, producers label materials as recyclable – possibly naively – when these are either not recyclable or poorly recyclable. Aluminium foil was given as one example, at least before the recent policy change permitting its inclusion in green bins. Foil seals for butter, or plastic seals which give the appearance of being foil, may still present a problem as these are not readily recyclable.

Processors face particular challenges recycling composite materials because of the low value of these. They said that the recyclability of packaging has decreased overall in recent years, rather than having improved. In contrast to commitments many producers made to improve the recyclability of their packaging, it was suggested that the value of recycled plastic

had been reduced overall as a result of producer packaging design decisions. While processors regarded some of these designs as defensible, others, such as those using coloured plastic, were argued to be avoidable. Homogeneity of material is the key factor permitting recyclability, although a market does exist for coloured "jazz flake" plastic, which permits more options for recyclability than higher-value transparent plastics that consist of purer materials. Tertiary packaging such as commercial plastic wrap was identified as among the most recyclable because of its uniformity. Most of the plastic packaging waste generated in Ireland is exported for recycling, largely to the UK. Landfill was said to account for just 7% of packaging waste handled by one processor, but a large amount of low-recyclable plastic currently finds its way to cement kilns or incinerators. The level of incineration is increasing, as observed earlier in this report.

Like aluminium foil, soft plastics are now accepted for recycling. However, although recyclable in principle, soft plastics generally have low value because of the different colours used and high levels of contamination. Indeed, soft plastics can contaminate other recyclable materials, such as paper, because of the difficulty of separating materials of similar density.

Consumer awareness

There was overall agreement that consumer awareness is low and is a major constraint on the amount of materials that become available for recycling, particularly due to contamination following use. The variety of bin colours used by local authorities was identified as unhelpful in this respect. However, inconsistent labelling and a lack of public education by government were also identified as major factors.

3.2.2 The producer survey and findings

The producer survey was designed around the issues which emerged from the interviews. The survey was prepared on the SmartSurvey platform. Repak provided the team with an anonymised membership list, and other participants were recruited through LinkedIn or emails to companies. All participants worked for companies providing food products to the Irish market. The survey was distributed to food producers in June 2021, after they were contacted by telephone. The questionnaire comprised introductory questions and questions on five topics: packaging decision-making, recycling, barriers to adopting new packaging, communication with other stakeholders and sustainable packaging solutions. Participants were assured that their responses would be anonymous, which secured a larger sample size and minimised the likelihood of false data in terms of inflated sustainability efforts, a risk identified by Bonini and Swartz (2014) among others.

A total of 76 responses were received from 14 industries (with some overlap) and four responses from "other" categories. As shown in Figure 3.2, the four main sectors were meat (16%), bakery (15%), alcoholic beverages (12%) and dairy (12%). Small businesses (fewer than 50 employees) accounted for 50% of respondents, 35% were from medium-sized

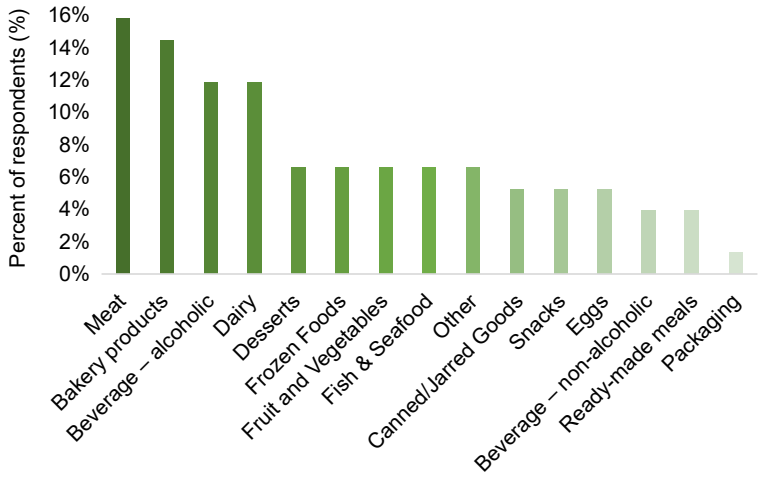

Figure 3.2. Distribution of industries by percentage of total respondents.

(50–250 employees) businesses and 15% were from large businesses (more than 250 employees).

Reasons for packaging

Results from the producer survey confirmed findings from the interviews that protection of the product and cost are the first and second most important priorities in packaging. These are closely followed by information, marketing, convenience, retailer specifications, extension of shelf-life and portioning. Nearly 60% of respondents agreed that protection is critical given that products can be subject to extreme conditions. Packaging often needs to be air-tight, especially for dairy and meat products. This may be done by gas flushing, vacuum packing or shrink wrapping. In a competitive market, especially with low-priced products, cost and packaging failure rates are very important.

Involvement in the packaging decision process

Figure 3.3 shows that the company departments most invested in packaging decisions are marketing and operations, closely followed by purchasing. Transport and logistics are lower down the scale, while involvement of an overseas parent company ranged from "not applicable" to "sometimes". Packaging design companies "almost always" have an influence, but so do in-house design teams.

The influence of different departments in an organisation varies depending on the stage of product development, but conception and early *product development* is often led by a marketing team or influenced by a retailer or packaging design company. Larger companies may have a dedicated technical team. None of the companies surveyed said that it had changed packaging in response to policy, although some did admit to monitoring EU and national policy. *Cost* emerges as an important consideration in the next stage of *feasibility*, in which the company compares its existing process with that necessary for the new packaging. Food producers often sign long-term contracts with packaging companies to ensure that their existing machinery remains appropriate. Marketing and conformity to retailer guidelines will also be considered at this stage, along with sustainability. The third stage, *capability*, tests the packaging under different conditions to determine its failure rate and shelf-life, the number of products that can be packaged per hour and whether new investment is needed. The aim of the final stage, *rollout*, is to see how consumers and retailers respond to the new packaging.

Away from the survey, Garcia-Arca *et al*. (2017) report that packaging design is primarily the responsibility

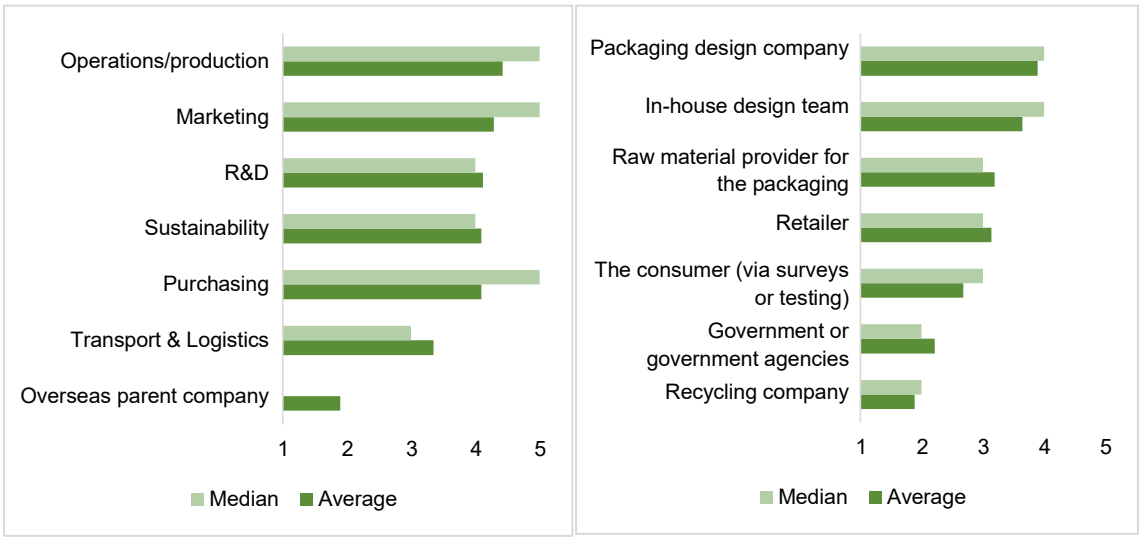

Figure 3.3. Involvement of internal departments (left) and external bodies (right) in packaging decision-making. Responses to the survey question: 'How often do internal departments/external stakeholders influence the packaging?' Scale from 1 to 5: 1 = never, 2 = rarely, 3 = sometimes, 4 = almost always and 5 = always.

of marketing and research and development (R&D) departments but that production and purchasing departments also have an input. They report that the range of requirements for packaging necessitates coordinated action within companies and externally in the supply chain through a proposed "sustainable packaging logistics" approach that brings together design requirements in a holistic organisational structure and also facilitates innovation to improve the packaging's sustainability.

Sourcing of packaging

Most companies surveyed (93%) source their packaging from packaging companies, while only 7% manufacture the packaging themselves. Meat trays and plastic bottles, however, are commonly moulded in-house. The range of packaging formats depends on the product, and many respondents produce several different types of product. Paper/cardboard and plastic are the most common materials (over 91%). Boxes, bags and pots/tubs/trays are the most popular formats (see Figure 3.4). Cardboard boxes are used by 86% of food producers, with 43% using these for shelf-ready packaging, while 31% of producers use reusable crates for business-to-business movement. More than half (51%) of producers use plastic wrap for tertiary packaging.

Sustainability

Larger global companies want their brand to be sustainable and present a positive image in this respect. For food companies supplying only in Ireland and the UK, however, the push for sustainability appears to have come mainly from retailers. Reducing packaging and introducing recyclable materials are considered the main solutions, while the use of recycled materials appears to be at an early stage. Reducing packaging may involve the removal of unnecessary packaging such as sleeves or the use of thinner packaging subject to stress tests. For food-contact materials, the options are more limited due to food safety regulations. To be acceptable under this legislation, new packaging needs to be of consistent material from a single source, which has been one argument in favour of DRS. The current low recycling rate of plastic is a reason why supplies of recycled materials are inadequate and inconsistent.

At present, most producers have opted to investigate recyclability (see Figures 3.5 and 3.6), with 62% using "partially recyclable packaging". Only 25% of producers use "fully recyclable packaging". Just 11% produce "reusable packaging", although whether this means reusable or just repurposing is not always clear. Many of these efforts have occurred in the last 5 years, with 60% of producers having moved to producing partially recyclable packaging in this time, indicating that there is potential for further innovation. The figures do, however, apply to all types of packaging and not specifically to plastics. At the time of the survey, soft plastics were not recyclable in Ireland, but 73% of respondents said their packaging would be more recyclable if this were the case.

Figure 3.7 shows that the main specific action proposed for the next 5 years is reducing the amount of packaging (21.0%), followed by producing fully

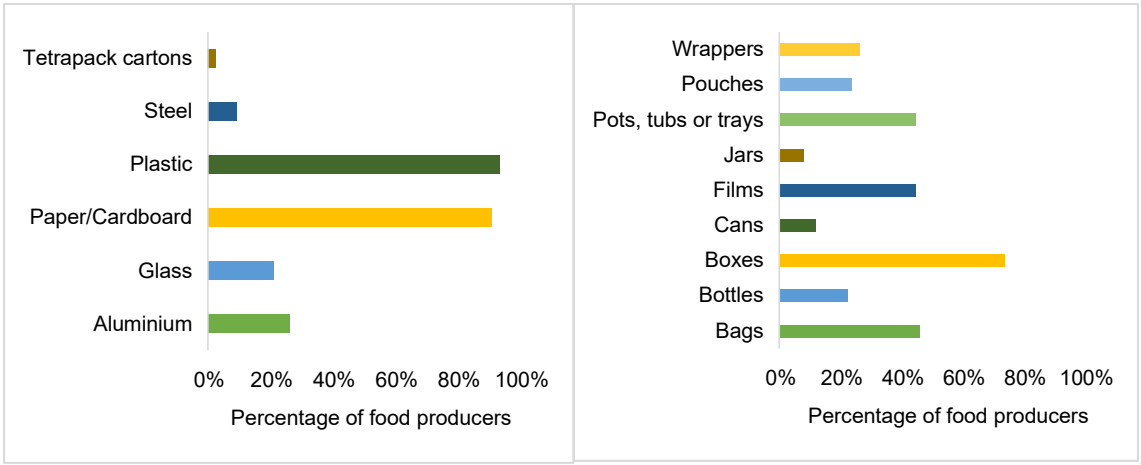

Figure 3.4. Producers' use of materials (left) and formats (right).

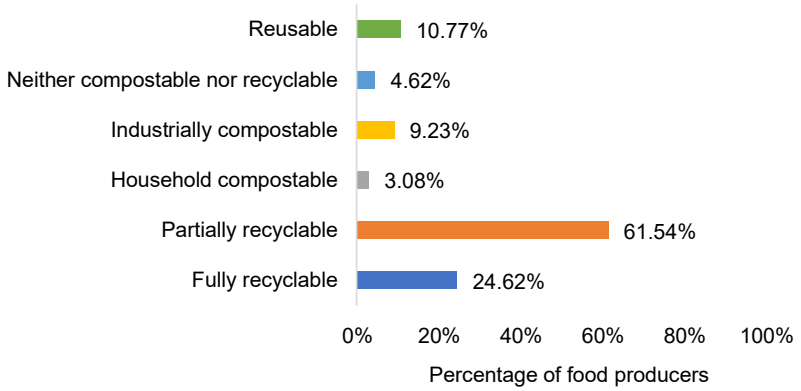

Figure 3.5. End-of-life primary packaging of food producers.

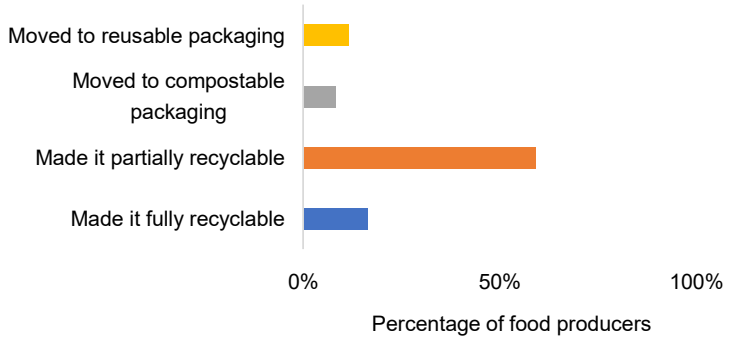

Figure 3.6. Changes made by food producers to their packaging in the last 5 years.

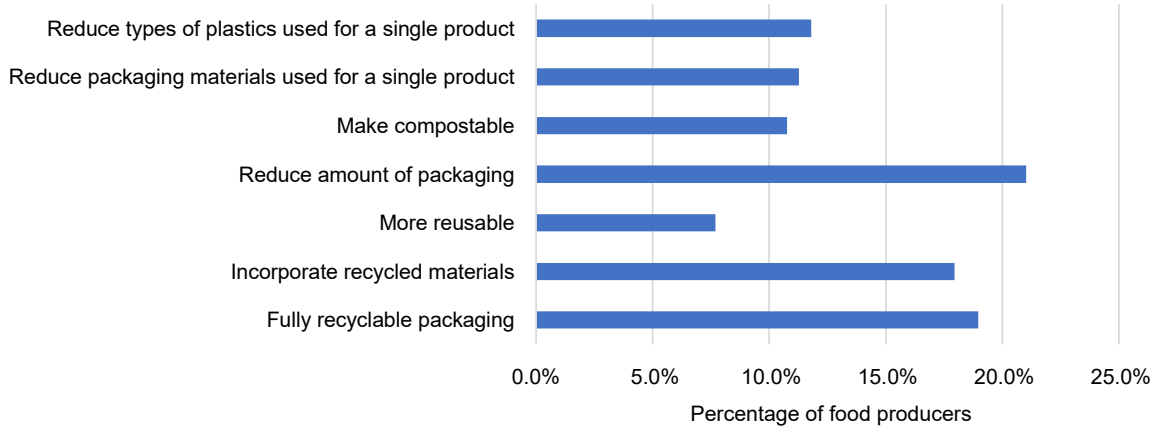

Figure 3.7. Plans for packaging in the next 5 years.

recyclable packaging (19.0%) and incorporating more recycled materials (17.9%). A lower, but still reasonable, proportion of companies intend to reduce the types of plastics they use (11.8%) or reduce the packaging materials (11.3%) used in a single product.

Figure 3.8 reveals the polymers used in packaging by those businesses that use plastic. PET, PP and HDPE are used by, respectively, 23.9%, 20.9% and 13.4% of producers, and these are commonly recyclable.

However, the options for some producers could be more limited. LDPE is used by 16.4% of producers in the survey but is less valuable as a recyclate and difficult to segregate. PVdC is an additional polymer which provides both heat sealing and good barrier properties and is commonly used in the meat and dairy industries, but it can contaminate waste streams (McKinlay and Morrish, 2016). Although composites of plastic and aluminium foil are not recyclable, they are used by 11.2% of producers. By comparison,

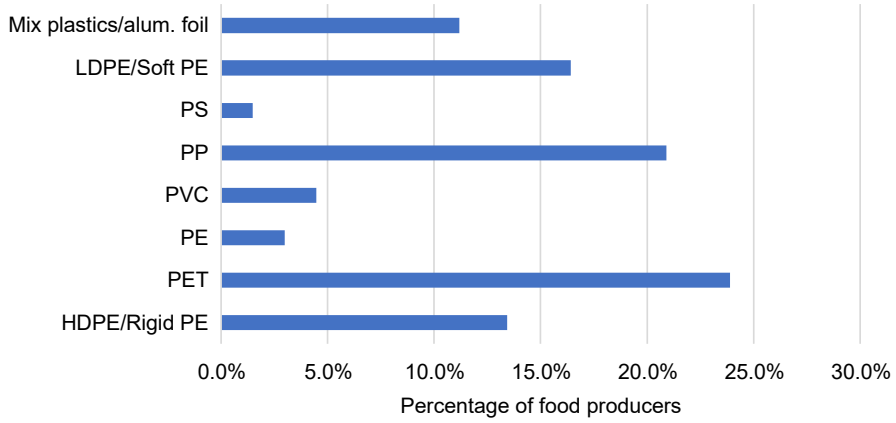

Figure 3.8. Polymers in plastic packaging used by producers.

mono-materials used in the beverage sector are highly recyclable. As current low supply levels are a restriction, these companies could benefit from a DRS in which increased supply and more consistent quality could be assured. At present, reusability is more common between businesses than between businesses and consumers.

Communication between stakeholders

The survey indicates that most stakeholder communication occurs between producers and retailers. Smaller companies are especially dependent on retailers with whose packaging guidelines they need to conform. Retailers have often been at the front end of the reduction in use of plastic materials, such as the cessation in use of PVC packaging by Tesco. Retailers are aware of the positive marketing that sustainable packaging provides. There has been engagement with producers, with retailers setting incentives that can include providing producers with favourable shelf space, in-store promotions and continuous sales data. The varying demands of different retailers can, however, cause confusion, and, although they have promoted sustainability in recent years, retailers have a shared interest in marketability, long shelf-life, low cost and convenience.

Communication also occurs with packaging solution companies, especially when it comes to new products or innovations, with these companies specialising in finding solutions that meet marketing and manufacturing needs. Most communication with consumers is indirect through the retailer, although some companies arrange periodic focus groups to obtain feedback. Consumers have a broadly 'moderate' influence on producers' choice of packaging (Figure 3.9). This includes the importance they attach to sustainability. Consumers also have other priorities, such as low cost, but were said by producers to be swayed more by product appearance than by sustainability. For instance, producers said that it was typically necessary to add transparent plastic windows to cardboard packaging to allow a product to be seen, and they were conscious that this reduces the sustainability of such packaging.

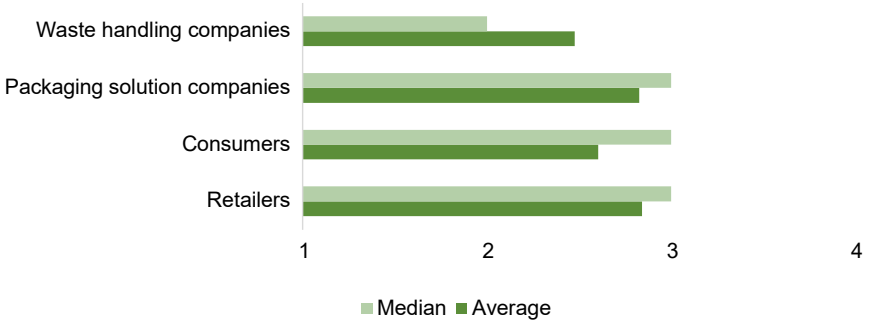

Figure 3.9. The impact of different stakeholders according to food producers. Scale from 1 to 4: 1, not at all; 2, slightly; 3, moderately; and 4, a significant amount.

Both the interviews and the survey confirmed that producers have minimal communication with waste processors, despite the latter's responsibility for disposal and recycling. The survey indicated that producers consider waste processors to be the stakeholders least likely to push the sustainability agenda. However, waste processors counter that they are often the stakeholders least likely to be consulted on packaging design measures, a criticism acknowledged also by the European Commission (EC, 2020b).

Government and EPR organisations are not directly involved in packaging decision-making. Repak was considered a good source of information and a bridge between producers, waste processors and other stakeholders, although its influence on decision-making was regarded as "slight". There has been criticism of Repak's previous fee structure, which was based on an index that prices plastic at only a slightly higher value per tonne than other materials despite its much lower weight. For example, while a half-litre glass bottle weighs 292 g, an equivalent plastic bottle weighs 9.9 g. This made the plastic bottle 2.5 times cheaper in terms of member fees. Eco-modulation has, however, been introduced recently to the fee structure. The fee for non-recyclable plastics and composites increased to €175 per tonne in July 2021, with further increments due to come into effect to achieve the 80% cost estimate of €271 by 2023. Respondents asked that more industry-specific advice be provided by both Repak and the Irish Government. They reported that government advice to date had been vague and that retailers had been far more influential in pushing the sustainability agenda. Some companies said that they favoured more legislation, arguing that this would give a competitive advantage to those who had adopted new standards. They were less keen to see revisions to legislation restricting the use of recycled plastics in the packaging of food for reasons of health and safety. Beverage companies in particular favour a DRS as they believe that this will lead to increased supply and greater consistency in the materials available for reuse.

Barriers to a circular economy

The most significant barrier to a circular economy is argued to be the large variety of materials currently used for packaging. Even so-called sustainable materials can cause confusion among consumers. Diverging paths have emerged: one towards biodegradability, or compostability, and another towards recyclability. However, these paths do not merge. Unless thoughtfully segregated at point of disposal into brown and green bins respectively, different products lead to contamination downstream once the waste reaches the processor. Many Irish households, particularly in rural areas, also still have no brown bin. Oxy-degradable materials are being banned by EU directives for this same reason.

Added to this is the problem of the use of additives such as adhesive labels or composite materials that cannot be separated, such as plastics, films and foil in meat trays or crisp packets. Priority is given to the protection of the product. Tight margins require packaging to constitute no more than a few cents of the price, causing respondents to argue that long lead times are needed to replace machinery and switch to more sustainable packaging. At the time of the survey, respondents called for soft plastics and aluminium foil to be made recyclable given their importance in the food industry. This packaging can now be placed in the recycling bin, although it remains unclear exactly how many of these materials are recycled given their small size or light weight and frequent contamination by food residue. Food safety regulations and the limited supply of clean plastics and aluminium restrict producers' ability to use recycled materials.

Figures 3.10 and 3.11 show that, overall, producers consider cost the principal internal barrier to a circular economy, followed by a limited supply of recycled materials, while also indicating that sustainable packaging could have drawbacks in terms of its ability to protect a product or endure various conditions. Among external factors were insufficient guidance, an absence of recycling facilities for some packaging, and the difficulty of meeting food standards.

Solutions

When asked about potential solutions, producers favour the incorporation of more recycled materials and the use of fully recyclable packaging; however, they acknowledge that a variety of solutions may be needed. Figure 3.12 shows that only a few food producers consider reusable packaging to be the future of their packaging. It is clear from the semi-structured interviews and the producer survey that

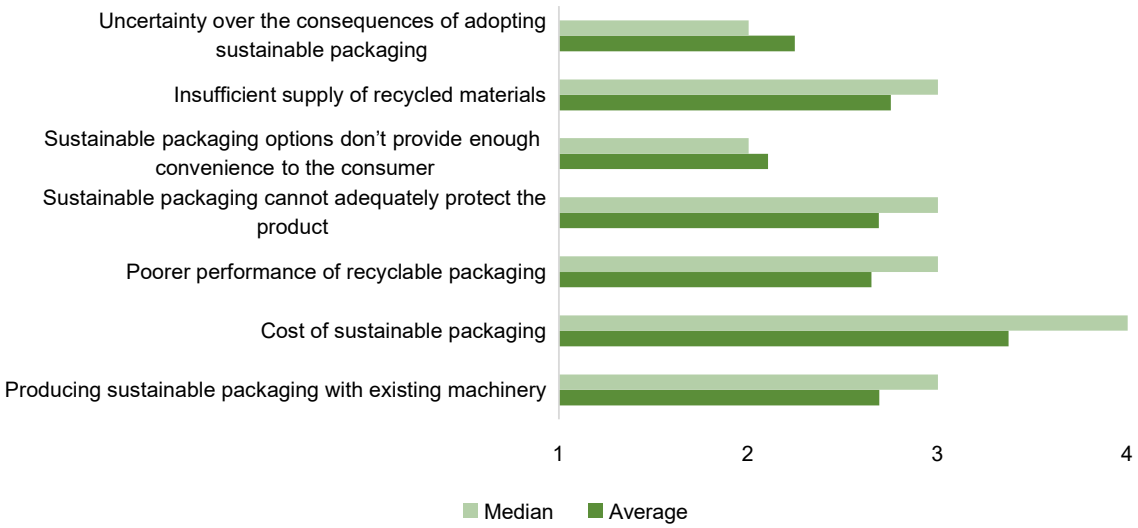

Figure 3.10. Significance of internal barriers for food producers in transitioning to a circular economy. Scale from 1 to 4: 1, not a barrier; 2, slight barrier; 3, modest barrier; and 4, major barrier.

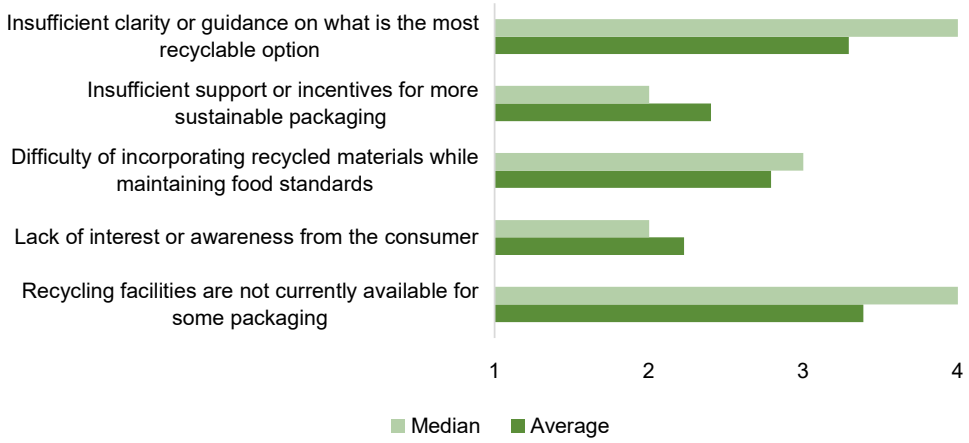

Figure 3.11. Significance of external barriers for food producers in transitioning to a circular economy. Scale from 1 to 4: 1, not a barrier; 2, slight barrier; 3, modest barrier; and 4, major barrier.

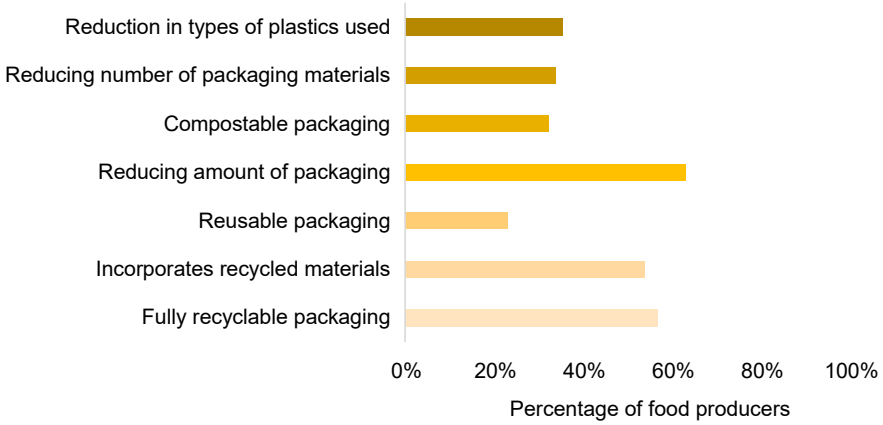

Figure 3.12. What solutions do food producers envisage for their future packaging?

there is not just one solution but multiple solutions, as well as a need for a process that works continuously towards a circular economy.

Figures 3.12, 3.13 and 3.14 show the extent to which respondents to the producer survey support various prospective solutions. The most favoured solutions were government support for companies to commit to more sustainable packaging, media campaigns to increase consumer awareness of sorting, and an expansion of recycling infrastructure. Figure 3.14 shows that producers were more likely to propose an expansion of national recycling infrastructure, but were slightly less in need of additional guidance or agreeable to a reduction in the use of coloured plastic.

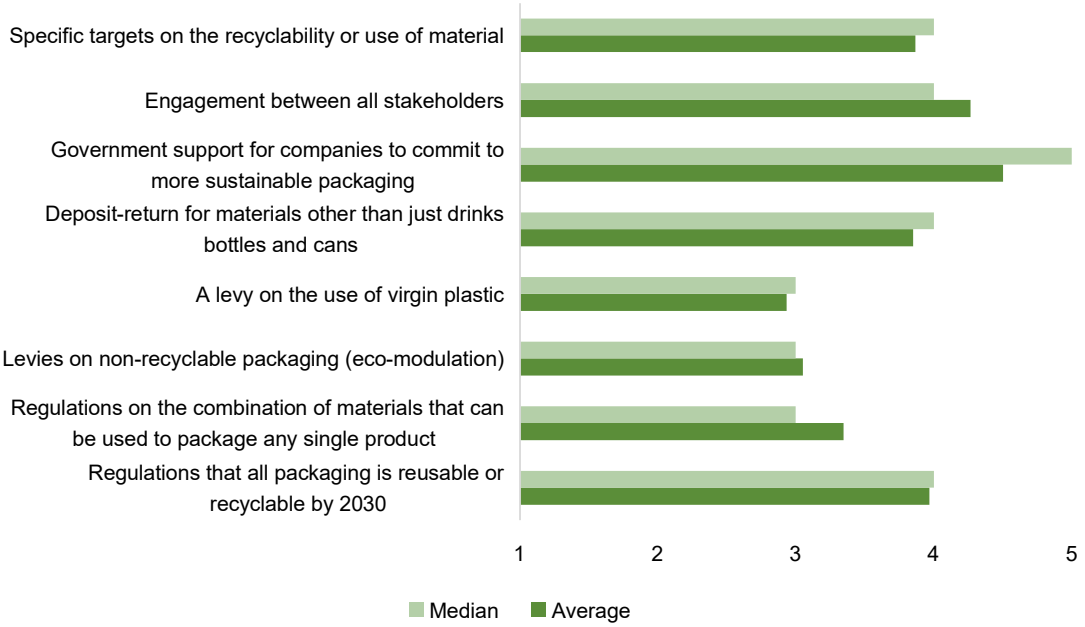

Figure 3.13. Support for solutions involving food producers. Scale from 1 to 5: 1, would strongly not support; 2, would not support; 3, neutral; 4, would support; and 5, would strongly support.

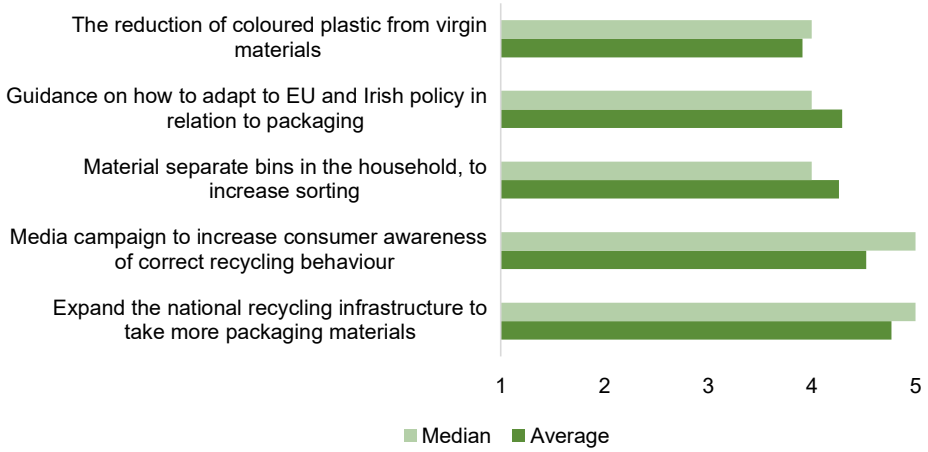

Figure 3.14. Solutions proposed by food producers to increase the sustainability of packaging. Scale from 1 to 4: 1, not a barrier; 2, slight barrier; 3, modest barrier; and 4, major barrier.

4 Consumer Behaviour Survey

While producers have a direct influence on the packaging placed on the market, consumers also have a significant indirect influence in terms of what they choose to buy and a more direct influence on what constitutes waste in terms of what they choose to do with packaging after a product has been used.

An online survey of 500 consumers was undertaken, consisting of six sections:

1. questions on socio-demographics and general sustainable behaviour;
2. questions on purchasing habits;
3. a discrete choice experiment (DCE) on packaging choices;
4. questions on waste and recycling behaviour;
5. an experiment on respondents' understanding of packaging labels;
6. questions to gauge respondents' understanding of, and opinion on, reusables and bioplastics.

The online survey was programmed on the platform Qualtrics. The questionnaire is provided in the more detailed consumer survey report available on the project website (https://rewrapped.ucd.ie) or from the authors. The survey was distributed through the online survey company Dynata in two rounds, first piloted with 50 people and then distributed to 450 people.

4.1 Results from Behavioural Questions

One of the most common problems with surveys that ask people about sustainable behaviour, particularly internet-based surveys, is self-selection bias. The consumer survey therefore drew on a random or stratified sample from an existing much larger sample of the public to ensure that representative views could be obtained. The benefit of this approach is apparent in the responses to the first survey question on environmental behaviour (Table 4.1), which enquired about people's interest in the environment based on the frequency with which they watch environmental programmes on TV, read environmental articles, donate to environmental organisations, become members of environmental organisations and contribute time to Tidy Towns or neighbourhood clean-ups.

The results in Table 4.1 show that respondents indicated a rather low level of engagement with most of these activities. The average score was increased somewhat by the relatively frequent activity of watching environmental programmes on TV. Only just under 19% of respondents regularly read environmental articles in newspapers and magazines, while just under 12% often contribute time to clean-ups, and only just over 8% often donate to environmental organisations, while less than 7% belong to one.

However, although the survey respondents were not very engaged with environmental activities, they did report reasonably sustainable behaviour when it came to purchasing products and packaging.

Figure 4.1 shows, for instance, that, on average, respondents almost always reuse their shopping bags, although of course the plastic bag levy has been an incentive in this regard. The choice not to buy products which have packaging that is difficult to recycle is less incentivised, as is the purchase of loose fruit and vegetables.

Table 4.1. Proportion of respondents who regularly choose to do "environmental" activities

Activities	Never	Sometimes	Often
Watch environmental programmes on TV	7.4%	73.4%	19.2%
Regularly read environmental articles in newspapers or magazines	20.8%	60.6%	18.6%
Donate to environmental organisations	49.8%	41.8%	8.4%
Belong to an environmental organisation	77.2%	16%	6.8%
Contribute time or work to local Tidy Towns or residents' group clean-ups	49.4%	38.8%	11.8%

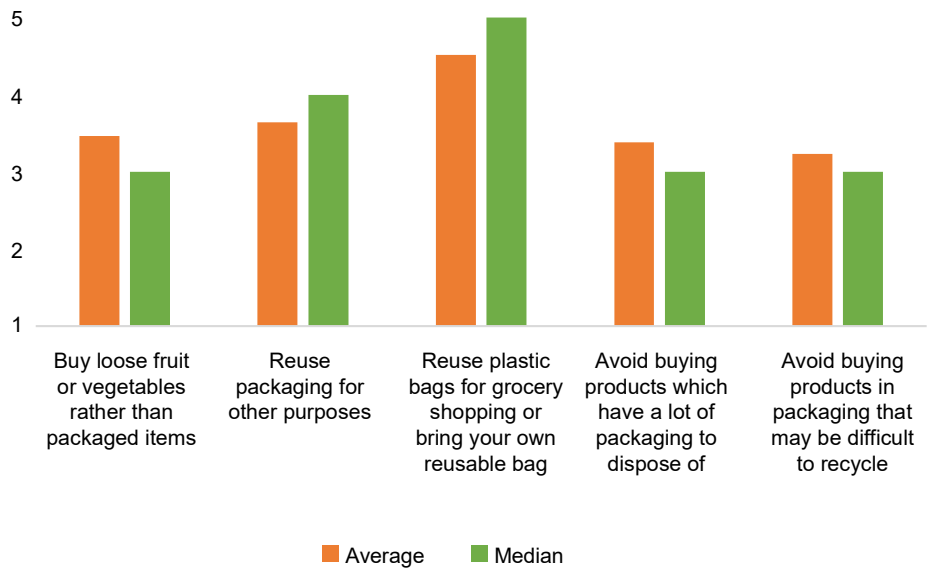

Figure 4.1. Frequency of respondents' purchasing behaviour. Scale from 1 to 5: never = 1, rarely = 2, sometimes = 3, usually = 4 and always = 5.

Respondents were also asked about the properties of packaging. Figure 4.2 shows a preference for packaging made of cardboard rather than plastic, for recyclable packaging and for packaging that makes a product convenient to store.

4.2 The Discrete Choice Experiment

A DCE was used to examine the effect of packaging properties on consumers' food purchasing behaviour. The experiment also explored whether different products influence consumers' purchasing decisions with respect to the packaging used. Two products were presented, namely beef burgers and yoghurt. Because in Ireland up to 8% of the population is vegetarian (Bord Bia, 2020), a question was added that asked whether the respondent ate meat. If the response was "no", the product was described as a vegetarian meat substitute (or "veggie burger").

Although people in the sample had been selected randomly and were not especially environmentally minded, there is still a risk that some could have

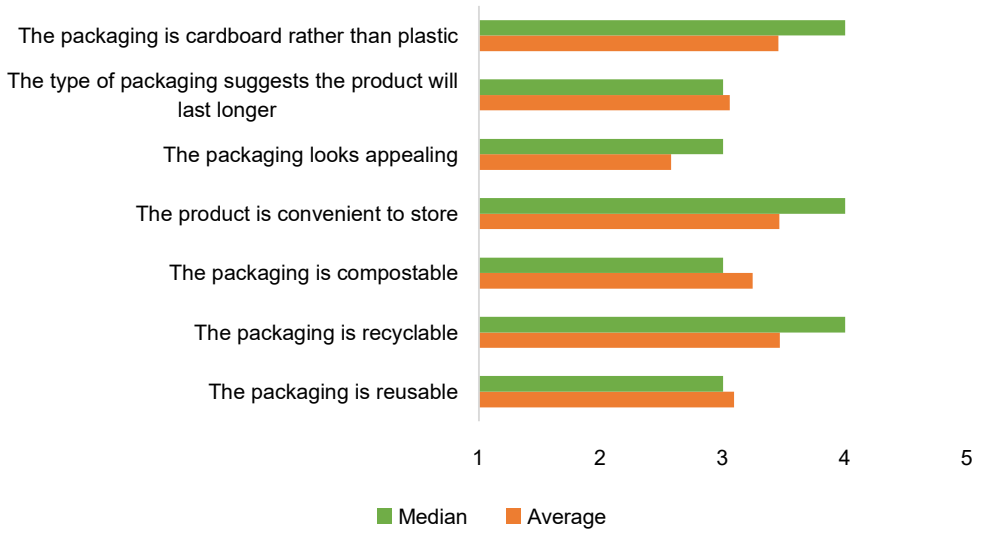

Figure 4.2. Value (average and median) of different packaging properties. Scale from 1 to 5: not at all important = 1, slightly important = 2, moderately important = 3, very important = 4 and extremely important = 5.

chosen to answer in ways that imply more pro-sustainable behaviour than they might actually practise. A DCE helps to minimise this risk, as a "desirable response" is less obvious. A DCE breaks down the description of a good into its key characteristics (or "attributes") and the "levels" at which these are realised (these can be continuous variables, such as price or weight, or categorical variables, such as quality). Three key influential attributes were identified from previous project findings, namely (1) the material used for the packaging, (2) the disposal of the packaging and (3) the price of the product. The levels presented for the packaging material were set as virgin plastic and recycled plastic. For the disposal of packaging, three levels were used: the packaging (1) goes to general waste, (2) is compostable or (3) is recyclable. The last attribute was the price of the product, which was presented as a continuous variable, i.e. the usual price paid by the consumer, 5% more than the usual price, 10% more and 20% more. Price was presented as a percentage rather than in euros so that it would be comparable between the two product options, given that one is more expensive per unit than the other. The attributes and levels are set out in Table 4.2. Choice experiments can be quite complex, at some risk to respondent comprehension. In this case, the experiment was kept deliberately simple to address key questions and increase the prospect for rational responses.

Although rather straightforward as an experiment, all combinations of the attributes and levels would cause a full factorial design to require $(2 \times 4 \times 3)^2 = 576$ different choice questions. However, the number of combinations can be reduced with some prior knowledge of the variability of the data. To obtain this, the DCE was first run in a pilot with 50 people. The results of the pilot were analysed in NLogit software to obtain initial coefficients, which were then entered into Ngene software to give an optimal discrete choice design. This design comprised 24 choice questions, which were then divided into six blocks of four questions. Each respondent was presented with eight choice questions; an example for yoghurt is presented in Figure 4.3.

Table 4.2. Levels and attributes of discrete choice experiment

Attributes	Levels
Packaging material	Virgin plastic or recycled plastic used in product
Packaging disposal	General waste, compostable or recyclable
Price	Usual price, 5% more than usual price, 10% more than usual price or 20% more than usual price

Full details of the experimental design are included in the full consumer survey report available at https://rewrapped.ucd.ie. The results were analysed in NLogit in accordance with random utility theory (McFadden, 1978), in which the utility of a choice can be expressed as what individual *n* derives from alternative *j* at choice occasion *t* using the following equation:

$$U_{njt} = V_{njt} + \varepsilon_{njt}$$

where V_{njt} is the systematic component of the utility function and ε_{njt} is a random component that accounts for the effects on preferences of unobserved attributes of the alternative and individual (Horowitz *et al.*, 1994). This was used to establish the function for the experiment:

$$U_{njt} = \text{ASC} + \alpha \text{PRICE}_{njt} + \beta_{\text{REC},n}\text{REC}_{njt} + \beta_{\text{COM},n}\text{COM}_{njt} + \beta_{\text{RECL},n}\text{RECL}_{njt} + \varepsilon_{njt}$$

where ASC is an alternative-specific constant for the "no buy" option. PRICE_{njt} is the price level of the product as a percentage of the usual price. REC_{njt} is effects coded with the value 1 if the choice is recycled material, –1 if the choice is virgin material and 0 for the "no buy" option. Both COM_{njt} and RECL_{njt} are

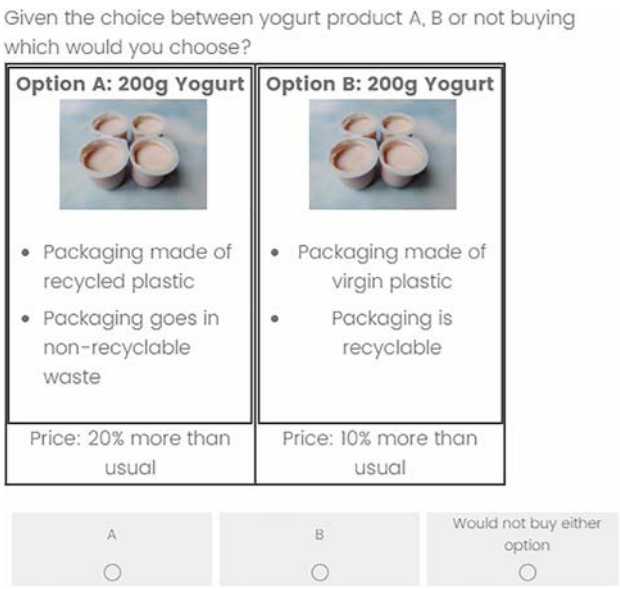

Figure 4.3. Example of a DCE question.

effects coded. COM_{njt} has the value 1 if the choice is compostable, –1 if the product is recyclable or goes in general waste, and 0 for the "no buy" option. $RECL_{njt}$ is similar to COM_{njt}, but it has the value 1 if the choice is recyclable, –1 if the product is compostable or goes in general waste, and 0 for the "no buy" option.

For the analysis, the data were sorted into "all products", which comprised the DCE results for all three products together, and separate results for yoghurt options, the meat burger and the vegetarian burger.

4.2.1 Results from the discrete choice experiment

Good results were obtained for the "all products" sample, with each attribute level coefficient being significant at 1% (see Table 4.3). A positive coefficient indicates that a change in the level of any attribute increases the odds of it being chosen, demonstrating that each attribute adds utility for the consumer. ALT3 is the axis level for the product option, with a positive value meaning simply that there is a preference for buying the product. Only a single level for the "packaging material" attribute and two of the three levels for the "packaging disposal" attribute are shown. This is because the command must provide for data variability, with the baseline attributes of "virgin plastic", "disposal in general waste" and "usual price" omitted from the analysis. However, as the coefficients for each attribute sum to 1 (indicating that the probability of choice for all levels sums to 1), the value and sign of the missing baseline levels can be determined. Hence, for packaging material, virgin plastic has a negative value equal to the positive value of recycled plastic. For packaging disposal, both recyclable and compostable choices have similar positive coefficient levels, although the level for the recyclable choice is slightly higher. Disposal in general waste would have a strong negative coefficient value of –0.663. Price is the only negative coefficient, indicating a preference for the less expensive alternative.

Taking the ratio of the physical attribute level coefficient to that of price indicates that people have a positive willingness to pay (WTP). In this case, price is represented in percentage terms rather than as an absolute amount. The material from which the packaging was made and the sustainable disposal options each lead to a positive WTP. The relative coefficients in Table 4.3 indicate that recycled plastic is preferred to virgin plastic, and compostable or recyclable packaging is preferred to packaging that can go only in general waste (Figure 4.4). An observation is that the Irish consumer gains more utility from sustainable disposal options than from the selection of material from which the packaging is made. The coefficients reflect current preferences. It can be inferred that consumers have greater understanding of the concept of recycling than of the benefits of a product being made of recycled plastic. This preference could change now that producers are actively advertising packaging that is made of recycled plastic, although it could be the case that consumers are wary of buying products made of recycled plastic for fear that they are contaminated. Indeed, current food standards require guarantees of purity and do not permit meat to be sold in recycled plastic. People also prefer recyclable to compostable packaging, but only by less than one percentage point. In both of these cases, there is likely to be an influence of awareness, for example greater awareness of recyclability than of recyclates, and perhaps a lower awareness of the practical limits to compostability once these materials are combined with recyclable products in the waste stream, as is currently the case when compostable

Table 4.3. Discrete choice experiment results

Coefficient	Value	Error	Prob. Z	|z|>Z*	95% interval negative	95% interval positive
ALT3	4.819***	0.214	22.530	0.000	4.400	5.238
Recycled plastic	0.145***	0.022	6.680	0.000	0.102	0.187
Compostable	0.301***	0.032	9.410	0.000	0.238	0.364
Recyclable	0.362***	0.032	11.170	0.000	0.299	0.426
Price all levels	–0.083***	0.004	–21.17	0.000	–0.090	–0.075

Log-likelihood function = –3527; *N* = 3592.

***Highly significant at 1%.**

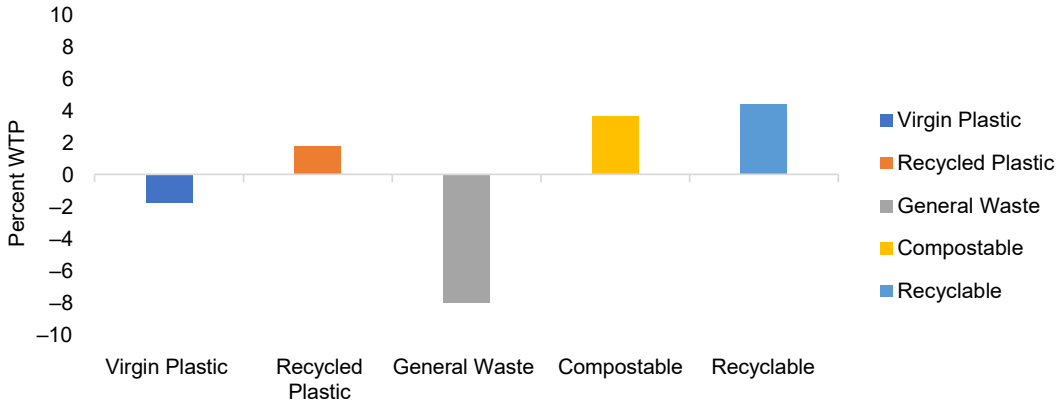

Figure 4.4. Consumers' willingness to pay for different properties of packaging.

material is disposed of in the green bin along with non-compostables.

If *price* is treated as a categorical variable using the individual percentage levels, then there is a predictable declining trend in values for the sustainable attributes when these are associated with higher prices, but especially for a 20% higher price among all population subsets. This is a threshold above which the choice experiment indicated that most people are not inclined to pay for greater sustainability.

The alternative product options were examined for any significant differences in consumer behaviour. A difference was observed in attitudes towards packaging for the yoghurt choices in that coefficient values were higher for use of recycled plastic (0.170), compostability (0.310) and recyclability (0.398) than the equivalent levels for the meat/vegetarian burger choices (0.120, 0.294, 0.325), especially in preference for recycled plastic over virgin plastic and preference for recyclability over compostability. All values were significant at 5%.

In terms of population subsets, vegetarians accounted for 7.8% of respondents. The coefficient values for vegetarians revealed the same pattern as for meat eaters, although with all attributes the sustainable levels were valued slightly more for recycled packaging (0.215), compostables (0.360) and recyclability (0.518) (compared with 0.111, 0.290, 0.309). All values were again significant at 5%. These higher values could relate to more sustainable choices by vegetarians given that one motivation for vegetarianism may be a preference for food that is more environmentally sustainable. However, it could also reflect non-represented factors such as income if vegetarians were assumed to have higher incomes (a question on income was not included). *Age* demonstrated no significant difference but for a possibly lower interest in sustainable attributes among older subsets. *Education* too revealed no significant difference but perhaps for higher values placed on recyclable plastic by subsets with progressively higher education levels, with graduates recording 0.401 and those with junior certificates 0.185. Families recorded a higher value on recyclability, but this was not explained by housing context as house occupiers valued compostability and recyclability only slightly higher than apartment dwellers, but at relative values for each level that were similar to those of the entire sample.

4.3 Waste-sorting Habits

Respondents' waste-sorting habits are listed in Table 4.4, which shows that 13.4% of consumers

Table 4.4. Results of consumers' waste-sorting habits in percentages

Activities	Have no facilities	1: Never	2: Rarely	3: Usually	4: Always
Sort recyclable packaging from other waste	3.2%	2.2%	10.8%	28.2%	55.6%
Put compostable packaging in the compostable or brown bin	13.4%	4.2%	13.4%	27.6%	41.4%
Put fruit/veg aside for home composting	13.4%	16%	15.4%	22.2%	33.0%
Wash packaging before putting in the recycling bin	2.2%	6.8%	14.2%	34%	42.8%

do not have either a brown bin or home composting and so compostable options were not available to this group. Although high proportions of respondents usually or always use the brown bin, generally home composting of fruit and vegetables is less prevalent than other sorting options, being more likely for those with garden space. “Sorting recyclable packaging from other waste” is habitual for a slight majority of respondents and is undertaken usually or always by 83.8%. A small number of respondents, 3.2%, claim to have no access to recycling facilities, and 2.2% said they do not have a recycling bin.

Respondents were also asked if they use a single-purpose bin for all waste. A majority (61.8%) said that they never use a single-purpose bin. However, a significant percentage of consumers, 22.8%, admitted to using a single-purpose bin for waste either usually or always. Apartment dwellers are less likely to have convenient options in this respect and possibly no brown bin at present (although this is due to change with new proposals). People were also asked about the materials they put in their recycling bin (see Figure 4.5). This revealed large variation in behaviour, with levels from 34.2% to 86.4%. The two materials most people put in the recycling bin were cardboard and paper, at 86.4% and 85.6% respectively. Nearly 60% recycle rigid plastic, and large proportions also recycle soft plastics and aluminium foil even though the option to recycle these officially became available only in September 2021, before the survey was undertaken.

4.4 Label Experiment

Another objective of the survey was to find out people’s familiarity with and knowledge about packaging waste disposal labels, some examples of which are shown in Figure 4.6. There was a huge variation in responses to these questions, as revealed in Figure 4.7.

On average, respondents got 47% of the labels correct. Only 13% of respondents properly understood the Mobius loop label, while the label that was most often understood was the OPRL (on-pack recycling

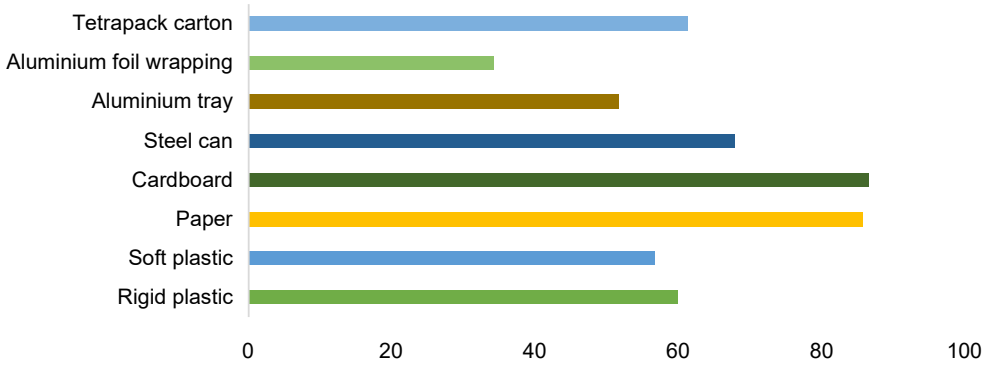

Figure 4.5. Materials consumers put in their recycling bin.

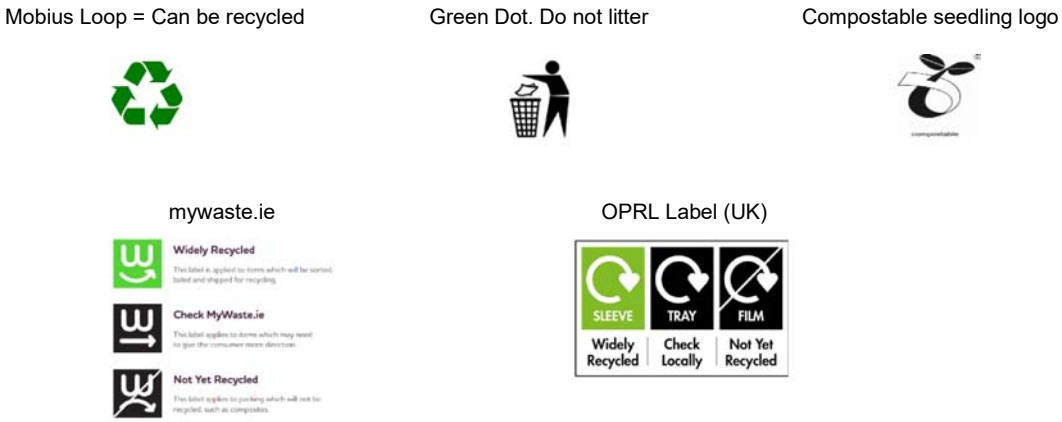

Figure 4.6. Some examples of sustainability logos.

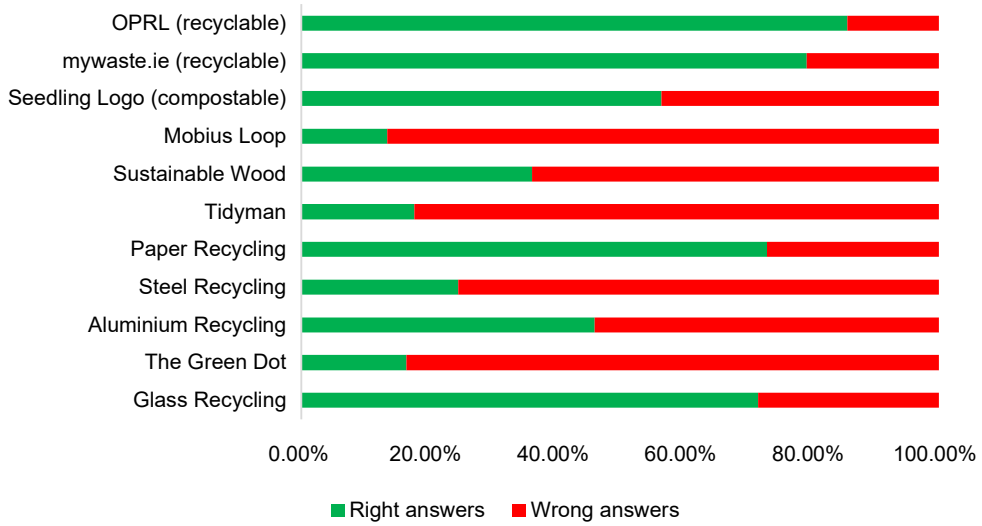

Figure 4.7. Proportion of consumers placing packaging in bins in accordance with the packaging label.

label) (86%). The mywaste.ie label was correctly described by 79% of respondents.

4.5 Attitudes to Future Strategies for Sustainable Packaging

The last part of the consumer survey concerned attitudes towards future packaging policy implementations that could affect consumers. The first question asked about measures to implement reusable packaging. Overall, the response to such measures was not very positive, with the most popular being “return the packaging to the supermarket to get deposit back”, at 55%, followed by an “extra bin for reusable packaging”, at 43%, and finally “pay a deposit for the packaging”, at just 18%.

The final question asked about bioplastics, in response to which 43.4% of consumers stated that these were either “very important” or “extremely important” for resolving the situation with packaging waste, a result which is somewhat at odds with the ability of recycling infrastructure to accept this packaging and EU policy on the current constituents of much biodegradable packaging.

4.6 Comparisons with Previous and International Findings

The consumer is the last person in the plastic consumption lifespan, while also being the first person in the packaging waste lifespan (Clapp, 2002). In our survey, 42.2%, 29.4% and 13.2% of respondents, respectively, said that they sometimes, usually or always avoid buying products which have a lot of packaging, with the average value being 3.1 (sometimes). By comparison, a survey for *Which?* in the UK reported that 54% of people tried to avoid overpackaged products, and 23% said that excess packaging was a reason to avoid buying a product (*Which?*, 2011). It is less clear whether these results indicate a desire to practise sustainability or to avoid the inconvenience or extra cost of disposing of a lot of packaging. The EPA-funded VOICE project found wide use of SUPs such as drinks bottles, crisp and biscuit packets and clingfilm in school lunch boxes (O’Callaghan-Platt and O’Brien, 2021), for which individually packaged portions are often marketed by companies.

The survey was focused on food packaging. The relatively low cost of food means that producers have limited options when upgrading from the cheapest forms of packaging and that consumers have been assumed to be disinclined to spend much more on packaging or to avoid packaging altogether. In Ireland, only 9.6% of income is spent on food (Gustavsson *et al*., 2011). However, the survey results do indicate that consumers are prepared to pay 5% or 10% more for products that have sustainable packaging. Although this willingness falls away rapidly once the premium reaches 20%, the 5% and 10% bounds do appear to allow producers more options than some companies in the producer survey had presumed.

The results for labelling are not restricted to Ireland but have also been observed internationally. Numerous

researchers have argued that consumers have difficulty understanding eco-labels (Thorgersen, 2005; Ketelsen *et al*., 2020), which could be exacerbated by a lack of awareness of the meaning of these labels or the consequences of packaging waste (Ballard, 2005; Thorgersen, 2005; Kumar *et al*., 2012). This is not helped by the variety of eco-friendly behaviour presented in labelling itself, which includes advice on avoiding littering, recycling, using biodegradable packaging or purchasing goods from companies that have contributed to sustainable waste schemes. The last of these groups could be argued to be any company that has joined Repak. If there is weak understanding of waste management, as assumed by producers in the survey, and if poor labelling does not help matters, then there is limited opportunity for consumers to use their purchasing power. As discussed earlier in this report, food packaging can be used to promote a sense of quality associated with freshness (Barber *et al*., 2014). It may also confer a perception of easy handling and convenience (Cochoy and Grandclement-Chaffy, 2005; Lindh *et al*., 2012). These perceptions can, of course, be at variance with a product's sustainability. Rhein and Schmid (2020) report that 70% of consumers are not influenced by eco-labelling on products. It has been argued that, in any case, consumers are inattentive to eco-labels when they are actually engaged in shopping (Andors and Fels, 2018), compared with when asked about these in surveys, although there is limited literature on the extent to which this is true, and evidence is anecdotal. For example, in the UK, an experiment by the Waitrose and Partners supermarket chain to encourage shoppers to purchase loose fruit and vegetables and packaging-free products failed even though these goods were cheaper than the packaged alternatives (Kumamaneni *et al*., 2019).

There is no guarantee that knowledge equates to changes in behaviour (Clapp, 2002) or even that opinions will change behaviour (Zsoka *et al*., 2013). According to the behavioural theory put forward by Stern *et al*. (1999), willingness to change behaviour, including towards the environment, is promoted by a conjunction between values, beliefs and norms that cause people to adopt social norms that are not necessarily tied to self-interest. This, the authors argue, depends on an acceptance of the consequences (in this case of the environmental impacts of plastic use) and a belief that individual actions can make a difference in promoting these same values.

However, while awareness of recycling may have reached a certain threshold, it is not clear whether people feel sufficient peer pressure to proactively avoid unsustainably packaged goods in practice. Changes in behaviour involve a personal investment in understanding packaging and its environmental impact. Each individual will have personal barriers to increasing their understanding when packaging guidance must compete with other advice on fair trade, nutrition, animal welfare and climate change. Barriers include time, money, knowledge, attention span and (often overlooked) the ability to read small lettering (Thorgersen, 2005). Consumers will not automatically respond to eco-labels even if they choose to look at them. There has to be a level of commitment and/or social pressure before people will contemplate change, particularly if this means replacing a habitually selected good with another. In this respect, campaigns such as Repak's Team Green (https://repak.ie/team-green/public) can begin to make a difference by identifying influencers and champions for recycling to encourage an overall societal change towards sustainability and recycling.

5 Conclusions

5.1 Consumers

Consumers have an impact on the characterisation and recyclability of packaging waste through their purchasing choices and waste-sorting behaviour. The poor level of recyclable waste sorting by Irish households has been widely cited (O'Doherty, 2018). In the absence of direct incentives, there will always be a proportion of consumers who are not inclined to spend much time sorting their waste, be this through habit, a lack of facilities or the absence of a recycling or compost bin. Indeed, the consumer survey found that only 55.6% of respondents always sort recyclable packaging waste from other waste, and just 41% always put compostable waste in the correct bin. The situation is not improved by low public awareness of what is recyclable. The survey showed a low level of comprehension of sustainability labels on products, a position not helped by the voluntary nature of labelling by producers and an absence of awareness campaigns. In addition, the survey found that 21% of consumers rarely or never wash the packaging that they place in the recycling bin, an observation reflected in waste characterisation surveys, which have found high levels of contamination by food residues that renders much packaging unrecyclable, even if the raw materials themselves could be recycled. Given the increasingly stringent controls being introduced by third countries on plastic waste imports for recycling, much of this material is instead being directed to energy recovery in Ireland.

In the survey, consumers reported that they are discriminatory in their choice of products. However, only 13.2% "always" avoid products which have a lot of packaging, while 12.4% "always" avoid buying products in packaging that might be difficult to recycle. At 53.8%, a high proportion of consumers "usually" or "always" seek to reuse packaging for other purposes, or reuse their plastic bags (86.8%), although this latter habit is incentivised through the plastic bag levy. It is, therefore, fair to observe that reasonably high proportions of consumers "usually" or "sometimes" avoid buying excess packaging, avoid non-recyclable packaging, reuse packaging or buy loose fruit or vegetables, as these habits are not encouraged by financial incentives or social pressures, and shopping decisions must focus on a limited range of competing products, are subject to heuristics and are made easily and rapidly. Respondents to the producer survey were less convinced, arguing that they do not believe that consumers are strongly motivated by sustainability relative to other product characteristics and that much of the incentive to improve the sustainability of packaging appears to come from major retailers that wish to promote a sustainable image which, in practice, is realised at corporate level more than through individual products.

The discrete choice experiment found that consumers have reasonable awareness of food packaging issues and a willingness to purchase recyclable and compostable packaging as long as the price premium is modest. It also found that recyclability is preferred to, or is more familiar than, compostability. The preference (or awareness) of the use of recycled plastics in packaging is positive but relatively low. This is perhaps not too surprising given that producers, such as those of soft drinks, cosmetics or detergents, have only recently begun to actively advertise the use of recycled materials in their packaging. Therefore, there is further potential to influence consumers' purchasing decision-making and sorting of waste, given that some progress has already been made in terms of awareness of the merits of recycling and a willingness to do the right thing, including acceptance of a small increase in price.

5.2 Producers

Producers seem to be conscious of the need to make their packaging more sustainable. A high proportion (61.5%) use packaging that is partially recyclable, and nearly one-quarter more use packaging that is fully recyclable. In the last 5 years, around 60% of producers have moved to make their packaging more recyclable, and a further 16.7% have made their packaging fully recyclable. In the next 5 years, over one-fifth of producers will aim to reduce their packaging, while just under one-fifth plan to use only fully recyclable packaging and others propose using recycled materials. Twelve per cent propose

reducing the range of plastic polymers they use. There are opportunities here, as the larger proportion of producers that use plastics use higher-value or highly recyclable polymers such as PET, PP and HDPE, while 17% use lower-value polymers and 11% use mixes of plastic and aluminium foil.

However, the limited opportunities for producers to use recycled plastics in food packaging (i.e. food-contact material) is a constraint that directs recyclable plastics towards drinks or non-food uses rather than for meat or dairy products. Producers said that consumer behaviour has a slight to moderate influence on their packaging decisions, but that the greater influence comes from retailers and the packaging solution companies that design the packaging. Retailers have a shared interest in ensuring good product sales, and so their influence is not only in the direction of sustainability. Likewise, packaging solution companies, while conscious of stakeholder concerns about sustainability, have an interest in designing practical yet unique and marketable packaging for their clients. Therefore, the operations and marketing divisions of companies have strong, if sometimes conflicting, views on packaging design. The operations divisions are keen to ensure low cost and protection of the product, with minimal risk from investing in the production of products that could fail to sell well because of unappealing packaging.

To date, the influence of government on producers would appear to be muted. Producers acknowledge that policy is changing in the direction of a circular economy but say that sales and retailer acceptability remain the current priority. At European Commission level, circular economy guidance has been agreed, including guidance on stricter limitations on SUPs, recyclability and composite materials, EPR and eco-modulation of packaging fees. However, anticipation of change has not been sufficient to have had a pressing influence on producer motivations but rather is seen as something to work towards on a more strategic timescale.

Producers say that barriers to the introduction of more recyclable materials, or uptake of recyclates, are unit cost, supply constraints, existing machinery, performance (protection of the product) and uncertainty (in that order). More strategic barriers include an absence of sufficiently clear guidance, a lack of recycling facilities, difficulty of incorporating recycled materials, insufficient support or incentives and a lack of consumer interest or awareness. This contradicts arguments by Repak that relevant information is provided. The findings from the survey indicate that producers are looking for specific guidance for their operations and resent paying producer responsibility fees. The current fee structure, although higher for plastic, has shortcomings in that it does not penalise plastic packaging sufficiently given its relative lightness. It is likely, however, that fees will rise over time, as required by the Packaging and Packaging Waste Directive and the Single Use Plastics Directive, and that eco-modulation of fees will soon account for recyclability and the overall environmental impact of packaging.

Furthermore, although producers complained about a lack of recycling facilities for certain materials, this has been partly mitigated by the recent decision to permit soft plastics and aluminium foil to be placed in recycling bins. Although it is somewhat unclear just how widely recyclable these materials currently are, it was apparent from the consumer survey that many people had assumed that this packaging was recyclable already. Furthermore, while producers expressed a wish for waste processors to provide a better recycling service, there would appear to have been little engagement between producers and the waste processing sector, as argued by the processors themselves in interviews undertaken as part of the project prior to the survey.

5.3 Packaging Statistics

The benefit from government and Repak actions to encourage greater levels of recycling and packaging recyclability could be undermined by statistics which appear to show that Ireland has a higher level of packaging and plastic packaging waste than other EU Member States. Accurate packaging statistics are essential for estimating the level of recycling and for designing and adopting appropriate policies, levies and incentives; however, these results are due to conflicting methods of estimating packaging waste. Most European states rely exclusively on the placed on the market method to estimate packaging generation. By comparison, Ireland uses the waste analysis method, which involves more direct estimation of packaging waste generation. Although there are limitations in the frequency and statistical accuracy of

waste characterisation surveys that are undertaken as part of WA, it does seem that much of the problem relates to the PoM method, which has a tendency to underestimate packaging waste. Many Member States using this method fail to provide estimates that account for known gaps in coverage due to, for example, free riders or *de minimis* thresholds.

In truth, Eurostat is aware of these issues and in 2020 undertook a peer review of statistical collection and analysis. Eurostat has recently responded by requiring more detailed "quality reports" on the application of methods by Member States and by publishing new guidelines on producer responsibility and reporting by smaller companies. However, the increasing volume of online sales by multinational companies compounds the problem. Neither has it been possible to retrospectively adjust recently published figures and ranking of performance by Member States to account for evident shortcomings in the methods applied.

5.4 Summary

It seems that issues of reporting have been affected by a governance approach that has only gradually coaxed EU Member States towards more sustainable solutions for packaging, beginning with the setting of ambitious targets but only later backing this up with firm implementation measures. Sustainability improvements in packaging design and the eco-modulation of packaging producers' fees are urgently needed, but these do not appear to be a priority for producers surveyed by the ReWrapped project. Improvements have been achieved, but it is rather frustrating that at the same time producers have moved towards the use of more complex packaging types, including mixed polymers and materials, that have low recyclability. Consumer awareness of packaging issues could also be better, and behavioural or economic incentives for adherence to waste management could be implemented. Meanwhile, the level of recycling, particularly of plastics, has stalled, with more material being directed to the inferior options of energy recovery through incineration. Litter remains a scourge in urban spaces and at rural roadsides, and marine litter, together with its ecological implications, continues to be a major global environment issue.

5.5 Recommendations

- Use a hybrid model to check waste statistics by applying a PoM method in line with Eurostat guidelines while continuing to use WA. This would provide important information for implementing policy through waste characterisation surveys and also evidence of the extent to which households and businesses sort materials. All Member States need to be encouraged to use a hybrid model for checking data.
- Improve public awareness and design of sustainability labelling to communicate the degree of recyclability or compostability of products, including, if possible, making the My-Waste logo mandatory on products produced in Ireland or imported from third countries (now including the UK).
- Reinvigorate efforts to raise public awareness of the benefits of recycling, composting and the proper sorting of household waste.
- Raise public awareness of the societal and environmental benefits of recycling and the use of recycled materials in new products. Investigate the role of social norms and behavioural nudging to encourage people to select more recyclable options.
- Improve guidance for producers and provide more targeted information from Repak or government on how to produce more recyclable products.
- Advance legislation to improve sustainability and recyclability in product packaging design.
- Advance legislation to extend producer responsibility to cover the environmental costs of packaging waste.
- Government, EPA or Repak should provide for more communication between stakeholders via such fora as webinars, conferences and roundtable workshops for policy-makers, packaging solution companies, producers, retailers and the waste processing sector.
- Investigate the role of third-level education and the availability of courses aimed at future packaging designers, producers, retailers and other key stakeholders.

References

ACC and Trucost, 2016. *Plastics and Sustainability: A Valuation of Environmental Benefits, Costs and Opportunities for Continuous Improvement*. American Chemistry Council.

Andors, M.A. and Fels, K.M., 2018. Behavioral economics and energy conservation – a systematic review of non-price interventions and their causal effects. *Ecological Economics* 148: 178–210.

Ballard, D., 2005. Using learning processes to promote change for sustainable development. *Action Research* 3: 135–156.

Barber, N.A., Bishop, M. and Gruen, T., 2014. Who pays more (or less) for pro-environmental consumer goods? Using the auction method to assess actual willingness-to-pay. *Journal of Environmental Psychology* 40: 218–227.

Bonini, S. and Swartz, S., 2014. *Bringing Discipline to Your Sustainability Initiatives*. Available online: https://www.mckinsey.com/business-functions/sustainability/our-insights/bringing-discipline-to-your-sustainability-initiatives.

Brunner, P.H. and Ernst, W.R., 1986. Alternative methods for the analysis of municipal solid waste. *Waste Management Research* 4: 147–160.

Brunner, P.H. and Rechberger, H., 2016. *Practical Handbook on Material Flow Analysis*. CRC Press, Boca Raton, FL.

Christiaens, P., 2015. *Analysis of Eurostat Packaging Recycling Data – A Study of the Years 2006–2012*. Extended Producer Responsibility Alliance (EXPRA), Brussels.

Cimpan, C., Lekve Bjelle, E. and Hammer Strømman, A., 2021. Plastic packaging flows in Europe: a hybrid input–output approach. *Journal of Industrial Ecology* 25: 1572–1587.

Clapp, J., 2002. The distancing of waste: overconsumption in a global economy. In Princen, T., Maniates, M. and Conca, K. (eds), *Confronting Consumption*. MIT Press, Cambridge, MA.

Cochoy, F. and Grandclement-Chaffy, C., 2005. Publicising Goldilocks' choice at the supermarket: the political work of shopping packs, carts and talk. In Latour, B. and Weibel, P. (eds), *Making Things Public: Atmospheres of Democracy*. ZKM and MIT Press, Cambridge, MA.

CTC (Clean Technology Centre), 2018. *Contamination Assessment of Waste Packaging Materials in Municipal Waste Streams*. CTC, Cork Institute of Technology, with assistance from RPS. Cork, Ireland.

Dahlen, L. and Lagerkvist, A., 2008. Methods for household waste composition studies. *Waste Management* 36: 12–23.

DECC (Department of the Environment, Climate and Communications), 2020. *Waste Action Plan for a Circular Economy*. Dublin.

DECC (Department of the Environment, Climate and Communications), 2021. *Whole of Government Circular Economy Strategy 2022–2023: Living More, Using Less*. Dublin.

EC (European Commission), 2004. *Methodology for the Analysis of Solid Waste (SWA tool).* 5th Framework Programme. European Commission, Vienna.

EC (European Commission), 2014. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Towards a circular economy: A zero waste programme for Europe". COM(2014) 398 final, 2.7.2014, Brussels.

EC (European Commission), 2018. *A European Strategy for Plastic Waste in a Circular Economy*. European Commission, Brussels.

EC (European Commission), 2019. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions "The European Green Deal". COM(2019) 640 final, 11.12.2019, Brussels.

EC (European Commission), 2020a. *Circular Economy Action Plan: For a Cleaner and More Competitive Europe*. European Commission, Brussels. Available online: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf (accessed 9 September 2022).

EC (European Commission), 2020b. *Effectiveness of the Essential Requirements for Packaging and Packaging Waste and Proposals for Reinforcement*. Prepared by Eunomia, COWI, ADELPHI, ECOFYS (NAVIGANT) and MILIEU. European Commission Directorate-General for Environment, Brussels.

Edjabou, M. E., Jensen, M. B., Götze, R., Pivnenko, K., Petersen, C., Scheutz, C. and Astrup, T. F., 2015. Municipal solid waste composition: sampling methodology, statistical analyses, and case study evaluation. *Waste Management* 36: 12–23.

EPA (Environmental Protection Agency), 2021. *Packaging Waste in Ireland in 2019*. EPA, Johnstown Castle, Ireland.

EU (European Union), 1994. European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste. OJ L 365, 31.12.1994, p. 10–23.

EU (European Union), 2004. Regulation (EC) No 1935/2004 of the European Parliament and the Council 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC. OJ L 338, 13.11.2004, p. 4–17.

EU (European Union), 2005. Commission Decision of 22 March 2005 establishing the formats relating to the database system pursuant to Directive 94/62/EC of the European Parliament and of the Council on packaging and packaging waste. OJ L 86, 5.4.2005, p. 6–12.

EU (European Union), 2008. Directive 2008/88/EC of the European Parliament and the Council of 19 November 2008 on waste and repealing certain directives. OJ L 312, 22.11.2008, p. 3–30.

EU (European Union), 2018. Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste. OJ L 150, 14.6.2018, p. 141–154.

EU (European Union), 2019. Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. OJ L 155, 12.6.2019, p. 1–19.

EU (European Union), 2021. Council Regulation (EU, Euratom) 2021/770 of 30 April 2021 on the calculation of the own resource based on plastic packaging waste that is not recycled, on the methods and procedure for making available that own resource, on the measures to meet cash requirements, and on certain aspects of the own resource based on gross national income. OJ L 165, 11.5.2021, p. 15–24.

Eunomia, 2018. *Plastic Packaging: Shedding Light on the UK Data*. Bristol, UK.

Eurostat, 2021. Municipal waste statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics (accessed 22 November 2022).

Eurostat, 2022a. Packaging waste statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php/Packaging_waste_statistics#Waste_generation_by_packaging_material (accessed March 2022).

Eurostat, 2022b. *Guidance for the Compilation and Reporting of Data on Packaging and Packaging Waste According to Decision 2005/270/EC*. European Commission. Available online: https://ec.europa.eu/eurostat/documents/342366/351811/PPW+-+Guidance+for+the+compilation+and+reporting+of+data+on+packaging+and+packaging+waste.pdf/297d0cda-e5ff-41e5-855b-5d0abe425673?t=1621978014507 (accessed 15 September 2022).

Gali, F. and Brunori, G., 2013. *Short Food Supply Chains as Drivers of Unsustainable Development: Evidence Document*. Foodlinks, Brussels.

Garcia-Arca, J., Gonzalez-Portela Garrido, A. T. and Prado-Prado, J. C., 2017. "Sustainable Packaging Logistics". The link between sustainability and competitiveness in supply chains. *Sustainability* 9: 1098.

Geijer, T., 2019. *Plastic Packaging in the Food Sector*. Economics Department, ING Bank, Netherlands. https://think.ing.com/uploads/reports/ING_-_The_plastic_puzzle_-_December_2019_(003).pdf

Geyer, R., Jambeck, J. R. and Law, K. L. S. A., 2017. Production, use, and fate of all plastics ever made. *Scientific Advances* 3: e1700782.

Gustavsson, J., Cederberg, C, Sonesson, U., van Otterdijk, R. and Meybeck, A., 2011. *Global Food Losses and Food Waste - Extent, Causes and Prevention*. Study conducted by Swedish Institute for Food and Biotechnology (SIK),Gothernburg and FAO for the International Congress "Save Food" at Interpack2011, Dusseldorf, Germany. Food and Agricultural Organization of the United Nations (FAO), Rome.

Horowitz, J., Keane, M., Bolduc, D., *et al*., 1994. Advances in random utility models: report of the Workshop on Advances in Random Utility Models – Duke Invitational Symposium on Choice Modeling Behavior. *Marketing Letters* 5(4): 311–322.

IEEP (Institute for European Environmental Policy), 2017. *EPR in the EU Plastics Strategy and the Circular Economy: A Focus on Plastic Packaging*. Institute for European Environmental Policy.

Ketelsen, M., Janssen, M. and Hamm, U., 2020. Consumers' response to environmentally-friendly food packaging – a systematic review. *Journal of Cleaner Production* 254: 120–123.

Kumamaneni, S., Jassi, S. and Hoang, D., 2019. Promoting reuse behaviour: challenges and strategies for repeat purchase, low-involvement products. *Sustainable Production and Consumption* 20: 253–272.

Kumar, S., Garg, R. and Makkar, A., 2012. Consumer awareness and perception towards green products: a study of youngsters in India. *International Journal of Marketing and Business Communications* 1: 35.

Leal Filho, W., Saari, U., Fedoruk, M., Iital, A., Moora, H., Klöga, M. and Voronova, V., 2019. An overview of the problems posed by plastic products and the role of extended producer responsibility in Europe. *Journal of Cleaner Production* 214: 550–558.

Lindh, H., Olsson, A. and Williams, H., 2012. *Consumer Perceptions of Sustainable Packaging – Limited by Lack of Knowledge?* Nordic Retail and Wholesale Conference, 7–8 November, University of Lund, Sweden.

Marsh, K. and Bugusu, B., 2007. Food packaging – roles, materials and environmental issues. *Journal of Food Science* 72(3): R39–R55.

Matthews, C., Moran, F. and Jaiswal, A. K., 2021. A review on European Union's strategy for plastics in a circular economy and its impact on food safety. *Journal of Cleaner Production* 283: 125263.

McKinlay, R. and Morrish, L., 2016. *REFLEX Project – A Summary Report on the Results and Findings from the REFLEX Project.* Axion Consulting, Stockport, UK.

Muncke, J., 2009. Exposure to endocrine disrupting compounds via the food chain: is packaging a relevant source? *Science of the Total Environment* 407: 4549–4559.

Nielsen, T. D., Hasselbalch, J., Holmberg, K. and Stripple, J., 2019. Politics and the plastic crisis: a review throughout the plastic life cycle. *Wiley Interdisciplinary Reviews: Energy and Environment*.

Nordtest, 1995. *Solid Waste, Municipal: Sampling and Characterisation.* NT ENVIR 001. Available online: http://www.nordtest.info/wp/1995/05/14/solid-waste-municipal-sampling-and-characterisation-nt-envir-001/ (accessed 26 August 2022).

O'Callaghan-Platt, A. and O'Brien, M., 2021. *No Home for Plastic*. Environmental Protection Agency, Johnstown Castle, Ireland.

Ocean Conservancy, 2015. *The Problem with Plastics*. Available online: https://oceanconservancy.org/trash-free-seas/plastics-in-the-ocean/ (accessed 15 December 2021).

O'Doherty, C., 2018. Failure of Irish households to recycle properly is a massive waste of time. *Irish Examiner*, 26 February 2018.

OECD (Organisation for Economic Co-operation and Development), 2014. *The State of Play on Extended Producer Responsibility (EPR): Opportunities and Challenges*. Available online: https://www.oecd.org/environment/waste/Global%20Forum%20Tokyo%20Issues%20Paper%2030-5-2014.pdf (accessed 15 September 2022).

OECD (Organisation for Economic Co-operation and Development), 2018. *Extended Producer Responsibility and the Impact on Online Sales.* Re-Circle Resource Efficiency and Circular Economy Project. Paris, France. Available online: https://www.oecd.org/environment/waste/policy-highlights-extended-producer-responsibility-and-the-impact-of-online-sales.pdf (accessed 8 September 2022).

Plastics Europe, 2021. *Plastics – The Facts 2021: An Analysis of European Plastics Production, Demand and Waste Data*. Available online: https://plasticseurope.org/wp-content/uploads/2021/12/Plastics-the-Facts-2021-web-final.pdf (accessed 22 November 2022).

Repak, 2018. *Plastic Packaging Recycling Strategy 2018–2030*. Repak, Dublin, Ireland.

Repak, 2019. *Repak Members' Plastic Pledge Report 2019*. Repak, Dublin, Ireland.

Repak, 2021. *Packaging and Design for the Circular Economy. Challenges and Opportunities in Irish Packaging Recycling*. Repak, Dublin, Ireland. Updated 2022. Available online: https://repak.ie/images/uploads/reports/Packaging___Design_Guide_Version_3_June_2022.pdf (accessed 8 September 2022).

Rhein, S. and Schmidt, M., 2020. Consumers' awareness of plastic packaging: more than just environmental concerns. *Resources, Conservation and Recycling* 162: 105063.

Robaina, M., Murillo, K., Rocha, E. and Villar, J., 2020. Circular economy in plastic waste – efficiency analysis of European countries. *Science of the Total Environment* 730: 139038.

Robertson, G. L., 2012. *Food Packaging Principles and Practice*. CRC Press, Taylor & Francis Group, Boca Raton, FL.

Sahimaa, O., Hupponen, M., Horttanainen, M. and Sorvari, J., 2015. Method for residual household waste composition studies. *Waste Management* 46: 3–14.

Schweitzer, J.-P., Gionfra, S., Pantzar, M., Mottershead, D., Watkins, E., Petsinaris, F., ten Brink, P., Ptak, E., Lacey, C. and Janssens, C., 2018. *Unwrapped: How Throwaway Plastic is Failing to Solve Europe's Food Waste Problem (and What We Need to Do Instead).* A study by Zero Waste Europe and Friends of the Earth Europe for the Rethink Plastic Alliance. Institute for European Environmental Policy (IEEP), Brussels.

Statista, 2022. Market share of grocery stores in Ireland for the 12 weeks ending January 23, 2022. Available online: https://www.statista.com/statistics/534106/grocery-market-share-ireland/ (accessed 9 September 2022).

Stern, P. C., Dietz, T., Abel, T. D., Guagnano, G. and Kalof, L., 1999. A value-belief-norm theory of support for social movements: the case of environmentalism. *Human Ecology Review* 6: 81–97.

SumOfUs, 2016. *Cutting the Crap: The Benefits of Implementing Resource Efficiency in German Supermarkets*. Wuppertal Institute for Climate, Environment and Energy, Germany.

Thorgersen, J., 2005. How may consumer policy empower consumers for sustainable lifestyles? *Journal of Consumer Policy* 28: 143–177.

TMR (Transparency Market Research), 2018. *Packaging Market – Europe Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2018–2026*. Available online: https://www.transparencymarketresearch.com/europe-plastic-packaging-market.html (accessed 8 September 2022).

Which?, 2011. *Which?* unwraps packaging in supermarkets. *Which*?, London.

WRAP, 2015. *Material Facility Reporting Portal: Q3 2015 – Commentary*. Available online: www.wrap.org.uk.

Yu, C. C. and Maclaren, V., 1995. A comparison of two waste stream quantification and characterization methodologies. *Waste Management Research* 13: 343–361.

Zero Waste Europe, 2015. *Redesigning Producer Responsibility: A New EPR is Needed for a Circular Economy*. Available online: https://zerowasteeurope.eu/library/redesigning-producer-responsibility-a-new-epr-is-needed-for-a-circular-economy/ (accessed 26 August 2022).

Zero Waste Scotland, 2015. *Guidance on the Methodology for Waste Composition Analysis for Local Authorities Commissioning Waste Composition Analysis of Municipal Waste*. Available online: https://www.zerowastescotland.org.uk/sites/default/files/WCAMethodology_Jun15.pdf (accessed 26 August 2022).

Zsoka, A., Szerenyi, Z. M., Szechy, A. and Koesis, T., 2013. Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production* 48: 126–138.

Abbreviations

CEAP	Circular Economy Action Plan
DCE	Discrete choice experiment
DRS	Deposit-and-return scheme
EPR	Extended producer responsibility
EU	European Union
HDPE	High-density polyethylene
MSW	Municipal solid waste
PET	Polyethylene terephthalate
PoM	Placed-on-the-market
PP	Polypropylene
PRO	Producer responsibility organisation
SUP	Single-use plastic
WA	Waste analysis
WFD	Waste Framework Directive
WTP	Willingness to pay

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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