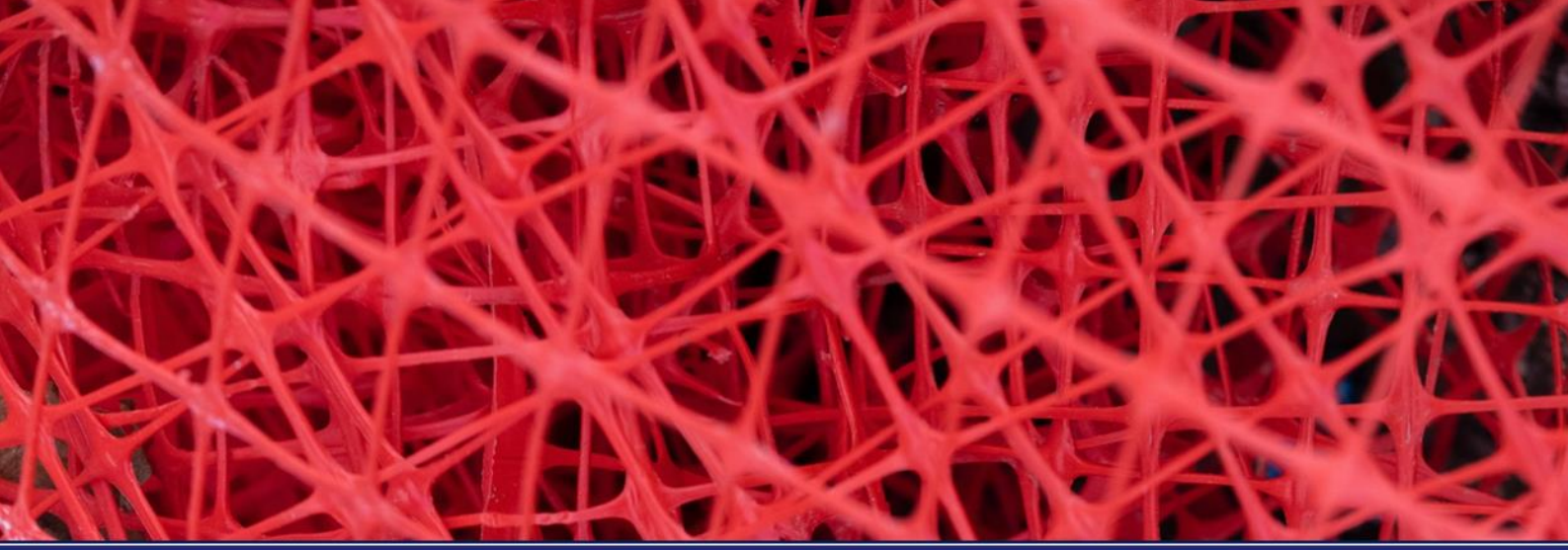

Plastics Circularity Index 2020

The EU Edition

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Plastics Circularity Index (PCI) 2020 - The EU Edition - is prepared by the authors in the scope of Policy in Emerging Markets co-training of Economics and Strategy in Emerging Markets programme, School of Business and Economics, Maastricht University and UNU-MERIT. The index addresses how EU countries perform relative to each other in their circular management of plastics and related waste products. A circular economy, encompassing plastics, is complex and entails several decisions and actions of actors. PCI analyses activities undertaken by governments, businesses and consumers that stimulate the circular usage of plastics. The PCI EU Edition covers each stakeholder category with a collection of indicators to gain an initial view of the state of plastics circularity in EU countries. In addition to 21 indicators in total from each actor category, the index also considers country profiles on plastics and circularity. Data and online map is available from the Lab of UNU-MERIT.

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TABLE OF CONTENTS

Introduction

In 2015, the European Union ("EU") initiated the Circular Economy Action Plan, which aimed to foster sustainable development through the recovery and reuse of waste in all member states. The main benefits of the circular economy ("CE") are twofold. Firstly, an economy that minimizes waste and maximizes values of existing waste will be more competitive on a global stage (Stahel, 2012). Secondly, a reduction in resource extraction inherent in a functioning CE provides environmental benefits to all members of European society and abroad. Meeting these goals has spillover benefits into technological development, employment rates, and other critical economic metrics (Stahel, 2012). In addressing the entire lifecycle of waste streams from design to reuse, the current EU approach to attaining a circular economy is comprehensive. Meanwhile, as the CE allows for differentiation between member states in how goals are met, it is a versatile framework capable for sustainable development in Europe.

Besides the waste streams of paper, metals, and glass that are measured under the CE goals, plastic waste is by far one of the more infamous challenges to our local ecosystems and global environment. There now appears to be plastic waste debris in every ecosystem on the planet (United Nations, 2018). The seriousness of this trend is reflected by the 2018 adoption of the EU Strategy for Plastic in a Circular Economy (European Commission, 2018) which marked the first continental drive towards enhancing circularity of our plastic goods networks. The remainder of this paper will be dedicated to the circular economies of plastic waste. This is due to its increasing environmental importance, as well as its economic gravity. Plastic production has skyrocketed since the 1950's (United Nations, 2018) and is only increasing as industries like packing and shipping are increasing in relevance to the average consumer. Likewise, plastic is prevalent in public discourse due to these concerns. There is not a better time to analyse how our policies and production cycles are performing in relation to plastic than now.

Our report addresses the research question: *How do EU countries perform relative to each other in their circular management of plastics and related waste products?* The circular economy, encompassing plastic, is extensive and entails several actors. Therefore, to answer our research question, we will analyse actions undertaken by the government, businesses and consumers that stimulate the circular usage of plastic. We will cover each stakeholder category with a comprehensive collection of indicators to gain an extensive view of the state of circularity in certain countries. In addition to the indicators per actor category we will also consider country data on plastics and circularity. The respective indicators and our methodology will be explained in more detail at a later stage in this paper.

Our research is operationalized by a scorecard. This scorecard incorporates the comprehensive collection of the afore mentioned indicators that determine the CE performance of the EU member states.

The goal is to measure the relative performance of EU member states in achieving circular plastics usage in comparison to other EU countries. By doing so, policy recommendations that

address shortcomings in respective indicator performances will be formulated to stimulate improvement and enhance the progress towards a circular economy across EU member states.

Furthermore, we hope that the provision of a CE performance ranking, based on a transparent measurement of quantifiable indicators, will incentivize the average citizen to consider their own habits and stimulate individual research. Likewise, the outputs of this report should motivate analysis and policy action at both Member State and EU Commission levels. Finally, we aim to contribute to the methodology of other institutions who have stakes in circular economy research: The United Nations University MERIT, Maastricht University, and the Ellen MacArthur Foundation.

Following this introduction to the CE, we engage in a sweeping literature review that tackles CE concerns at all stakeholder levels. This is done by first further defining aspects of CE systems, specifically related to plastic wastes. We include discussion on the economic and political justifications for circularity, as well as current impediments and opportunities for the implementation of CE. Furthermore, a review is conducted on how previous studies have empirically studied the CE in order to enlighten the reader towards potentials for further research in this field. Next, we introduce our set of indicators and the scorecard structure. This section will also include rationales for each indicator's inclusion. Subsequently, we report our scorecard findings. A discussion section follows that analyses notable results and trends seen in the scorecard reports before. The report will conclude with policy recommendations that can help to further close the gap to full circularity of plastic usage in Europe.

1. Literature Review

1. Literature Review

Section Focus

What is the current state of research surrounding the circular plastics economy?

Which key actors need to be considered?

1.1 Definition of Key Concepts

1.1.1 The Key Concept of Circularity

The circular economy has become an increasingly important facet of modern environment policy. To fully understand what the circular economy entails it is vital to establish a clear definition. According to Kirchherr et al (2017) there is no clear overarching definition for circular economy. The authors analysed 114 different definitions of various practitioners and scholars. This analysis revealed strong disparities in definition and a lack of consensus. The author's work further reveals that the most commonly adapted definition is that provided by the Ellen MacArthur Foundation (2013, p.7).

> *"A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models."*

To better assess what the Ellen MacArthur Foundation's definition of circular economy encompasses, it is important to further dissect the definition. The restorative and regenerative aspect of the circular economy implies that circular economy shall be sustainable in the sense that it aims to decrease the amount of 'virgin' material necessary for producing goods and services. The current model of make-take-dispose, ergo the linear economy, is clearly not a sustainable model as it relies on a perpetual supply of raw materials amidst finite global resources.

Figure 1 below showcases how the circular economy is envisioned to function. The figure shows how more utility is derived from virgin materials if circular practices are adopted to

production and consumption processes. The depicted circular practices encompass both biological and technical components.

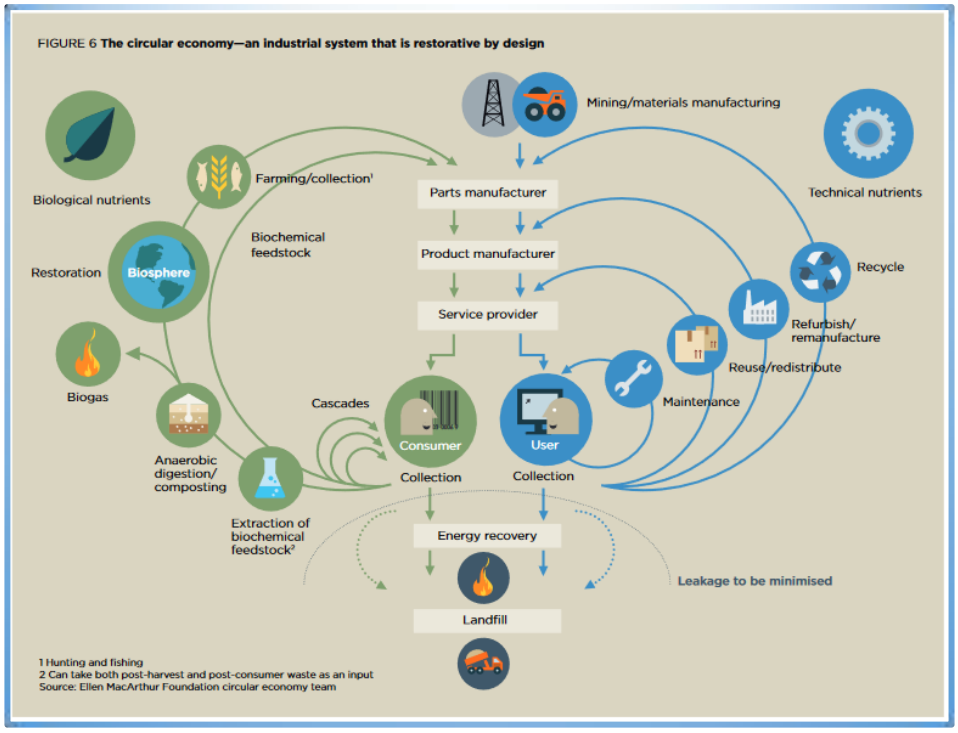


Figure 1: The functioning of the circular economy (Ellen MacArthur Foundation, 2013)

1.1.2 The 4R Framework & Waste Hierarchy

Following established literature, the circular economy entails two core principles: The systems perspective and the R-framework(s). The latter functions as an implementation guideline to circular activities. It consists of four main concepts - namely the reduction, reuse, recycling and recovery of materials (Kirchherr et al, 2017). Specific definitions for each aspect are provided in section 1.6.

There is also a hierarchy to the 4R-Framework. While this so-called waste hierarchy is less implemented in practitioner's definitions, scholars declare it to be crucial in order to guarantee the concept's efficiency. The proposed hierarchy puts the different 4R components in a priority-related ranking order so that e.g. recycling only takes place if reusing is not possible anymore. The highest priority is attributed to reduce, followed by reuse, recycle, recover.

1.1.3 Systems Perspective

The systems perspective addresses circular economy as a holistic system that consists of a micro-, meso- and macro system and understands the successful implementation of circular

economy as a matter of change on all three levels. The micro system focuses on the product and consumer level, the meso system focuses on adjustments at the regional level and the macro system encompasses the structural modification of the economy and industry. The systems perspective is well in line with the underlying principles and goals aimed for by the concept.

1.1.4 Enablers

The circular economy comprises various stakeholders, also referred to as enablers. While the Ellen MacArthur Foundation was the first to introduce companies as an integral part to their definition, new business models seldom remain in the spotlight when analysing circular activities. Further enablers are constituted by consumers and policy makers. There seems to be a debate about which stakeholder is most important when striving for circularity. While some argue that businesses are at the core, others mention consumers as the main drivers (Kirchherr, 2017). To our understanding, it cannot be pointed out who is the core enabler, since it is a holistic system and as such needs to be addressed at all levels.

1.1.5 Types of Plastic Waste

Single-Use Plastics

Single use plastics (SUPs) are often referred to as disposable plastics that are used for packaging and include items intended to be used only once before they are thrown away or recycled (United Nations, 2018). Hence, the definition should exclude plastic products that are conceived or designed to accomplish multiple usages within their life span (European Parliament, 2019b). Such items may, among others, include grocery bags, plastic bottles, straws, food containers, plates, cups, and cutlery. Figure 2 introduces the main polymers used to manufacture SUPs.

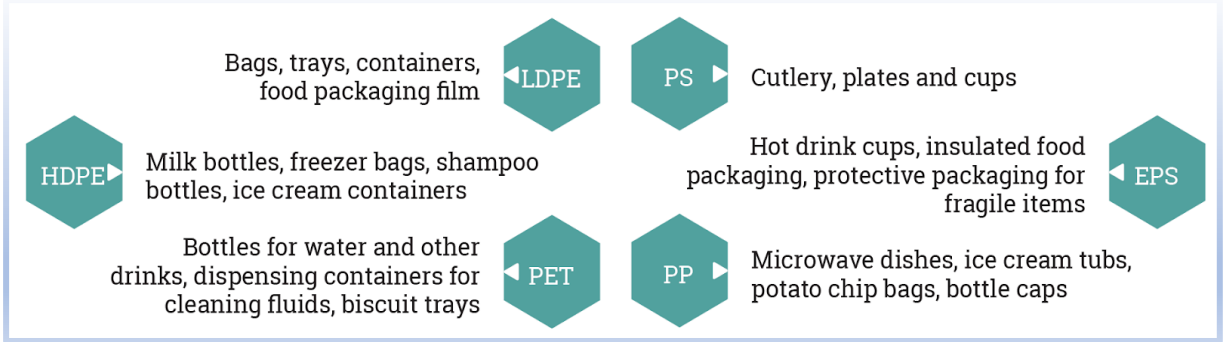


Figure 2: Division of different plastic materials (United Nations, 2018)

Microplastics

Unlike organic materials, plastics do not biodegrade but instead photodegrade, thus slowly breaking down into small fragments known as microplastics (GESAMP, 2015b). Such fragmentation is commonly observed in coastal areas and beaches due to high UV irradiation and abrasion by waves, while the degradation process is much lower in the ocean due to

cooler temperatures and lower UV exposure (GESAMP, 2015a). Not only do Microplastics that entered the ocean take longer to biodegrade, they may also be consumed by maritime organisms and thus re-enter our food value chains (Thiele & Hudson, 2018)

Bioplastics

Bioplastics are plastic substitutes made from polymers derived from plants (Lam et al 2018). As a result, bioplastics decompose extremely fast compared to oil-based plastics, and they are also more readily reusable and recyclable. Bioplastics are significantly less harmful to ecosystems, though they are currently more expensive than oil-based plastics (Lam et al 2018).

1.1.6 Reduce, Reuse, & Recycling of Plastic

Reduce

Reduction strategies are twofold in that they need to address both the overall generation of plastic products by businesses as well as consumer behaviour at lower parts of the value chain. From a business perspective, incentives for the reduction of plastic may entail push factors such as e.g. increased taxation or extended producer responsibility schemes (European Commission, 2018a). Consumer incentives, by contrast, build on an understanding that long-lasting changes in behaviour need to be voluntary and based on choice (United Nations, 2018). Consequently, a vital component of incentivising consumers to reduce their usage of plastic and hence the generation of waste is the provision of attractive and cost effective alternatives. Section 1.3 (Policy) and Section 1.5 (Opportunities) will delve deeper into the specificities of such schemes.

Reuse

According to the Ellen MacArthur Foundation (2013 p. 25), the reuse of goods refers to the "use of a product again for the same purpose in its original form or with little enhancement or change." According to Plastic Recyclers Europe (2018), the responsibility to reuse would primarily lie with the consumer by finding creative and novel usages for acquired plastics.

Recycling

In the broadest sense, plastic recycling refers to the process of recovering plastic waste and re-processing it into novel products or product components. However, the rising of share of sub-types of plastics as well as varying degrees of recyclability complicate the creation of a single suitable definition. To counteract this rising complexity, *Plastics Recyclers Europe* and the *Association of Plastic Recyclers* have developed a global definition governing the use of the term 'recyclable'. As published by Plastics Recyclers Europe (2018), plastics should meet four conditions to be considered recyclable.

1. The product must be made with a plastic that is collected for recycling, has market value and/or is supported by a legislatively mandated program.
2. The product must be sorted and aggregated into defined streams for recycling processes.

3. The product can be processed and reclaimed/recycled with commercial recycling processes.
4. The recycled plastic becomes a raw material that is used in the production of new products.

Recovery

The concept of recovery more specifically refers to energy recovery within waste treatment processes that generates energy in the form of electricity, heat or fuel (Energy Information Administration [EIA], 2018). Due to the energy generated in the process, recovery is seen as a more preferable waste handling practice than e.g. landfilling (United Nations, 2018). However, the EIA (2018) stresses that, in line with section 1.2, it should be considered as one of the last options at the end of a product's lifecycle, after reusing and recycling.

1.2 Importance of Circular Plastic Waste Treatment

1.2.1Global Developments

Since the 1950s, growth in the production of plastic has outpaced that of any other material (Geyer, Jambick, and Law, 2017). At the current rate of production growth, the World Economic Forum (2016) estimates that by 2050, the plastic industry may account for 20% of the world's total oil consumption.

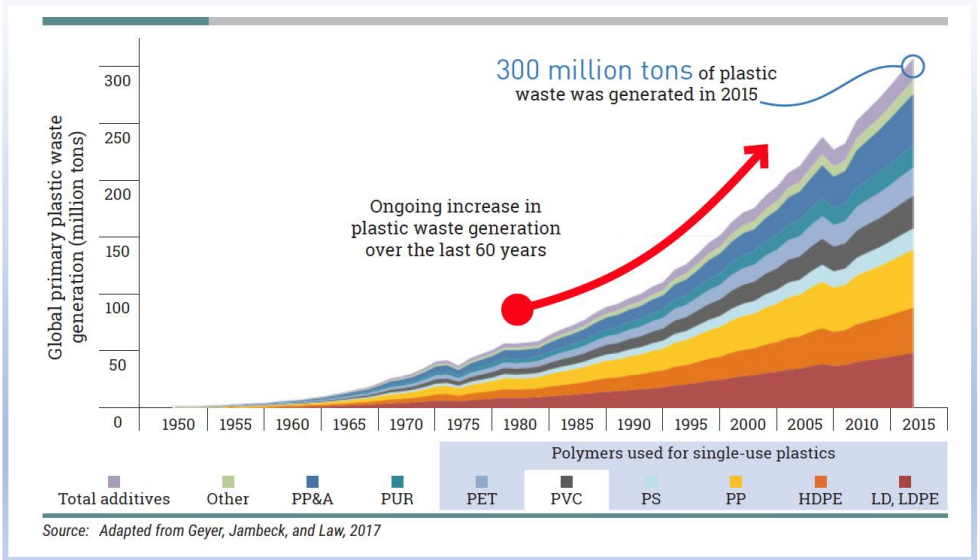


Figure 3: Plastic waste generation (United Nations, 2018)

Of the total share of global plastic waste generated, the majority of it is accounted for by packaging material, which is mostly single-use in nature (United Nations, 2018). Geyer, Lambeck and Law (2017) further show that generated plastic packaging waste can vary significantly when differentiating between total and per capita plastic packaging waste

generation. Interestingly, although the EU has a greatly smaller generation of total packaging waste, its per capita generation is very close to that of China. (Figure 4). The European situation around plastic waste will be assessed more thoroughly in the next section.

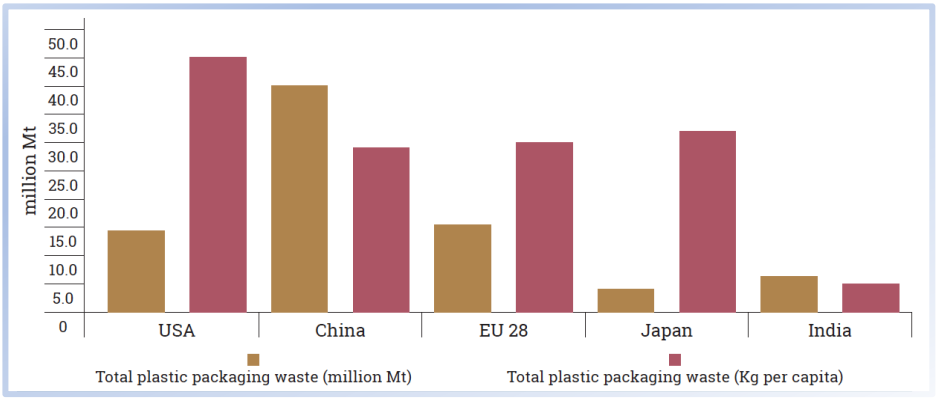


Figure 4: Total packaging waste in absolute numbers and per capita (United Nations, 2018)

According to Geyer, Lambeck, and Law (2017), 79% of all plastic waste generated now sits in landfills, dumps or the environment, while 12% are incinerated and only 9% has been recycled. Apart from environmental concerns, this clear lack of circular usage of plastics also represents a significant source of unused economic value. According to Unilever (2017), annually, USD 80-120 Billion in economic value are lost by not recycling the profound amount of plastics generated each year.

1.2.2 Plastic Waste Treatment

According to recent estimates by the European Parliament, the potential for recycling and reuse of plastic waste remains largely unexploited in the EU (European Commission, 2018). Of the 25.8 Million tonnes of plastic waste generated each year, only 30% are collected for recycling (Plastics Europe, 2019). Conversely, landfilling and incineration rates of plastic waste remain high at 31% and 39%, respectively (European Commission, 2018). Not only does recycling remain a small share of plastic waste management, a significant share of material collected for recycling also leaves the EU to be treated in third countries, where different environmental standards may apply. As such, plastic value chains are increasingly cross-border in nature and should thus be considered in light of international developments such as e.g. China's recent decision to restrict imports of certain types of plastic waste. A schematic representation of the global value chains underlying the recycling of plastics waste is provided by Hestin et. al (2015)

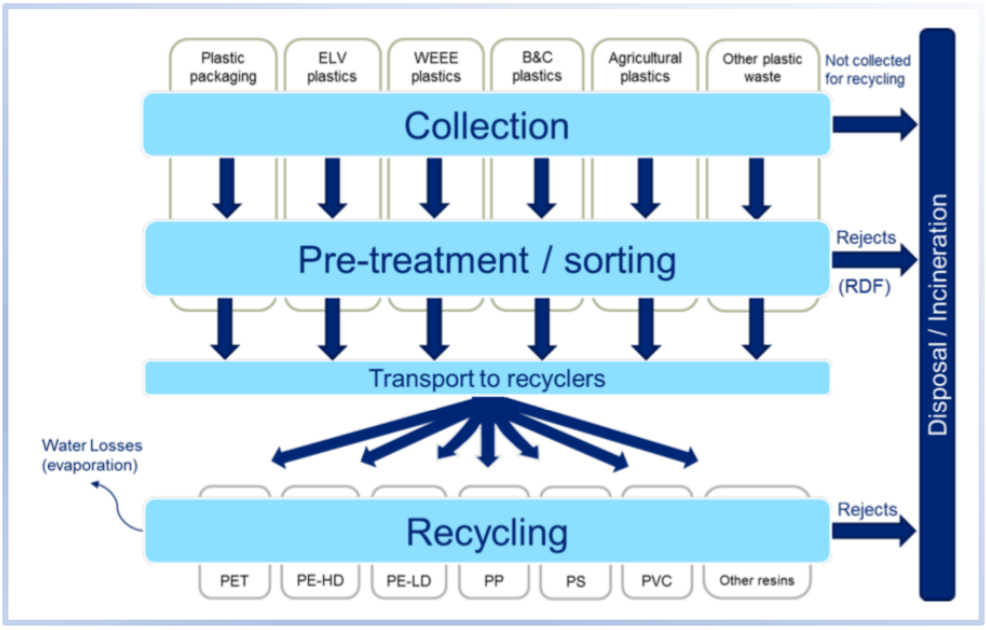


Figure 5: Structure of plastic waste value chain model (Hestin et al, 2015)

The relatively low share of domestic recycling within the EU reflects a clear lack of cost-effective and economically viable alternatives to landfilling, incineration, or export of plastics waste (European Parliament, 2018a). This is further reflected by the fact that demand for recycled plastic accounts for only 6% of total plastics demand in the EU while the share of single use plastics has continued to rise over recent years (European Parliament, 2018a). The presence of such low demand, insufficient recycling rates and lack of attractive alternatives for both consumers and businesses outlines the clear need for regulatory frameworks that incentivise a stronger circular usage of plastic waste. The next section will assess the current state of EU frameworks and legislations in more detail.

1.3 Incumbent Policy Frameworks

From an EU policy perspective, there are three major policy frameworks that need to be considered: The EU Plastics Strategy, the EU Single Use Plastics Directive, and the EU Waste & Packaging Waste Directive.

EU Plastics Strategy

The EU Plastics Strategy serves as an overarching guideline on how to reduce the amount of plastic waste being generated, as well as incentivising its reuse and recycling. More specifically, it aims to increase the share of recycled and reused plastic in the EU, increase the share of recycled plastic finding its way into new products, as well as raising the share of recycled and reused plastic packaging. Additionally, the presented measures shall reduce the share of plastic waste being generated in the EU while also increasing the attractiveness of recycling to both businesses and consumers.

Date	Intended Policy Goal
2025	10 million tonnes of recycled plastics shall find their way into new products in EU markets
2030	All plastics packaging placed on the EU market shall either be reusable or recyclable in a cost-effective manner
2030	More than half of all plastics waste generated shall be recycled
2030	Sorting and recycling capacity shall have increased fourfold compared to 2015 levels. This is expected to create 200,000 jobs throughout Europe
Outstanding	Develop quality standards for sorted plastic waste and recycled plastics & make it easier to trace chemicals in recycled streams
Outstanding	Restrict the use of oxo-plastics in the EU. The Commission has requested the European Chemicals Agency to review the scientific basis for taking regulatory action at EU level
Outstanding	Process to restrict the use of intentionally added micro plastics, by requesting the European Chemicals Agency to review the scientific basis for taking regulatory action at EU level

Single Use Plastics Directive

The Single Use Plastics Directive's objectives clearly follow the objectives outlined by the EU Plastics Strategy. In essence, its approach is two-pronged. For one, it aims to promote the transition to a circular use of plastic waste through innovative and sustainable business models, products and materials. Secondly, it serves to promote the usage of reusable products opposed to single-use products, thus reducing the quantity of waste generated.

Date	Intended Policy Goal
3 October 2019	The Commission shall request EU standardisation organisations to develop harmonised standards relating to the requirement referred to in Article 6(1)

3 July 2020	The Commission shall publish guidelines, in consultation with Member states, including examples of what is to be considered a single-use plastic
3 July 2021	Member states shall notify the Commission of rules on penalties applicable to infringements of national provisions adopted pursuant to this Directive
3 July 2021	Member States shall prepare a description of the measures which they have adopted pursuant to the first subparagraph, notify the Commission and make it publicly available
3 July 2021	Member states shall bring into force the laws and regulations required to comply with this Directive. However, member states shall apply the measures necessary to comply with Article 6(1) by 3 July **2024**, Article 8 by 31 December **2024**, but in relation to SUP products listed in Section III of Part E of the Annex by 5 January **2023**
2025	Beverage bottles listed in part F of the Annex should contain at least 25% recycled plastic. This threshold shall be raised to 30% by 2030.
2026	Measures towards consumption reduction as outlined in Article 4 shall receive a measurable reduction in the consumption of SUP products listed in Part A of the Annex by 2026 compared to 2022
3 July 2027	The Commission shall carry out an evaluation of this directive

EU Waste & Packaging Waste Directive

Overarching objectives of this Directive include increasing the recycling of packaging waste as well as reducing the waste's environmental impact. This shall be achieved through extended Producer Responsibility Schemes as well as reducing the EU's import dependency on imported plastic raw materials. Moreover, the Directive aims to set long-term objectives for waste management and set clear direction for required investments

Date	Intended Policy Goal
31 December 2025	A minimum of 65% by weight of all packaging waste shall be recycled
31 December 2025	No later than this date, the following minimum targets shall be met: (1) 50% of plastic (2) 25% of wood (3) 70% of ferrous metals (4) 50% of aluminium (5) 70% of glass (6) 75% of paper & cardboard
31 December 2030	A minimum of 70% of weight of all packing waste will be recycled
31 December 2030	No later than this date, the following minimum targets shall be met: (1) 55% of plastic (2) 30% of wood (3) 80% of ferrous metals (4) 60% of aluminium (5) 75% of glass (6) 85% of paper & cardboard

1.4 Current Main Impediments

1.4.1 Operational Barriers

Villalba (2002) developed an index measuring the deteriorating quality of plastics after recycling. 'Deteriorating quality of plastics after recycling'. This index, which is measured by a ratio of the value of recycled material to the value of its virgin state, shows that recycled plastics typically are less valuable than new plastics. The indicator takes a value of 1 for when the value of the recycled material is equal to a brand new material. Furthermore, the index can change as valuations change. While some materials such as steel can have an index higher than 1, that is not usually the case for any type of plastic. Policy intervention is needed to keep recycled plastic competitive as plastics typically have a recyclability index lower than 1 (Villalba, 2002).

Furthermore, plastic collection is lacking as only 41% of the packaging waste is collected for recycling. Increasing this rate is essential for a circular economy. Existing methods and guidelines for glass and paper can be used as a model (Hestin et al, 2015). Additionally, the number of sorting and recycling facilities need to be improved upon. Hestin et al (2015) show that a moderate amount of investment can lead to high environmental and societal benefits

through improved economies of scale and reduction of waste exports. Hestin et al measure that to achieve 2020 EU goals, net costs of 1.1 billion euro a year are needed. An option could be to improve intra-European waste management. However, this could skew this research paper' indicators as recycling rates of countries with a high amount of recycling facilities would appear as further along in the implementation of circular economy.

1.4.2 Policy Barriers

Besides operational barriers, there are policy implementation barriers as well. Di Maio et al (2015) determine a key barrier in the policy implementation and evaluation of circular economy to be the lacking precision of indicators. Indicators for the recycling rates of materials and products have been calculated inconsistently, thus often overestimating the amounts actually recycled. Therefore, Di Maio et al propose the *Circular Economy Index* (CEI) which is the ratio of the material value produced by the recycler (market value) divided by the material value entering the recycling facility. This indicator has the benefit of adjusting to substitution of materials in case of price changes while staying simple to calculate. In order to calculate the CEI accurate data from recycling plants is necessary.

The need for a sound and standardised indicator is further stressed by Hestin et al (2015), advocating for increased accountability and transparency in the way data is calculated since the reporting of recycling rates is currently voluntary by recyclers. Exporting waste to be recycled abroad could further skew the actual recycling rates as foreign recycling standards may differ significantly. Requiring certifications of international recyclers could be made mandatory but appears not to be translated into specific policy action.

Hennlock et al (2015) identify the limitations of recovering plastic products in order to reduce their usage. High taxes could lead to producers and consumers substituting other products with equal or higher externalities. Likewise, efforts to full recovery rates may reduce sustainability, as the costs to collection and processing plastic may be socially inefficient. Recovery strategies should therefore be carefully considered and only implemented if the efforts improve social efficiency and sustainability. Hennlock et al suggest a two-tiered system that focuses on reducing the pool of products produced and then aiming for high, but not full recycling.

1.4.3 Firm Barriers

Hestin et al (2015) report lacking demand in recycled plastics as a barrier for plastic recycling companies. The quality of recycled plastic has to be increased and more uses for it have to be found, while ensuring a competitive price. This can be done through policy incentives like subsidies and improved plastic waste quality assurance.

Kirchherr et al (2017) conducted a survey with businesses, governments and circular economy experts. They found that a major barrier to the implementation of circular economy stems from cultural barriers. This includes lacking consumer interest and hesitant company culture. Businesses encounter problems attempting to apply circular economy concepts in a

linear economy as suppliers and retailers have limited knowledge of circular economy and thus rarely incorporate circular economy strategies.

Schaltegger & Figge (2000) highlight that corporate actions regarding environmental protection will only go as far as is required to protect shareholder value. The differences between a shareholder valuation and societal valuations of environmental protections are directly related to the public policy decisions surrounding this system.

1.4.4 Information Asymmetries

Information asymmetries between suppliers of plastic and the purchasers of recycled plastics constitute another reason why the adoption of circular economy practices towards plastic recycling faces barriers. Hennlock et al (2015) writes that both sellers and buyers of recycled plastics face negative effects of adverse selection. Sellers of low quality plastics and high quality plastics are treated equally by the purchaser of plastics because the purchaser does not have the same information about the plastic quality. Because of the information asymmetry, purchasers are cautious when buying recycled plastic as quality may be low. Therefore, the purchaser will likely try to pay the lower price for plastic - fostering producers to only create lower quality plastic as the information asymmetry will prevent proper pricing of high quality plastics - making them less profitable. This is assuming that the cost of recycling high quality plastic is higher than the cost of recycling low quality plastic.

Related to this information asymmetry problem is another barrier highlighted by Messenger (2017). The author states that one of the biggest reasons for lower adoption rates of recyclable plastic as a raw material is that producers have difficulties finding high quality recycled plastics to use in their products. This is partly a result of the information asymmetry where low quality plastic production is fostered and high quality plastic production lags behind. The logic flows as follows: due to information asymmetry, lower quality plastic recycling is promoted while higher quality plastic recycling lags behind - meaning that producers who rely on high quality plastics have difficulties sourcing that plastic from recyclables, which means adoption of recycled plastic lags behind.

1.5 Potential Opportunities

Apart from environmental and economic considerations, a well executed circular strategy around plastics may enable a range of potentially valuable synergies.

1.5.1 Policies

Plastics have the potential to be recycled many times while retaining their value and functional properties. However, as highlighted by Hestin et al (2015) and the European Parliament (2018a), a large share of plastic is currently not recycled, landfilled or incinerated

for energy recovery. Increased recycling performance, as per proposed EU targets, could save up to 8 Mt of GHG emissions per year by 2020 and up to 13 Mt by 2025.

Job creation with a rising population is considered to be a high priority for various policy makers at this time. It is estimated that nearly 50,000 new jobs could be created directly in the recycling value chain of plastics by 2020, with over 75,000 additional indirect jobs supporting the sector and its operations. By 2025, employment could increase considerably by 80,000 direct jobs and 120,000 indirect jobs (European Parliament, 2018a). Figure 6 below shows the magnitude of potential job creation.

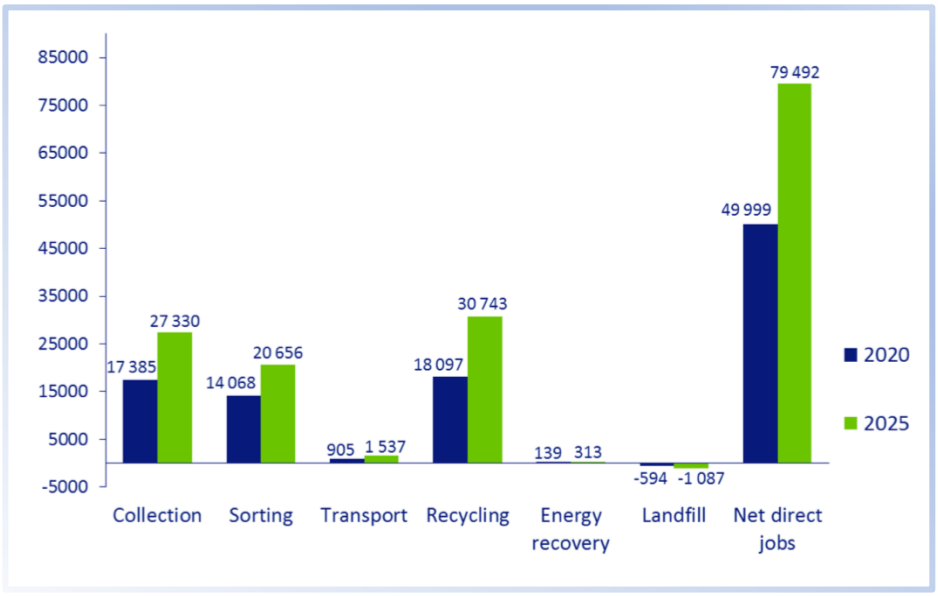


Figure 6: Number of extra direct jobs created along the plastic recycling value chain in Targets2020 and Targets2025 (Hestin et al, 2015)

1.5.2 Cost Reductions & Fiscal Incentives

Monetary incentives often act as a motivation to get the attention from corporates. According to the World Economic Forum, plastic packaging waste represents an $80–120 billion loss to the global economy every year. New, innovative delivery models and evolving use patterns are unlocking a reuse opportunity for at least 20% of plastic packaging (by weight), worth at least USD 9 billion (Unilever, 2017). Section 5.3 goes into more details about such business models.

A McKinsey (2017) study of 28 different industries found that at least 10 can adopt 5 or 6 circular activities and that all analysed industries can benefit by adopting at least 3 or 4 activities.

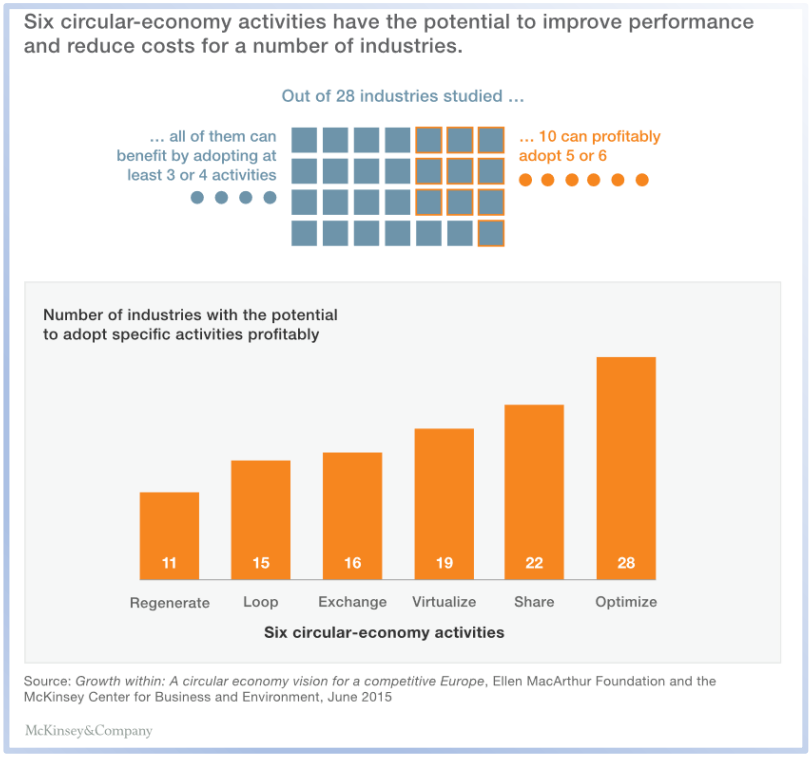


Figure 7: Circular economy activities, cost reduction & performance improvement (McKinsey, 2017)

1.5.3 Business Practices

Circularity around plastics brings about potential economic benefits for businesses. If practiced ethically, businesses have a lot to gain as highlighted by a variety of sources. The Ellen MacArthur Foundation (2017) evaluated the actions required to create a positive transition around circular use of plastics. The identified actions cover top down approaches with business enterprises driving the changes.

There is a push for business enterprises to recreate a positive design which is easier to recycle/reuse (Unilever, 2017). Plastics Europe (2019) stress the importance of increasing efficiency when the responsibilities are shifted to the producers. Villalba (2002), showcases that the sector is mostly market driven but with proper incentives, efficiency can be increased.

In their 2017 case study, Unilever e.g. introduced a new category of plastic packaging which achieved a significant reduction of annual plastic usage. As such, designing for circularity at the very beginning of a product's value chain is essential in enabling subsequent steps of reuse and recycling.

1.5.4 Consumer Incentives

The circular economy is such an all-including system as essentially everyone will be affected by the system. Therefore, not only producers, but also consumers are an important part of the

circular economy value chain. Consumers are the people that use recycled plastic and also the people that have to make sure that plastic, once used, returns to the producers of plastic products so that the plastic can start a new life. If these consumers neglect sorting their trash well, not only will there be less plastic to recycle, the quality of the recycled plastic would also be worse due to contamination. This means that plastic recycling companies will lack access to enough plastic to recycle meaning producers of plastic will again have to look for more virgin materials to create new plastic products.

To increase consumer engagement with recycling plastics, they need to be incentivized to properly dispose of plastic waste. This incentive schemes can be achieved in multiple ways. For example, consumers could be punished or rewarded for properly/improperly disposing of waste. They could also be rewarded for using less plastic and instead use other more sustainable materials. Prices of non-circular goods can also be increased to incentivize consumers to instead buy more sustainable products. Furthermore, consumers can be incentivized through 'green' packaging to choose the environmentally friendly choice.

An example of when consumers were incentivized to use less plastic is when plastic bag taxes were introduced. In an effort to reduce the use of single use plastic bags, many countries have started enforcing laws that require either a complete ban of plastic bags or they require that plastic bags have to be sold for a certain price or at least not free. Ireland is a success story of how a levy on plastic bags reduced consumption of plastic bags by 90% (Nielsen et al, 2017). Other examples include Schotland (80%), Portugal (74%), Belgium (86%).

Linderhof et al (2019) determine that deposit return schemes (DRSs) are extremely useful at incentivizing consumers to return their used bottles. They name the success of the Netherlands where a DRS for large bottles has achieved a 95% recycling rate for these bottles. In their paper Linderhof et al argue that also other products would benefit from a DRS, such as batteries.

Gitlitz (2013) shows that that DRS is an effective way of increasing the recycling rates. She compares the recycling data of states with and states without DRSs in place. The data points out that states with DRS have average recycling rates of 70.2% while states that do not have DRS in place reach recycling rates of 27.6% on average.

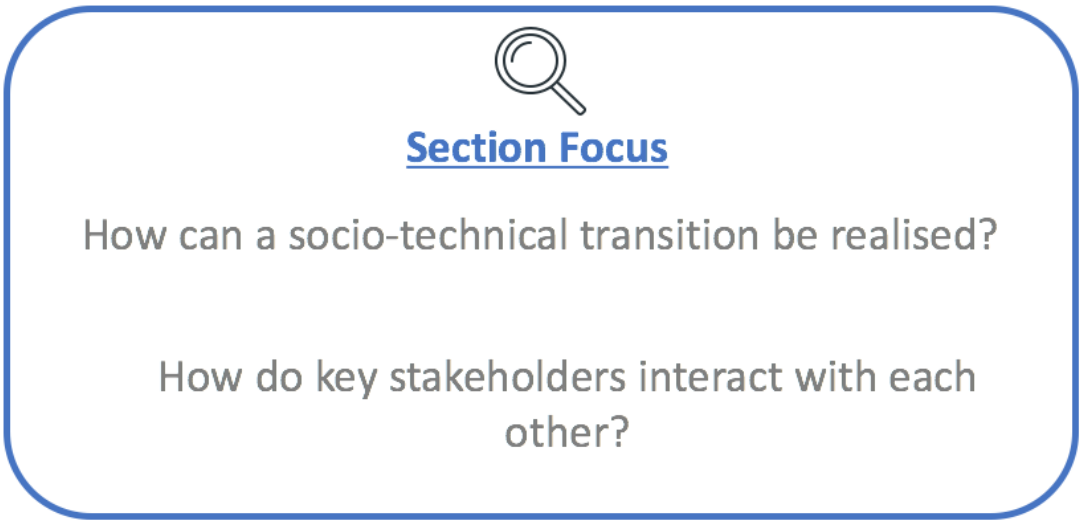
Moreover, sustainable packaging does help in increasing the consumer likeliness to buy more circular goods. Rokka & Uusitalo (2008) determine that sustainable packaging has a positive influence on the preference of a consumer. In their conjoint analysis they find that sustainable packaging is an important factor in the decision making process of a customer. If packaging is clearly made from more sustainable materials, consumers are more likely to buy them.

1.5.5 Demand for Plastic Waste

The use of bioplastics represents an opportunity to replace conventional plastics with a less persistent, degradable solution (Lam et al, 2018). Bioplastics have the additional quality of

acting as a carbon sink (Owen, Brennan, & Lyon, 2018). As bioplastics require plant material, CO2 is removed from the atmosphere and processed into a solid good. At the end of bioplastic's lifespan, they can be recycled back into the system, or reused for ecological purposes, for example, as fertilizer (Lam et al 2018).

1.6 Requirements to Realise a Transition Towards Circularity



As evident from previous sections, realising an effective transition to circular practices requires the coordination of a multitude of stakeholders. A particular challenge in realising such transition stems from the fact that the interests of both producers and users of plastic need to be aligned in a common legal framework. While producers may be largely driven by cost and operational considerations, consumers may e.g. demand more environmentally friendly practices, thus creating conflicting incentive structures. This, in turn, complicates the exact pinpointing of barriers that hamper the transition towards a circular economy. To address the prevailing dynamics among the various stakeholders, and identify conditions necessary for a circular transition, this research will draw upon the multi-level perspective established by Geels (2004).

As the concept of the circular economy interlinks both society and technology, it can be classified as a socio-technical system (Geels, 2004). In such a multi-faceted environment, it is vital to consider the interactions between the different entities interacting with one another. Figure 8 (Geels, 2004), serves to showcase the fundamental interactions around the socio-technical system.

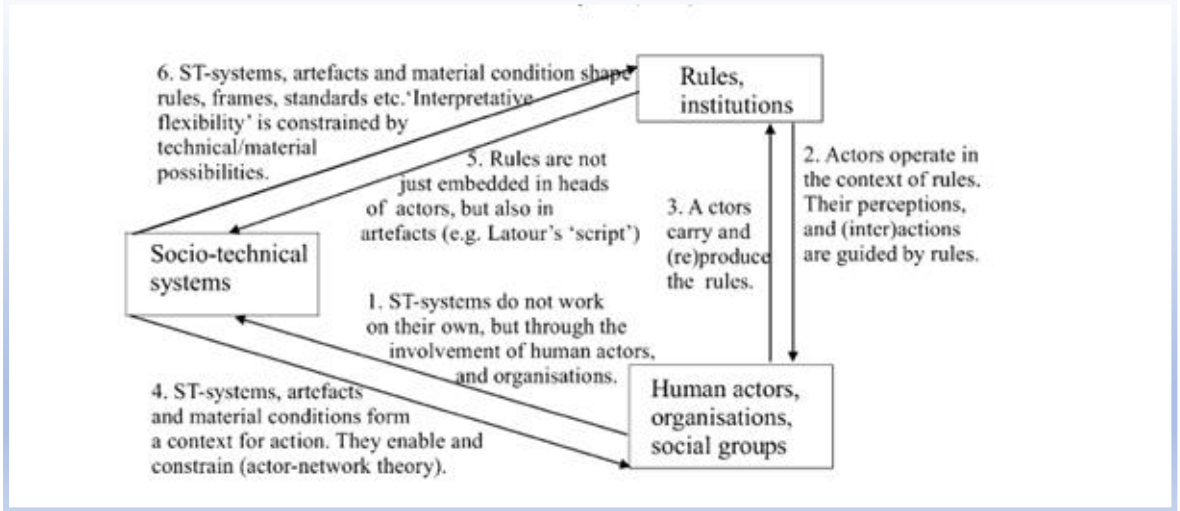


Figure 8: Socio-Technical Transition Framework (Geels 2004)

Clearly, socio-technical systems do not exist in isolation but are embedded in an ongoing feedback loop between Rules & Institutions as well as Human Actors, Organisations, and Social Groups. Hence, on their own, stringent policies, innovative technological solutions, or committed citizen initiatives will not have a lasting impact on circularity, unless executed with a clear understanding of surrounding dynamics and stakeholders.

Building on the interaction of the presented factors, Geels & Schot (2007) propose the following framework to capture the dynamics inherent in a socio-technical regime transition. As showcased by figure 9, there are three key factors that need to be considered.

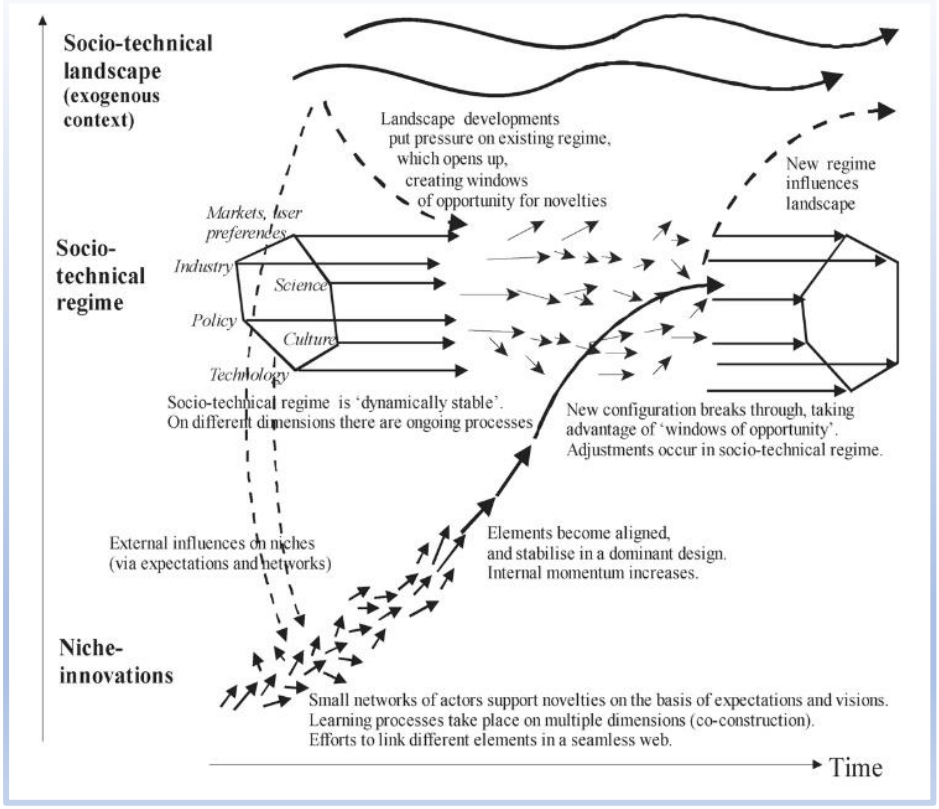


Figure 9: Extended Socio-Technical Transition Framework (Geels & Schot, 2007)

In essence, the multi-level perspective argues that transitions occur through interactions between processes at these three levels (Geels & Schot, 2007). Niche innovations build up internal momentum through various channels. These can include learning processes, price / performance improvements, and support from powerful groups such as e.g. lobbying from an industry or citizen perspective. Next, changes at the landscape level create pressure on the existing regime. The increasing destabilisation of the regime in turn creates opportunities for niche-innovations to affect the prevalent socio-technical regime. Finally, the alignment of these processes enables these novelties to enter the mainstream market where they compete with and possibly overtake the existing regime.

In the specific context of a circular management of plastic and related waste products in the EU, it is vital to understand the interactions between relevant stakeholders in achieving a transition of the current, largely linear economic, socio-technical regime. To this end, an adapted framework was created. By doing so, the framework shall allow for an assessment of incumbent dynamics as well as the identification of specific actions needed to advance the level of circular practices in the EU.

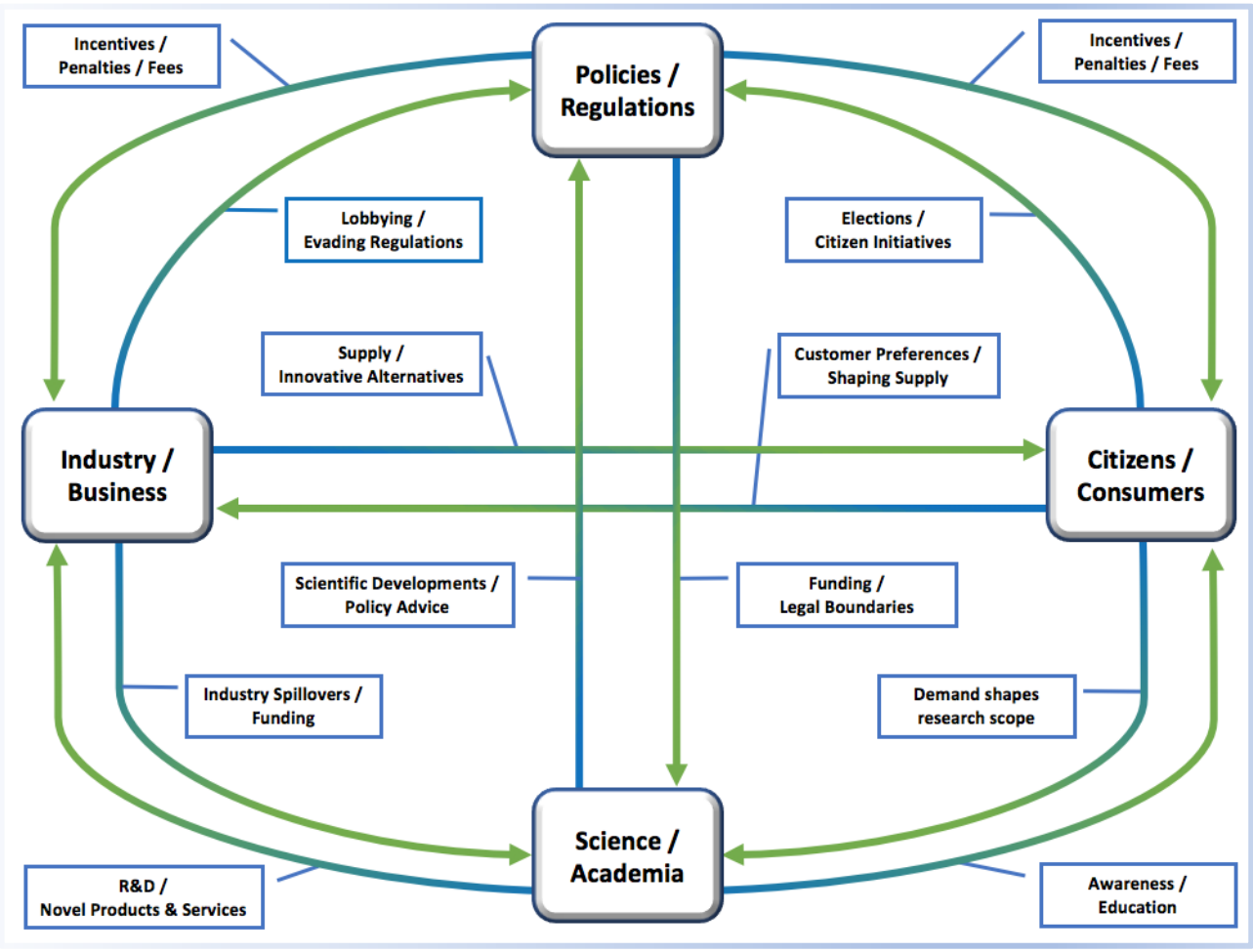


Figure 10: Dynamics between key circular economy stakeholders

Policies / Regulations:

Policies and regulations clearly have a widespread impact on all relevant stakeholders. For both industry / business as well as citizens / consumers, they play a vital role in shaping the set of rules under which different entities interact. This influence can take the form of both incentives or levies to stimulate or reduce economic activity, respectively.
Towards the industry / business sector, incentives may e.g. include subsidies or government grants to ensure the undertaking of products which would not be commercially viable on their own. Penalties or fees, on the other hand, may be constituted by industry standards to restrict certain operations or strict fees to disincentives e.g. environmentally harmful undertakings.

Concerning consumers, the underlying principle of incentives or fees remains largely similar. Regulations may e.g. subsidise environmentally harmful products while levying taxes on single-use plastic products to disincentive their usage.

Apart from businesses and consumers, policies and regulations exert a strong influence on science and academia. As an example, the policy focus of a given country strongly affects the scope of research as well as the amounts of government funding allocated to certain sectors.

Citizens / Consumers:

Although subject to the policies and regulations in place, customers / citizens are not inaptly exposed to the government's influence. They are capable of shaping of policies and regulations through both elections or initiatives such as citizen lobbying. While the latter has only recently gained popular attention in the EU, it is a force that is not be neglected (Alemanno, 2017).

Operations of the industry / business sector are not exempt from the influence of customers / citizens. In fact, their operations are largely coined by assessing to customer preferences and responding to developments in their market environment. As shown by the World Economic Forum (2016), recent years have witnessed a burgeoning number of companies that put environmental and social concerns at the core of their business in response to shifting customer preferences.

Towards science / academia, the exerted influence is arguably more of an indirect nature. Nonetheless, customer preferences and citizen initiatives undeniably have an effect on the scope of research carried out in a particular country (Alemanno, 2017).

Business / Industry:

Not only is the business / industry sector subject to policies and regulations, it also exerts significant influence on them through targeted lobbying efforts. As shown by Alemanno (2017), lobbying expenditures have starkly increased over recent years and constitute a critical force towards policies and regulations. Rather than trying to alter policies, businesses may also evade certain rules or restrictions by locating part of their operations outside the EU.

Clearly, businesses have a close-knit relationship with prospective customers. While business and industry indeed react to customer preferences, they can also improve the price and performance of technologies that were previously not in high demand due to e.g. lacking performance or overly high cost. Examples include e.g. renewable energy or electric vehicles that only recently became competitive and cost-effective enough to compete with incumbent technologies.

These improvements in cost and performance were not possible without a strong involvement of science and academia. While a plethora of research is clearly carried out independent of industry interests, commercial motives arguably do have a distinct impact on the scope of research through both funding as well as knowledge spillovers from industry / business to science / academia and vice versa.

Science / Academia:

As mentioned before, there are strong interactions between science / academia and the commercial sector. While the scope of research may be influenced by business / industry, scientific developments and breakthroughs exert profound influence on commercial operations through cost or performance improvements (UNEP, 2018). Examples may include increasing advances in e.g. bioplastics, recycling technologies, or renewables that were previously not competitive from a commercial perspective.

Towards policies / regulations, new scientific developments also affect the need for adapted or novel legal frameworks. At the same time, scientific and academic experts play a vital role in advising the drafting and implementation of novel policies and regulations.

Finally, science and academia distinctly affect citizens / consumers through education at different levels as well as channelling awareness towards particular areas.

1.7 Existing Methodologies

One of the central goals of economic analysis is to create recommendations for the future. Evidence for a proper policy direction to take is bolstered by the inclusion of hard data and econometric modelling. In a report prepared for the European Commission ("EC"), Mudgal et al (2011) analysed the share of plastic waste being recovered in the EU. Based on metrics gathered from the EC Waste and Packaging Waste Directive, researchers built a baseline database out of recovery rates from 1995-2008. Then, based on an anticipated GDP growth rate of 2.1% annually, projections were made to 2015 and 2020. The authors admit that these estimates do not account for significant factors to the waste recovery system, and that the linear nature of the projections may not be accurate.

Looking in closer than projection models, it is important to create and standardize indicators for promoting a circular economy. Instituting such an indicator would aid policy determination of state actors. Di Maio & Rem (2015) devised the Circular Economy Index

("CEI"), a ratio of the values of recycled products to the costs needed to reproduce such goods. Classic "recycling rate" metrics typically overvalue the circularity of a system, as there may be material losses during the recycling process. Furthermore, as the CEI measures valuations of materials, it is more responsive to market and technology changes than recycling rates would be. The CEI represents a possible indicator for our studies.

Other sources of economic modelling focused themselves on more specific factors to analysing the circular economy of plastic. Villalba et al (2002) utilized economic fundamentals of price depreciation to develop a "recyclability index" of various materials. The value of virgin material was compared to the values of used material, and then to recycled material. By incorporating annual data through the 1990's. the paper accounts for changes in the business cycle. The result of this process was a dollar quantification of the ability for a recycled product to reacquire its original characteristics and value. Most importantly, it shows recyclability is driven by market conditions specific to the cost of recycling relative to producing virgin material.

In an analysis on the Dutch recovery system, Bing, Bloemhof-Ruwaard, & van der Vorst (2014) compared the societal sustainability against the efficiency of the recovery process. The model is very complex, incorporating explanatory variables of transportation factors and processing centre characteristics. Furthermore, market conditions and system efficiency are described. The paper aims to minimize the summation of many of these factors. As a result, they claim a 25% increase in sustainability without reducing efficiency. This process indicates that there should be additional weight given to how the system is run. Perhaps a fully circular economy based on recovery rates would miss net losses due to an unsustainable system design.

From reviewing empirical methods to studying the circular economy of plastic, there are several considerations to take note of for any future models. Firstly, there should be a cost evaluation between the recycled material and its virgin state. Most importantly, the cost evaluations help to explain trend variations, as well as represent a better metric for recovery rates. Secondly, we propose the inclusion of sustainability as an important factor to the system. An efficient circular system may have a net negative social effect, which should be avoided. Finally, it seems reasonable to scale circularity by the size of the target economy, as measured by GDP.

2. Methodology, Limitations & Future Research

2. Methodology, Limitations & Future Research

In order to map the gap to a circular usage of plastics, a set of indicators was developed. In order to establish a holistic analysis, the indicator set was constructed with four main sub-categories included. In order to make relevant and effective policy advice possible the categories were defined to be Plastic-Benchmarks, consumers, industry and government. Each category covers an important aspect of the circular economy, and all must be addressed in order to achieve meaningful progress towards a circular usage of plastics. While this set of indicators is tailored towards mapping the circular use of plastics, the method can be adjusted towards other resources or be expanded into a more general circular economy indicator.

The countries being analysed are the European union 28. While including Norway could be interesting for comparisons it was excluded in this research as there are data-limitations at present. Lichtenstein was excluded for similar reasons and additionally its small size made population adjustments unreliable and a large share of its recycling is outsourced into neighbouring countries.

On the basis of the four chosen categories a cross sectional data set was constructed. Similarly, to the process of choosing the categories, the indicators were chosen to allow an expansive view on the relative positions of the EU-countries in their progress towards a circular plastic use. The indicators chosen, and their relevance will be presented in the upcoming section.

Once the Data set was constructed each indicator was normalized to a value between one and ten in order to make different indicators comparable (detailed explanation in appendix). This resulted in a score for each country in each indicator, making it possible to analyse the detailed position of a country in each single measure. Using the scores for the indicators, an average was taken of the indicator scores of a subsection resulting in a score for each sub-category (benchmark, consumer, industry, government). These subsection-scores allow a broader view of a country's strengths and weaknesses. Appendix C provides a detailed description of the research's specific quantitative methodology.

Finally, to create the final scorecard an equal weighted average of the four categories was calculated. This normalized score, the **Plastics Circularity Index (PCI)**, gives a measure of assessing the progress of a country towards circular usage of plastics. An equal weight of each sub-category was used to calculate the final score. Using an equal weight for each sub-category gives a balanced view of the identified aspects of the circular economy. Different weights can be placed depending on the specific research question and the identified importance of each sub-category. We invite future researchers to utilize the developed framework and adjust it to their research.

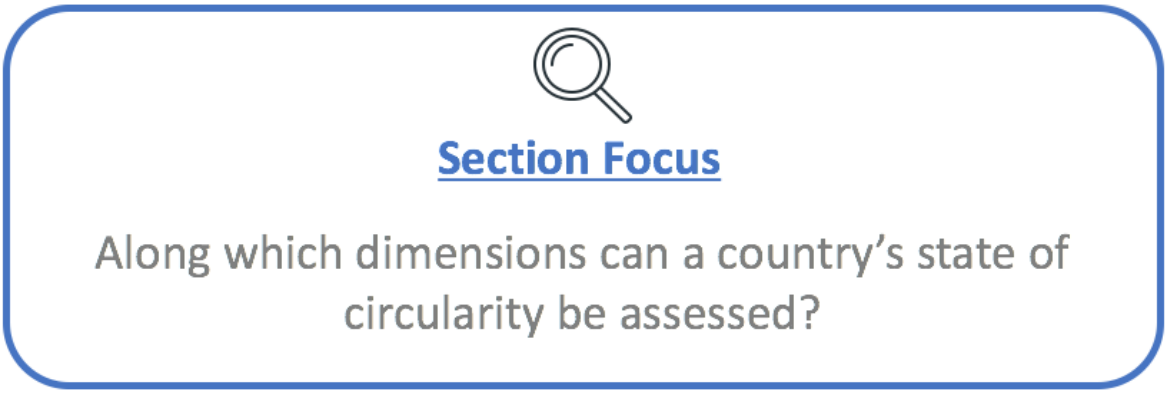
The calculated scorecard allows policymakers and researchers to quickly gain an understanding of the relative standings and shortcomings of each included country. To further facilitate an accessible, meaningful and informative presentation of the resulting data the scorecard was designed to be colour coded and ordered by standing in the relative results.

In order to determine the external validity of the completed scorecard the developed indicator set was compared to established indicators like the SDGs, Eco-innovation index etc. This was done in order to assess the external validity of the gathered data. By running a Pearson-correlation function comparing the developed scorecard to the selected indicator-sets it was possible to assess the validity. The results are listed in Table (1). The created composite-index is correlated at the 1% significance level with the Sustainable Development Index (0.69), the INNO4SD-Index (0.77), the Global Green Economy Index (0.6145), Social Progress Index (0.70), Sustainable Governance Index (0.62) and the Eco Innovation Index (0.67). These robust results support the validity of our developed composite Index. The strong external validity hints at the potential merits of utilizing alternative indicators to assess issues of both economic and social importance.

Table (1) *Correlation between our results and comparable indices*

		Sustainable development Index	**INNO4SD**	**GGEI (2016)**	**SPI**	**SGI**	**Eco Innovation Index**
Correlation	*1% Sig.	0.6932*	0.7740*	0.6145*	0.7069*	0.6261*	0.6724*

2.1 Selection of Indicators



The research's scorecard makes use of key metrics reflecting the state of circular management of plastic and related waste products. To allow for a more accurate distinction of domestic circumstances, and building on the framework from the methodology section, the selected indicators were grouped into the following sub-sections: general benchmarks, consumer / citizen, business / industry, as well as the countries' regulatory environment. The applied metrics are predominantly taken from a micro perspective to allow for precise distinctions of each member state's specific dynamics of each member state's specific dynamics. The chosen approach makes use of both ultimate metrics such as the circular material usage rate and

degree of landfilling as well as proximate metrics such as a country's innovative capability and social awareness centred around circular economic practices.

	Name	Time Frame	Source	Unit	Category
1	Plastic Recycling	2017 (Missing entries 2016)	Eurostat	Percentage	General
2	Plastic Packaging Waste per Capita	2016	Eurostat	Kilogram per million Inhabitants	Consumer
3	Share of incinerated post-consumer plastic waste	2018	Conversio	Percentage	General
4	Share of landfilled post-consumer plastic waste	2018	Conversio	Percentage	General
5	Net Trade of recyclable Plastics per capita 2018 (Import divided by export)	2018	Eurostat	Tonnes per million inhabitants	General
6	Circular Material Usage	2016	Eurostat	Percentage (ratio of circular material use to the overall material use)	General
7	Climate Strike Attendees	2019	Fridays for Future	Attendees per million Inhabitants	Consumer
8	Electronic Mass Media Mentions	2016	EIO	Mentions per million Inhabitants	Consumer
9	Eco-industry revenue, in % of total revenue	2017	ORBIS Database	Percentage	Consumer
10	Bought a remanufactured product	2013	Flash Eurobarometer 388	Percentage	Consumer

11	Leased or rented a product instead of buying it	2013	Flash Eurobarometer 388	Percentage	Consumer
12	Used sharing schemes	2013	Flash Eurobarometer 388	Percentage	Consumer
13	Patents	2000-2015	Eurostat	Number per million inhabitants	Industry
14	Difficulty to implement	2016	Flash Eurobarometer 441	Self-reported Percentage	Industry
15	Employment in Circular Economy related fields	2016	Eurostat	Percentage of total employment	Industry
16	Circular activities of Small and Medium Companies	2016	Flash Eurobarometer 441	Self-reported Percentage	Industry
17	Amount of self-Financing for circular economy activities by companies	2016	Flash Eurobarometer 441	Self-reported Percentage	Regulatory
18	Bottle Deposit Schemes	2011	European Parliament	Average Price adjusted for purchasing power	Regulatory
19	Plastic Recycling Centres per Million Inhabitants	2019	ENF (Directory of Recycling Companies)	Plants per million Inhabitants	Regulatory
20	Plastic Bag Tax Rates & Bans	2019	European Environmental Agency	Tax Amounts	Regulatory
21	Publication Mentions	2000-2017	Web of Science	Number of Publications per Million Inhabitants	Regulatory

Appendix A covers each indicator and its specific considerations in more detail.

2.1.1 General Benchmarks

Plastic Recycling, Landfilling, and Recovery:

All three of these components constitute an essential component of the scorecard. For one, the rate of recycling of plastic and related waste products is a straightforward indication of a country's approach towards waste management. Additionally, in tandem with a country's share of plastic waste ending in landfills or being recovered, it creates a sound overview of a country's dominant plastic waste management strategy. In light of the indicators' merits, they

are commonly used as a benchmark for plastic waste management by organisations such as UNEP (2019) or Plastics Europe (2019).

Plastic Packaging Waste per Capita:
In order to account for a country's per capita plastic waste generation, it is vital to take other measures such as a country's number of recycling centres and the relative employment in the CE sector into consideration. Additionally, it is critical to assess the relative differences in per capita waste generation between various countries to allow for a viable comparison. In practice, methodologies of e.g. Plastics Europe (2019) or Gourmelon (2015) make frequent use of per capita plastic waste generation to allow for relative comparisons with other benchmarks.

Net Trade of Recyclable Plastics per million inhabitants
Import and export of recyclable plastics (per million inhabitants) reveal important information on a country's plastic waste management. Most plastic waste exports arrived in China before its plastic import ban in January 2019, since then Malaysia and other developing countries took over the role of main importers. This is important, since especially the developing countries lack in sufficient plastic recycling infrastructure, which implied that around 33% of China's imported recyclable plastics ended up in landfills or the ocean instead of being used in the concepts of circularity (Brooks, Wang & Jambeck, 2018). Therefore, being a net exporter of recyclable plastics is perceived as leading to more environmental pollution and is treated as a negative influencing factor on a country's progression regarding circular plastic usage. A European country being a net importer of recyclable plastics is in contrary assumed as increasing the share of circular plastic usage because it underlines that an economically efficient and adequate recycling infrastructure is in place in that respective country.

2.1.2 Social Indicators

Climate Strike Attendees:
Although the Friday for Futures demonstrations did not have a specific focus on plastic and its related waste management, the number of attendees, adjusted for population size, provide valuable insights into the degree of social awareness and willingness to act on environmental topics. Very low participation numbers hint at lower levels of social awareness and motivation to undertake tangible actions as well as display the degree of importance of environmental issues to the country's society. Despite not being commonly used in academic methodologies, the phenomenon of social movements such as the *Fridays for Future* demonstrations is receiving increasing popularity amidst academic literature such as Sommer, Rucht, Haunss, and Zajak (2019), Wahlström et. al (2019), or Huth (2019). It is therefore considered to be a relevant measure that adds valuable contribution to mapping the current state of circular plastic usage across Europe.

Media Mentions:
The role of media cannot be neglected in processes of complex socioeconomic changes such as the transition towards a circular economy. Media mentions, adjusted for population size, act as a valuable approximation for the prominence of the circular economy in the social

debate. To this end, media mentions concerning the circular economy are in fact utilised by the European Commission (2016) to serve, among others, as an approximation of societal behaviour. It should be noted that the amount of media mentions does not only reflect the awareness of consumers but also acts as an indication of how prominent the topic is among political agendas as well as the business sector.

Eco-Industry Revenue as % of total revenue

According to the European Environmental Agency (n.d., para. 1) the eco-industry entails "Companies providing goods and services for environmental protection. The term includes the provision of clean technologies, renewable energy, waste recycling, nature and landscape protection, and ecological renovation of urban areas." In light of the circular economy it is therefore a strong indicator for how much businesses are involved with their strides in making the economy as a whole more circular. Sarkar (2012) discusses how important it is for the eco-industry to develop in order to foster sustainable development and growth.

Purchases of remanufactured vs. novel products:

Remanufactured products are defined as a used product, which faulty components have been substituted, and which is sold with the same guarantee as a new product (European Commission, 2013). The circular economy will depend on citizens engaging in alternative forms of consumption. Hence, the readiness to adapt remanufactured products opposed to novel ones is a crucial component in assessing citizen's sentiment towards alternatives to purely linear economic consumption. As such, the assessment of remanufactured versus novel products constitutes an essential part of the European Commission's (2013) evaluation of a country's eco-innovation status.

Leased or rented a product instead of buying it:

Leasing or renting schemes are commonly advocated as a method to mitigate the extent of make, take, and dispose approach taken by numerous citizens (Ionascu & Ionascu, 2018; Financial Times, 2019). An increasing share of consumers willing to engage in such leasing or renting schemes could serve as a valuable approximation of citizen readiness to sway away from purely linear consumption behaviour. Very low prevalence of such schemes, on the contrary, hints at a lack of both demand and supply for comparable alternatives. In light of these considerations, the assessment of leased or rented versus novel products constitutes an essential part of the European Commission's (2013) evaluation of a country's eco-innovation status.

Usage of Sharing Schemes:

Sharing schemes can materialised in various ways. They may encompass formal sharing schemes such as car / bike sharing, or informal ones, like neighbours sharing their lawn mowers (European Commission, 2013). The underlying principle, however, remains the same. Shared, instead of individual, usage would reduce the time a certain product sits idle and hence increase the productive usage of respective resources. Once again, citizen willingness to engage in such schemes serves as a viable approximation of social readiness in adapting novel, less resource intensive, consumption methods. As such, assessing the

prevalence of sharing schemes in a particular country constitutes an essential part of the European Commission's (2013) evaluation of a country's eco-innovation status.

2.1.2 Business Indicators:

Patents:
The number of patents in a particular sector are often utilised as a proxy for innovation. An example of research utilising such indicator is constituted by e.g. Türkeli, Kemp, and Janzen (2019). In the specific context of circular economy, the focus was laid on patents related to recycling and secondary raw materials. By limiting the scope of patents to this specific field, the related data should allow for a sound approximation of domestic innovative capability in the business / industry sector.

People employed in CE related fields:
The people employed in CE related fields reflect both supply and demand for professional positions within a country's economy. Higher employment numbers arguably reflect increased opportunities in related sectors such as recycling, repairs, refurbishment, or waste separation. A low level, on the contrary, can be interpreted as a lack of both job opportunities as well as interest in finding employment in CE related fields. Practical usages of assessing employment in 'Green Jobs' such as the CE in academic methodologies can be found in e.g. Horbach, Rennings & Sommerfeld (2015) as well as Mitchell & Morgan (2015).

Circular Activity of Small & Medium Companies:
The respective data utilised in the research's scorecard stems from a large-scale enterprise survey carried out by the Flash Eurobarometer (European Commission, 2016). Dimensions include the usage of water, energy, waste generation, recycling, usage of recycled or refurbished materials, and re-design of products for circular requirements and lower resource consumption. The survey's results constitute a valuable addition to the scorecard as it captures firms' responses to their regulatory as well as commercial environment. The indicator's merit is further supported by the fact that it is utilised by the European Commission to assess circular business operations.

2.1.3 Regulatory Indicators:

Government Grants for CE activities carried out by SMEs:
Government grants represent a sub-category of overall financing sources for CE activities, such as e.g. bank loans or self-financing. Isolating the share of government grants can serve as a valuable indication of the degree of government support towards SMEs in carrying out circular practices. Clearly, a high share of government grants demonstrates strong government commitment in supporting an increasing share of CE practices among SMEs. Markedly low grants, on the contrary hint at a lack of such support. Government grants, in the context of assessing socio-technical transitions, are commonly used in academic literature. Examples include the work of e.g. Owen, Brennan, and Lyon (2018), Ilić & Nikolić (2016), as well as Rizos et. al (2016).

Bottle Deposit Schemes:

The degree and nature of a country's bottle deposit scheme gives indication about the extent to which the government deploys incentives towards consumer behaviour. Very high refund amounts imply a stronger presence of cost nudges to direct purchasing and recycling behaviour. Lower amounts, on the contrary, showcase lower markups on products such as plastic bottles as well as lower incentives for consumer to return such products. In turn, insufficient refund amounts may prompt more consumers to dispose their plastic bottles instead of returning them to be recycled. The described deposit schemes find popular application in various academic publications such as Grimes-Casey et. al (2007) Viscusi, Huber, and Bell (2011), as well as Schuyler et. al (2018), to only name a few.

Plastic Recycling Centres per Million Inhabitants:

The number of plastic recycling centres per million inhabitants acts as an approximation of the extent of a country's plastic waste management infrastructure. Paired with the country's overall recycling rate, it provides a fair estimate of a country's recycling capability. A clear fallacy of this indicator is constituted by a lack of available data which represents a plant's efficiency and size. As such, countries with highly efficient recycling plants may require a lower total number of facilities. Despite these methodological constraints, assessing the prevalence of domestic recycling centres can act as a valuable approximation of a country's waste stream management and is utilised by authors such as Faraca, Martinez-Sanchez, & Astrup (2019), as well as Huysman et. al (2017).

Plastic Bag Tax Rates & Bans:

The extent of taxation or the presence of plastic bag bans provides a fair estimation of the degree of government actions to curb the use of single-use plastic bags. Higher rates or even bans indicate higher cost transfers to the consumer side as well as the strictness of regulatory enforcement. Lower rates or even the absence of any taxation clearly hint at a lack of cost nudges to influence the plastic consumption of consumers. The effect of plastic bag taxes or bans on consumer behaviour has been subject to vivid discussion among the academic community. Prevalent examples include the work of e.g. Brennan & McLeod (2009) or Martinho, Balaia, & Pires (2017).

Publication Mentions:

Although not specific to scientific publications centred around the circular economy, the overall number of domestic scientific publications act as a sound proxy for a country's economic vibrancy. Overall, the number of scientific publications is commonly used as a proxy for a country's or sector's innovative capabilities or vibrancy. Methodological examples include the work of e.g. Lerner & Wulf (2007), as well as Hall & Jaffe (2012).

2.2 Survey

In addition to building our model upon existing data, we aim to extend the existing measures in place by collecting primary data. Therefore, we created a survey to send to experts in the field of circular economy. Thereby, we aim to gather direct feedback about the situation of circular plastic usage in that particular EU country and identify the role of the main drivers in achieving this.

Furthermore, the answers allow to assess whether the results on a country's circularity derived from the hard measures are reflected by the subjective experience (sentiment) of a country's current state of affairs in sustainable plastic waste management. In addition the surveys are a useful tool to identify targets where policies could act as efficient incentives. Although it is a subjective measure, experts are able to make grounded assessments of the current state of their country in the progress of achieving circularity of plastic waste management.

The survey design consists of three questions, each addresses another driver towards circularity namely: the government, the consumers, the businesses. The assessment of the actions undertaken by the respective party are made on a scale from 1 to 10, with the following indication of nuances: 10-9: Effective contribution, 8-6: Mostly effective contribution, 5-3: Insufficient contribution, 2-1: Largely failing to contribute.

The particular questions that are to be answered are the following:

3. On a scale of 1-10, how do you perceive the effectiveness of actions undertaken by your government to promote the circular usage of plastic and related waste products?
4. On a scale of 1-10, to what extent do consumers contribute to the circular usage of plastic and related waste products? Examples may include more conscious product selection, responding to recycling incentives, and actively aiming to reduce the usage of plastic products.
5. On a scale of 1-10, to what extent do you perceive businesses to engage in the circular usage of plastic and related waste products? Examples may include active waste reduction, recycling generated waste, or incorporating recycled materials into novel products.

The selection of survey recipients, hence the expert selection, was made to a large share by a LinkedIn research, researching for e.g. circular economy expert, circular economy consultant, circular economy policy maker, circular economy professor, sustainability consultant, etc. Furthermore, the latest reports, publications and events on circular economy where checked for expert speakers, specialised journalists and else. In addition, NGOs, foundations and think tanks in the field of circular economy were contacted.

In total over 80 experts were contacted. The substantial part was contacted via mail while some were also contacted via phone to ensure a response. However, all survey answers were

collected in a written manner and are saved respectively. The recipients were asked for permission to publish their answers and whether they liked their answers to be anonymized.

Despite the effort, time and resource constraints did not allow to collect enough answers to create a yet meaningful indicator out of the received answers. To date we received 21 answered surveys in total, being 1 to 3 answers for each EU country except receiving no answers for: Croatia, Czechia, Denmark, Germany, Greece, Ireland, Luxemburg, Malta, Romania, Slovakia.

In order to create a meaningful indicator that could be implemented in the model, we argue that at least 12 experts need to answer the survey for a specific country and that there is an equal distribution of whether these experts belong to the government, businesses, NGO, Academic sector. The diversity of backgrounds is important in order to control for biased answers, e.g. rating the actions undertaken by the government higher than actions undertaken by others when working for the government.

Limitations of a survey indicator are therefore: a subjective nature, a single point in time assessment and a lack of informational value about causality.

Given the mentioned reasons we decided to not yet include our survey indicator to the model and to not draw any comparison between the findings from the responses and the results of our scorecard, especially because of our current low response rate and the simple lack of responses for some countries.

In a nutshell, we see the survey indicator as an ongoing project that will add valuable and valid insights when enough responses are collected and the limitations are carefully taken into consideration in the analysis of the results. It will shed light on where policies can be targeted at to efficiently increase the countries circularity of plastic waste management. Furthermore, the survey indicator, allows to assess whether the results on a country's circularity derived from the hard measures are reflected by the subjective experience (sentiment) of the country's current state of affairs.

2.3 Limitations & Future Research

Limitations to the research's finding are predominantly limited to the specifics of data collection and analysis. Whereas data on domestic recycling rates is largely accessible, quantitative information on aspects such as reuse of plastics or their reduction are frequently unavailable. Similarly, many datasets do contain information about e.g. the circular material usage rate of a certain country but do not allow for a plastic-specific distinction. Although still providing a fair assessment of a country's domestic waste management status, the lack of plastic-specific data does present an impediment to the accuracy of the research's findings. Lastly, the accuracy of the presented PCI indicator could be improved through more refined data in each of the selected sub-categories. Examples could include complementing existing sub-indicators with the average distance of consumers to the next recycling plant, plastic-

specific waste management costs, as well as opportunities to repair or substitute prominently used plastic products.

In some instances, quantitative estimates may be skewed due to limited options of making them comparable across countries. Despite strong efforts to normalise estimates across countries by e.g. adjusting for population size or economic activity, certain fallacies remain. As an example, the research compared the number of recycling plants, adjusted for population size, across countries. A problem of this approach may be constituted by the fact that recycling plants of a certain country may be more efficient than those of another and hence decrease the merits of assessing the mere number of recycling plants.

Results selected through the conducted survey may only offer limited representativeness due to a limited subsets of respondents. In light of both time and resource constraints, each country only had limited respondents. Additionally, responses are only comparable to a limited extent as respondents often had different occupations and thus perception of certain country's sector. It is crucial to highlight, however, that the collection of more respondents is ongoing. As such, over time, both representativeness and comparability of the collected results will increase and thus allow to complement the existing analysis of quantitative datasets with country-specific evaluations.

Future research will be essential in extending and leveraging the presented findings towards different contexts. As described in section three, our research opted for an equal weighting of the selected sub-categories. Future research may benefit from altering these specific weights to allow for a more refined assessment of a country's approach towards managing plastics and related waste products.

Moreover, future research on circular plastic management should pay specific attention to the role played by emerging alternatives such as bioplastics. Although profound quantitative analyses of such alternatives are clearly lacking at the moment, their contribution towards increasing circularity will be vital to assess as research progresses.

To allow for a holistic assessment of a country's state of circular waste management, future research should broaden its focus to incorporate alternative waste streams such as electronics, metals, organic materials, and food. Eventually, the concept of circularity is all-encompassing and each of its components should be thoroughly assessed. As such, we call upon future researchers to contribute to a holistic assessment of circular waste management in the EU. In doing so, the merits of potential cooperation towards waste stream management across member states would provide a valuable contribution to assessing the state of circular practices in the EU

Finally, it should be noted that the concept of circularity is by no means limited to the EU. Hence, the scientific debate concerning the circular economy could be greatly advanced through a comparative analysis of circular practices across the globe. Doing so would allow for a better understanding of incumbent challenges and barriers that would need to be overcome to gradually increase the circularity of global resource management.

3. Results & Discussion

3. Results & Discussion

Section Focus

How do EU countries perform relative to each other in their circular management of plastics?

3.1 Overall Results

Rank	Country	Overall Score	Benchmark Average	Average Consumer	Average Business	Average Government
1	Netherlands	6.61	6.80	6.81	6.42	6.41
2	Germany	6.30	5.29	6.74	7.13	6.05
3	Finland	5.73	4.08	7.14	5.95	5.62
4	Sweden	5.70	5.49	6.38	5.24	5.81
5	Spain	5.70	5.14	7.22	6.12	3.86
6	Czechia	5.59	6.44	4.44	6.47	4.78
7	Slovenia	5.56	5.36	7.11	4.19	5.59
8	Denmark	5.53	5.89	5.34	5.83	5.75
9	Belgium	5.49	5.62	6.30	5.97	3.99
10	Lithuania	5.47	5.83	4.97	4.25	6.92
11	Austria	5.42	5.33	5.62	6.68	4.04
12	Italy	5.22	5.20	5.30	5.51	4.03
13	UK	5.01	5.11	5.63	6.34	3.79
14	France	4.90	4.67	5.92	5.82	3.22
15	Poland	4.87	5.12	3.71	5.68	4.96
16	Latvia	4.67	5.08	4.62	4.36	3.92
17	Estonia	4.64	4.32	4.25	3.58	6.39
18	Luxembourg	4.49	4.71	6.12	5.62	2.23
19	Ireland	4.49	3.86	5.32	5.41	3.35
20	Bulgaria	4.39	6.15	3.20	3.19	4.44
21	Portugal	4.33	4.87	4.36	4.17	4.18
22	Croatia	4.24	5.22	2.80	3.79	5.54
23	Hungary	3.95	3.91	3.67	3.75	4.48
24	Romania	3.92	5.37	2.90	3.19	4.01
25	Slovakia	3.87	4.65	3.88	3.55	3.59
26	Greece	3.78	4.14	3.83	3.76	3.39
27	Cyprus	3.58	4.30	3.34	4.27	2.40
28	Malta	3.49	3.49	3.00	4.28	3.20

Figure 11: Plastics Circularity Index (PCI) Scorecard

As evident from the Plastics Circularity Index (PCI), the top five countries leading in the circular management of plastics and related waste products are constituted by the Netherlands, Germany, Finland, Sweden, and Spain respectively. The very bottom of the scorecard, in turn, is occupied by Malta, Cyprus, Greece, Slovakia, and Romania. The following sections will assess each sub-component in more detail. It should be noted that a "10" in each of the subsections does not indicate impeccable performance but rather highlights an exceptional performance in this aspect, relative to other countries. Concrete details about each scorecard's individual reasoning and methodology can be found in Appendix A.

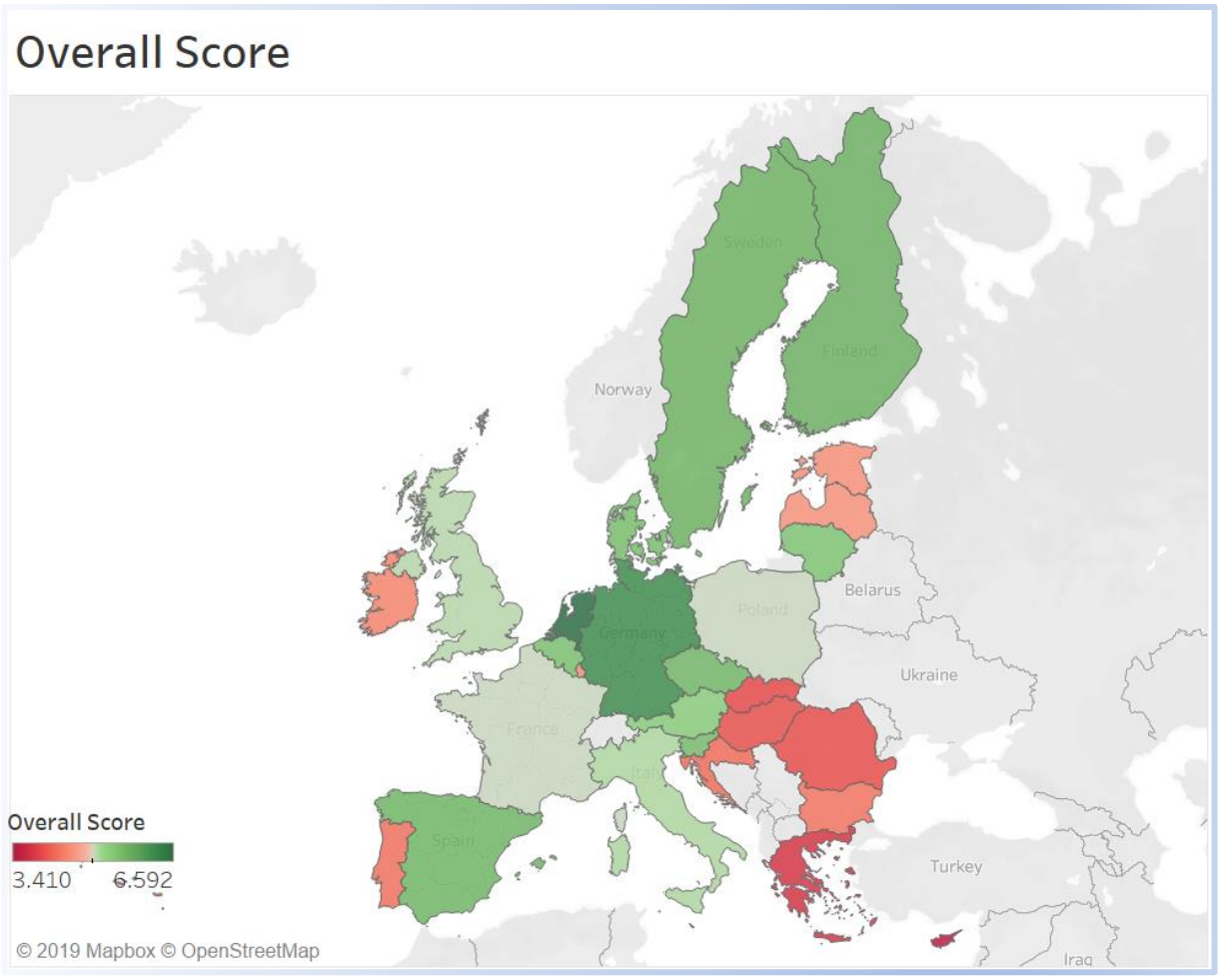


Figure 12: Map of the overall scores

3.2 Benchmark Scores

	Country	Benchmark Average	Plastic recycling 2017 (missing filled in with 2016 data)	Plastic packaging Waste kg per capita	Share of incinerated post-consumer plastic waste	Share of landfilled post-consumer plastic waste	Net Trade of recyclable Plastics per capita 2018 (Imports divided by exports)	Circular Material Usage (CMU)
1	Netherlands	6.80	6.12	4.84	1.51	10.00	8.34	10.00
2	Czechia	6.44	7.16	6.08	7.04	3.33	10.00	5.01
3	Bulgaria	6.15	7.87	7.35	8.84	0.00	10.00	2.83
4	Denmark	5.89	4.68	3.46	2.28	9.50	10.00	5.40
5	Lithuania	5.83	9.02	6.00	6.14	3.33	7.53	2.97
6	Belgium	5.62	5.41	4.71	1.77	9.67	2.14	10.00
7	Sweden	5.49	5.88	5.80	2.28	9.83	4.47	4.68
8	Romania	5.37	5.65	6.91	8.33	0.33	10.00	0.99
9	Slovenia	5.36	7.34	6.08	4.98	5.00	3.13	5.60
10	Austria	5.33	4.06	4.04	1.00	9.83	6.07	6.99
11	Germany	5.29	5.83	3.43	2.15	10.00	2.80	7.51
12	Croatia	5.22	4.53	7.71	9.23	0.00	6.93	2.90
13	Italy	5.20	5.15	3.62	5.76	4.00	2.66	10.00
14	Spain	5.14	5.82	4.26	7.56	3.50	4.33	5.40
15	Poland	5.12	4.20	5.36	6.14	2.83	5.44	6.72
16	UK	5.11	5.61	3.98	4.08	6.33	0.66	10.00
17	Latvia	5.08	4.45	6.41	8.84	0.17	8.03	2.57
18	Portugal	4.87	4.24	3.60	6.14	3.83	10.00	1.38
19	Luxembourg	4.71	4.06	1.54	1.77	9.83	6.76	4.28
20	France	4.67	3.22	4.30	4.47	4.50	1.51	10.00
21	Slovakia	4.65	6.37	6.16	7.04	2.17	2.92	3.23
22	Estonia	4.32	3.22	1.42	2.41	9.17	1.95	7.78
23	Cyprus	4.30	7.57	6.62	9.61	0.00	0.46	1.52
24	Greece	4.14	5.03	6.97	9.74	0.00	2.25	0.86
25	Finland	4.08	3.22	6.09	0.00	9.83	1.87	3.49
26	Hungary	3.91	3.89	4.50	7.43	0.50	2.92	4.22
27	Ireland	3.86	3.71	0.00	2.15	8.50	7.70	1.12
28	Malta	3.49	2.86	4.42	10.00	0.00	0.22	3.43

Figure 13: Table of benchmark indicator scores

Each country's benchmark score serves as general indication of a country's progress towards a circular management of plastic and related waste products. As showcased by top performing countries along these dimensions are the Netherlands, Czechia, Bulgaria, Denmark, and Lithuania. The lowest performers, on the contrary are constituted by Malta, Ireland, Hungary, Finland, and Greece, respectively.

It should be highlighted that the Netherlands remain at the top of the scorecard while subsequent positions vary greatly from the overall scoring. Especially surprising are the sudden low performances of Finland as well as a strong rise in the ranking by Bulgaria and Lithuania. These differences stress the importance of not relying on singular indicators but rather retaining a holistic perspective to draw conclusions and build recommendations upon. Nonetheless, the presented Benchmark remains a vital component of the overall scorecard as it highlights performance in critical areas around the management of plastic waste.

Irrespective of a specific country score, particular attention should be paid to sub-indicators that stand out due to exceptionally bad performance. In the context of figure 13, distinctly low-performing areas are constituted by waste incineration, waste landfilling, net trade of recyclables, as well as circular material usage. Hence, it will be crucial to pay particular attention to these areas when devising policy recommendations. Section five will address these concerns in detail.

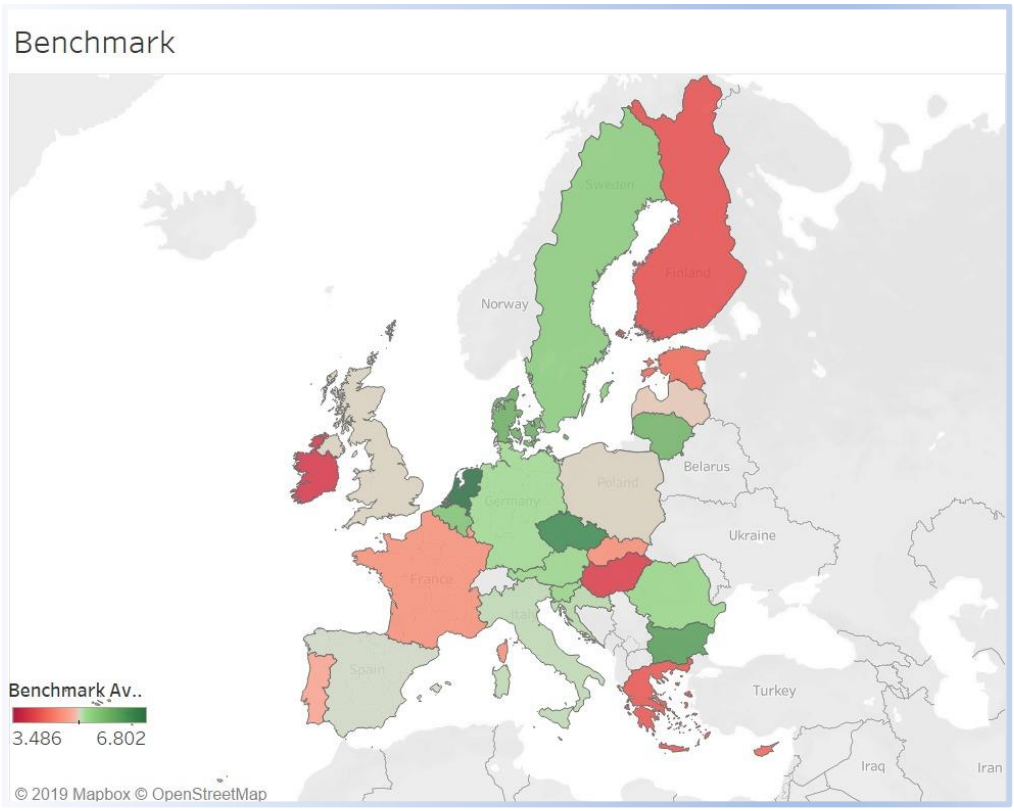


Figure 14: Map of average benchmark scores

3.3 Consumer Scores

	Country	Average Consumer	Climate strike Attendees 20-27.09.2019	Media Mentions	Eco-industry revenue, in % of total revenue	Bought a remanufactured product	Leased or rented a product instead of buying it	Used sharing schemes
1	Spain	7.22	10.00	10.00	6.53	6.17	4.72	5.90
2	Finland	7.14	5.12	10.00	6.04	5.50	6.21	10.00
3	Slovenia	7.11	10.00	10.00	8.07	4.83	4.97	4.79
4	Netherlands	6.81	3.22	10.00	10.00	5.83	6.46	5.35
5	Germany	6.74	10.00	5.92	3.33	8.00	7.45	5.71
6	Sweden	6.38	10.00	7.91	5.02	3.83	6.71	4.79
7	Belgium	6.30	3.50	8.20	4.41	5.83	9.19	6.64
8	Luxembourg	6.12	8.91	10.00	0.00	4.83	6.71	6.27
9	France	5.92	4.37	5.90	6.72	5.83	6.21	6.45
10	UK	5.63	8.23	3.89	4.39	7.50	5.71	4.06
11	Austria	5.62	10.00	4.95	1.72	5.67	6.21	5.16
12	Denmark	5.34	5.76	9.95	3.18	3.83	4.72	4.61
13	Ireland	5.32	10.00	2.86	2.76	5.50	6.21	4.61
14	Italy	5.30	10.00	6.17	4.98	3.67	3.48	3.50
15	Lithuania	4.97	0.04	2.96	5.05	5.50	7.95	8.29
16	Latvia	4.62	0.14	1.68	7.83	5.17	5.71	7.19
17	Czechia	4.44	0.25	1.54	8.33	5.83	6.46	4.24
18	Portugal	4.36	3.89	2.12	6.04	4.83	3.73	5.53
19	Estonia	4.25	1.37	1.67	6.20	4.33	7.70	4.24
20	Slovakia	3.88	0.32	0.95	5.50	4.83	6.71	4.98
21	Greece	3.83	0.13	5.86	3.84	4.17	3.48	5.53
22	Poland	3.71	1.99	0.84	5.75	6.17	3.48	4.06
23	Hungary	3.67	1.24	0.52	5.28	6.00	4.72	4.24
24	Cyprus	3.34	2.37	5.95	0.07	4.00	3.23	4.42
25	Bulgaria	3.20	0.17	2.28	6.18	4.50	2.73	3.32
26	Malta	3.00	3.21	4.45	3.84	2.00	1.74	2.76
27	Romania	2.90	0.15	1.39	7.05	4.17	2.24	2.40
28	Croatia	2.80	0.38	5.97	0.00	2.67	2.24	5.53

Figure 15: Table of consumer indicator scores

The composite score of the various sub-scores serves to capture general consumer / citizen awareness as well as willingness to act towards circular resource management. Assessed from this perspective, the lead is taken by Spain, Finland, Slovenia, the Netherlands, and Germany, respectively. On the contrary, Croatia, Romania, Malta, Bulgaria, and Cyprus, occupy the lowest positions.

The distribution among the five top performing countries only changes slightly, with Spain and Finland rising to the top whereas the Netherlands and Germany showcase a marginally lower ranking. Noticeably, Slovenia is now among the top five performing countries, whereas it previously ranked seventh in the overall ranking. While the leading positions are largely in line with the overall scorecard, a significant drop in ranking of Bulgaria and Lithuania, relative to the overall scorecard, is noticeable.

Considering the individual sub-indicators, particularly bad performances are noticeable for both climate strike attendees as well as media mentions. As both these sub-indicators

approximate social awareness towards the circular economy and environmental issues in general, these dimensions are in clear need of improvement. Noticeably, awareness seems to be particularly low in many Eastern European countries as well as in Portugal, Greece, and Malta.

Additionally, attention should be paid to product offerings making use of remanufacturing, leasing, or sharing schemes. Although the scoring is these areas is not as low as for e.g. awareness, the majority of countries scores in the lower half of the ranking. As such, it will be vital to foster both demand and supply for the aforementioned product schemes across EU member states.

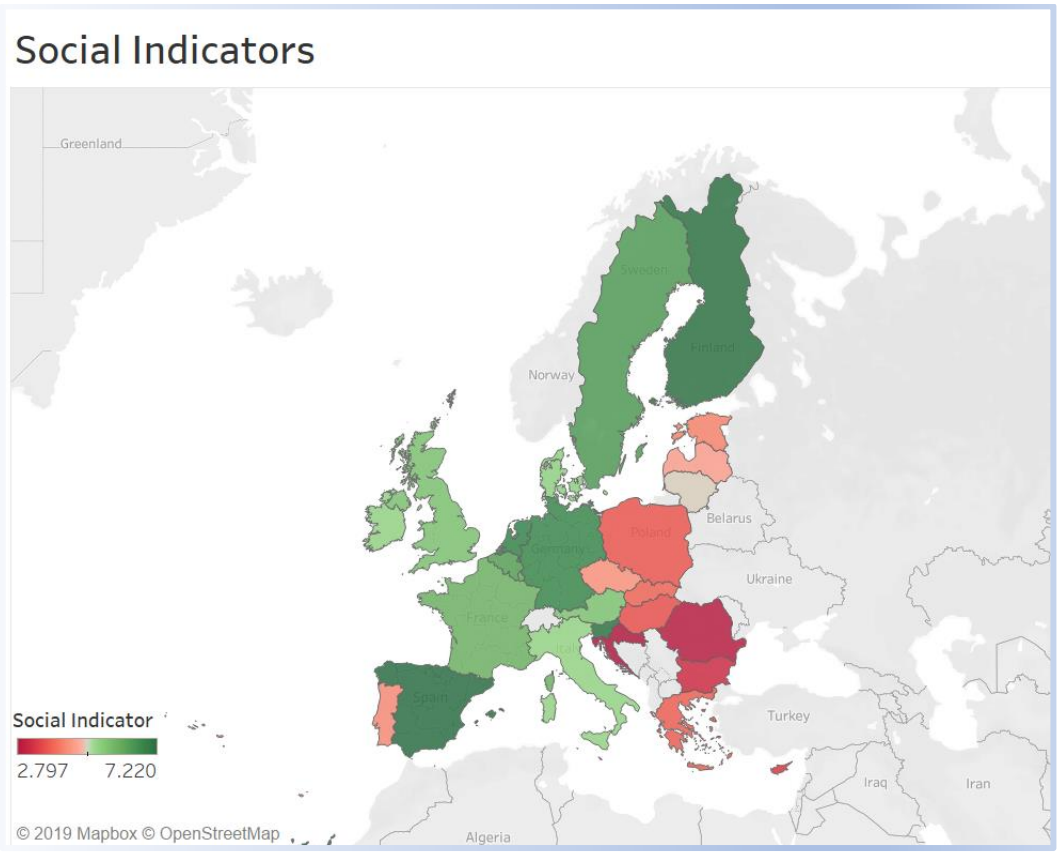


Figure 16: Map of average consumer scores

3.4 Industry Scores

Position	Country	Average Business	Patents	Difficulty to Impleme	People Employed in CE	Circular activities of small
1	Luxembourg	7.29	10.00	5.99	N/A	5.88
2	Austria	6.49	10.00	5.99	4.16	5.81
3	Czechia	6.45	10.00	4.52	N/A	4.84
4	Germany	6.41	10.00	6.16	N/A	5.40
5	Finland	6.35	10.00	5.34	4.60	5.47
6	Denmark	5.81	8.05	7.06	3.79	4.36
7	Ireland	5.76	5.96	5.17	N/A	6.16
8	Netherlands	5.52	8.58	5.17	3.29	5.05
9	Malta	5.51	4.28	5.66	N/A	6.57
10	Belgium	5.29	7.34	4.93	3.10	5.81
11	Spain	5.16	4.20	4.85	5.69	5.88
12	Latvia	5.13	4.79	3.95	8.06	3.74
13	UK	5.12	3.32	6.24	N/A	5.81
14	Poland	5.09	6.36	3.54	6.16	4.29
15	Cyprus	5.03	4.18	5.75	5.55	4.64
16	Slovenia	4.85	3.38	5.34	5.83	4.84
17	Sweden	4.84	4.20	5.91	4.35	4.91
18	Lithuania	4.84	3.03	5.58	7.50	3.25
19	France	4.77	5.87	3.87	4.24	5.12
20	Portugal	4.59	1.88	5.75	5.08	5.67
21	Croatia	4.42	0.60	5.58	6.11	5.40
22	Italy	4.39	3.03	4.19	5.72	4.64
23	Estonia	4.16	2.49	5.50	5.61	3.04
24	Hungary	3.98	2.45	4.19	5.36	3.94
25	Slovakia	3.97	2.40	4.27	4.91	4.29
26	Greece	3.70	0.21	4.93	4.60	5.05
27	Romania	3.37	1.23	3.54	4.41	4.29
28	Bulgaria	3.29	1.08	4.11	4.91	3.04

Figure 17: Table of industry indicator scores

In conjunction, the various sub-indicators capture a country's vibrancy of economic activities centred around the concept of circularity. In this regard, Germany, the Netherlands, Austria, Czechia, and the UK position themselves at the top of the scorecard. The lowest performing countries, on the contrary, are Bulgaria, Romania, Slovakia, Estonia, and Hungary.

Interestingly, the UK showcases a marked increase in its ranking, relative to its overall position in the **PCI**. Moreover, it should be noted that Bulgaria ranks lowest when considered from an industry / business angle whereas it ranked among the top five performers from a consumer / citizen perspective.

Considering the specific sub-indicators, areas with noticeably low scores are constituted by the number of people employed in CE related fields, as well as circular activities of SMEs. Hence, a multifaceted approach to increasing economic activity centred around circular activities and addressing incumbent difficulties faced by businesses will be essential. Section five will address this concern in more depth.

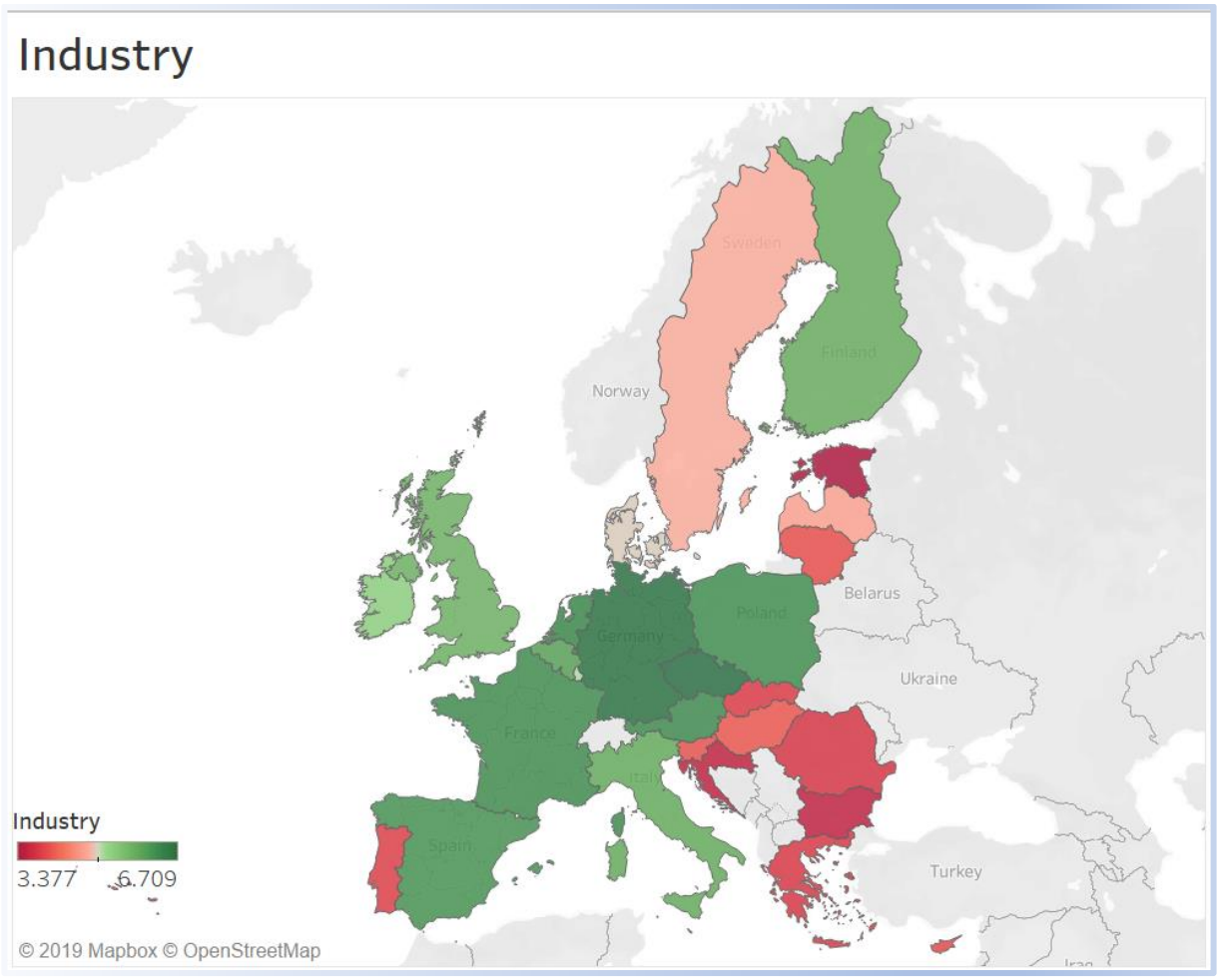


Figure 18: Map of average industry scores

3.5 Regulatory Scores

	Country	Average Government	Self Financing of Circular Activities by Companies	Deposit bottle Scheme	Plastic Bag Tax Rates and Bans	Plastic Recycling Centers per million inhabitants	Publication Mentions
1	Lithuania	6.92	4.90	10.00	6.59	9.92	3.22
2	Netherlands	6.41	4.62	10.00	3.78	5.21	8.42
3	Estonia	6.39	4.34	10.00	5.50	7.75	4.34
4	Germany	6.05	5.86	10.00	3.97	4.94	5.46
5	Sweden	5.81	4.62	10.00	3.43	1.01	10.00
6	Denmark	5.75	4.62	10.00	3.23	0.89	10.00
7	Finland	5.62	4.21	10.00	3.44	0.46	10.00
8	Slovenia	5.59	5.24	0.00	5.18	8.64	8.89
9	Croatia	5.54	5.38	9.89	6.58	3.09	2.75
10	Poland	4.96	5.03	0.00	7.28	10.00	2.47
11	Czechia	4.78	4.41	0.00	6.15	10.00	3.35
12	Hungary	4.48	4.83	0.00	6.89	7.82	2.87
13	Bulgaria	4.44	5.52	0.00	8.43	7.21	1.05
14	Portugal	4.18	4.62	0.00	5.08	3.22	7.97
15	Austria	4.04	5.17	0.00	3.83	4.35	6.84
16	Italy	4.03	5.59	0.00	4.32	5.69	4.57
17	Romania	4.01	5.03	0.00	8.16	4.56	2.32
18	Belgium	3.99	5.52	0.00	3.85	2.92	7.65
19	Latvia	3.92	4.69	0.00	6.04	6.57	2.28
20	Spain	3.86	5.52	0.00	4.65	3.18	5.97
21	UK	3.79	4.76	0.00	3.86	3.05	7.30
22	Slovakia	3.59	5.10	0.00	6.17	4.22	2.46
23	Greece	3.39	4.90	0.00	5.18	2.14	4.73
24	Ireland	3.35	5.10	0.00	3.76	2.65	5.26
25	France	3.22	5.31	0.00	3.89	1.68	5.21
26	Malta	3.20	5.52	0.00	5.04	5.45	0.00
27	Cyprus	2.40	4.55	0.00	4.78	0.00	2.66
28	Luxembourg	2.23	5.38	0.00	3.46	0.00	2.30

Figure 19: Table of regulatory indicator scores

The presented sub-indicators serve to capture the extent of government schemes to either incentivise or dis-incentive activities in certain sectors. The highest performing countries in this regard are constituted by Lithuania, the Netherlands, Estonia, Germany, and Sweden. The lowest rankings, on the contrary, are occupied by Luxembourg, Cyprus, Malta, France, and Ireland.

Interestingly, both Lithuania and Estonia perform significantly better in this sub-category, compared to their overall PCI ranking. The lower parts of the ranking show no exceptional developments and remain in line with the scorecard's overall ranking.

The sub-indicator scores showcased by Figure 19 highlight the need for stark improvements in various areas. To begin with, government grants or subsidies to SMEs remain fairly low across the entire set of Member states are in clear need of improvement. Another area in critical need of improvement is constituted by domestic bottle deposit schemes. Across the EU, only few countries deployed stringent schemes whereas a majority of members fails to implement any notable incentive schemes. Plastic bag tax rates are mandatory in each member country, adhering to the EU single-use plastic directive. Despite being legally

binding, execution of the Directive vary greatly across countries and both organization and implementation often remain insufficient (European Commission, 2018).

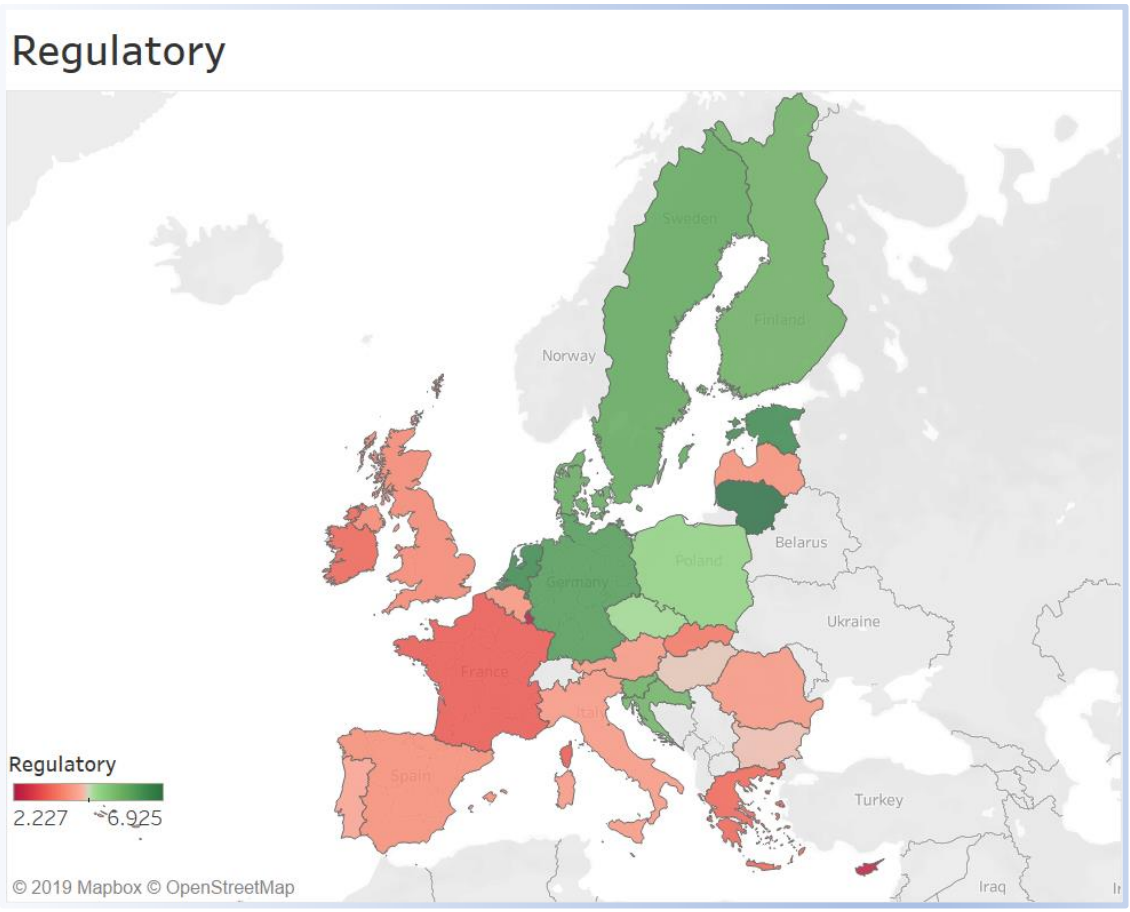


Figure 20: Map of average regulatory score

4. Recommendations

4. Recommendations

Building on the previous' sections results, the following focus objectives are proposed.

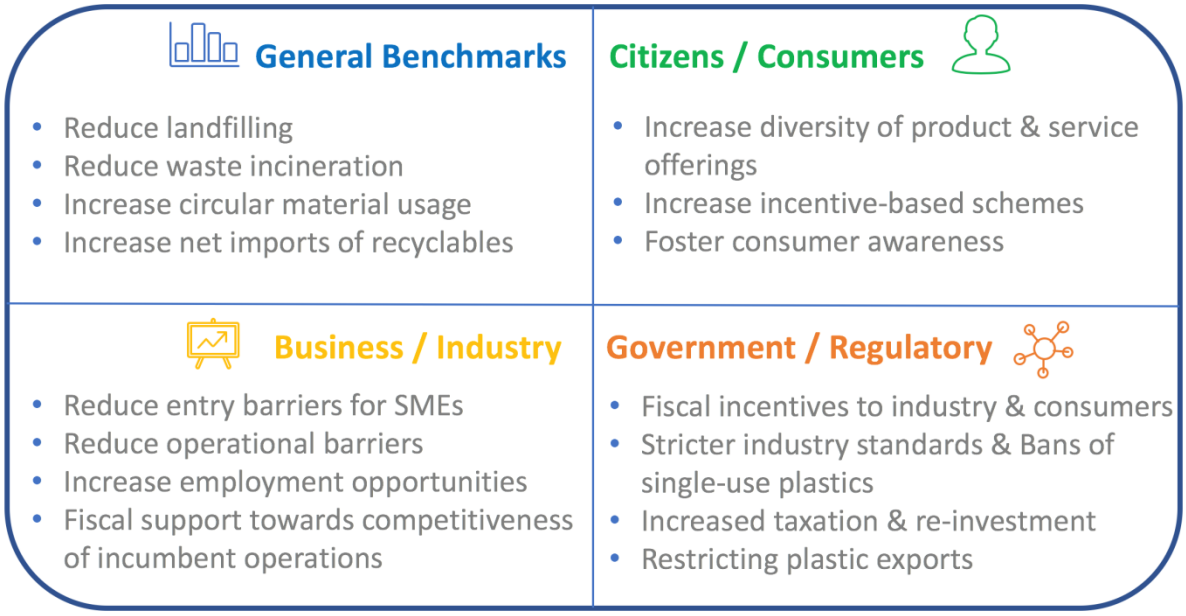
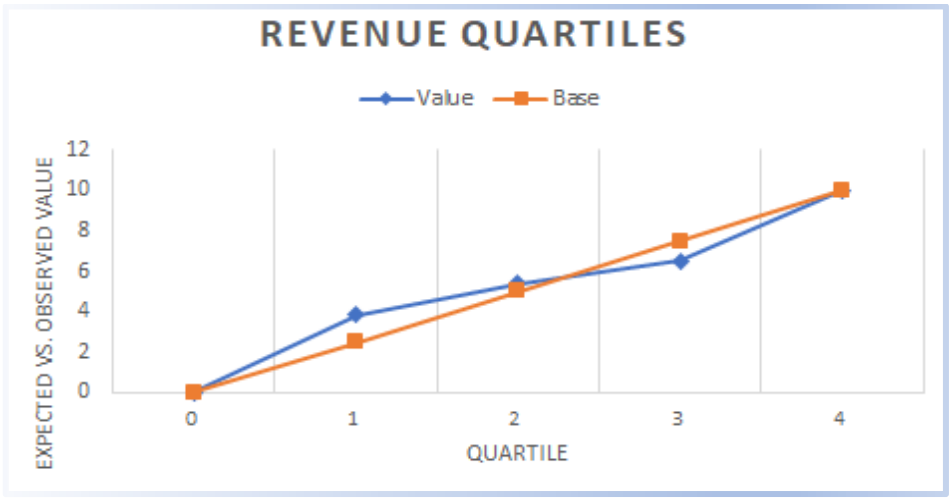


Figure 21: Proposed Focus Objectives

1) Increasing Diversity of Feasible Alternatives:

As highlighted by Geels (2004), consumers constitute a vital component in achieving significant changes of a country's economic structure. Hence, recommendations towards consumption behaviour will be treated in additional depth. When observing the scorecard data, a sector that had notable differences between high and low scoring countries was the consumer sector. Our objective in creating policy should therefore be to equalize and increase indicator scores in Media Mentions of CE and Consumer Revenues in CE. These two indicators present a good opportunity for insight: Media Mentions act as the awareness consumers receive about CE, while the Revenue indicator serves as a representation of how that awareness is acted upon in the market.

In Figures 1 and 2 below, the scorecard results for the two indicators are analysed to find quartile values. These results are then compared with baseline quartiles that are even to the percentage they represent (e.g. 25% = 2.5, 50% = 5, etc.). Deviations from the baseline quartile line indicate an over or underperformance of that quantile. Within our eco-industry revenue graph, we see that countries with lower scores are outperforming their quartile prediction. Meanwhile, higher scoring countries are below what we'd expect from their quartile. The opposite is true for media mentions indicators. Instead, countries with higher levels of media mentions are outperforming expectations, and vice versa.



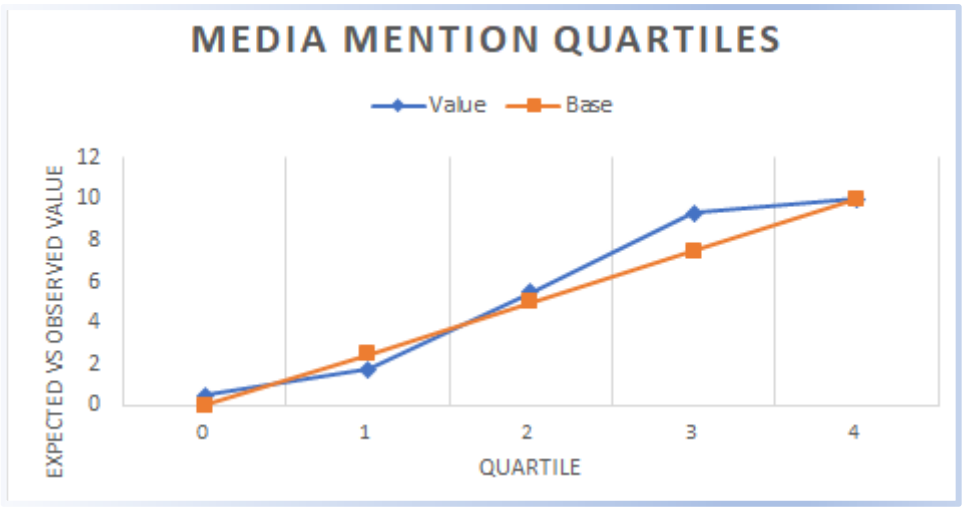


Figure 22: Revenue & Media Mention Quartiles

Why would countries with supposedly higher awareness be spending less of their income on CE related goods? In a study on Dutch consumers, Pellikaan and van der Veen (2002) argue that consumers respond negatively when they feel their freedoms of choice are being threatened. In societies that may have more awareness of CE, the process of creating awareness may backfire and encourage negative responses to CE.

Our policy response to this phenomenon is to encourage governments to increase their involvement in advancing CE with the specific goal of creating a more diverse market. Increasing product diversity enhances consumer choice. This policy action fulfils objectives for both actionable awareness and increasing government support for the CE industry.

A specific example of policy that would meet these qualifications would be a government subsidy program to consumer-facing industries in the CE system. We justify the use of subsidies under the idea that government intervention is acceptable to address externalities. Linear economies do not appropriately price products as they do not include social costs such as environmental pollution or resource depletion (Andrew, 2008). Therefore, CE products that internalize more social costs could justifiably be subsidized by the government.

2) Setting stricter incentives for both business & consumers

As showcased by section four, both incentive based systems such as bottle deposits as well as penalty-oriented schemes like bag taxes are severely lacking in several countries. (Oliver 1980) and Belsky (2008) showcased that incentive-based schemes are usually more effective in nudging consumer behaviour than penalty based systems. In line with their findings, Overall CE scorecard performance is typically higher when countries involve themselves in deposit-refund schemes than in plastic bag taxes. Based on our results, we recommend governments to increase efforts to reward consumers for activities that positively impact the CE. Incentive-based recycling has already been experimented with to some degree of success in the UK (Read 2012). Moreover, similar systems in the UK created incentives for reuse, meaning incentives can be deployed at multiple layers of the reduce, reuse, recycle structure. Hypothetically, systems that are more comprehensive and include more plastics than just bottles would have corresponding positive outcomes on consumer behaviour. Therefore, we recommend countries interested in raising their overall CE score to increase nationwide incentives for the recycling or reuse of plastic products.

It is vital to understand that the previously described recommendation does not aim to malign the implementation of bans on single-use products such as plastic bags. Whereas additional costs from e.g. taxation of such products may have a lower relative impact on consumer behaviour than incentive-based schemes, the efficiency of bans in nudging consumption behaviour is clearly proven (European Commission 2018 & Plastics Europe, 2019). Hence, we strongly advise domestic governments to consider implementing bans on single-use plastic products, rather than marginal taxation, to achieve marked changes in consumer behaviour.

3) Fostering Business Activities centred around CE:

Government funding in the form of grants or subsidies are critical in supporting the competitiveness of companies in emerging fields such as the circular economy. As there are always fewer producers than consumers to regulate, the implementation of producer subsidies may benefit from a higher ease of implementation relative to consumer-oriented subsidies. Furthermore, producers are usually registered with the government for tax purposes, codifying whether or not they are part of the CE, unlike consumers.

We recommend an immediate increase in subsidies that are then gradually reduced over time. Though subsidies can help to grow new industries, this “infant industry” protection can also shield firms from competition, thus allowing inefficiencies to persist. If subsidies are reduced over time, the firms are slowly exposed to competition. Market forces will then encourage more efficient firm behaviour, nullifying some of the concerns about producer subsidies (Szirmai 2010). Under the stipulations above, government subsidies would aid significantly in increasing businesses’ competitiveness in early stages and encouraging a wider variety of products for consumers. Such fiscal support should ideally assist both large companies as well as SMEs with less capital to retain a competitive stance in the market and thus indirectly raise the number of people employed in CE related fields in the medium to long term.

4) Improving domestic waste management capabilities

As showcased by section four, the majority of EU member states displays a clear lack in their capacity to fully recycle plastics and related waste products. Consequently, shares of both landfilling and incineration rates remain relatively high. Although incineration allows for some energy recovery, the environmental impact of toxins released to the air in the process renders it far from being an optimal solution. Hence, we strongly urge policy makers to direct additional efforts to increasing their country's recycling capacity while disincentivising the utilisation of landfills and incineration. Potential measures may include increased funding to establish government-run recycling centres or subsidise privately run operations to increase their profitability. Landfills and incineration, in turn, could be relatively disincentivised by pricing in the environmental cost of each respective method. An increased cost of disposing waste with these methods may also nudge individuals towards using recycling opposed to landfilling or incineration if it becomes relatively cheaper.

Additionally, a paradigm shift in international trade of plastic waste is of utmost importance. In recent decades, a feasible approach towards plastic waste management was constituted by shipping waste to countries with less stringent waste policies and lower disposal costs. In light of recent bans on plastic imports by China and the Philippines (McNaughton & Nowakowski, 2019; Endo, 2019), the incumbent approach of exporting a large share of plastic waste is clearly not feasible in the long-term. Not only does it put additional strain on the already burgeoning plastic generation in these countries, it is also often associated with more environmentally harmful methods of waste disposal. As such, it will be critical to restrict the export of plastic waste into foreign countries in pursuit of less stringent regulations or cost savings. Instead, a stronger focus on domestic waste management and increased cooperation among EU countries will be paramount in achieving a sustainable waste management infrastructure. The exact regulations to achieve a paradigm shift, both domestically as well as across EU countries unfortunately lies beyond the scope and expertise of this research. Nonetheless, we urge researchers and policy makers alike to treat the improvement of domestic waste management infrastructure with utmost relevance.

5. Conclusion

5. Conclusions

Through our process of researching the circular economy, identifying indicators, collecting data, and analysing our results, we have some thoughts to leave our readers with regarding future research within the CE. Firstly, we want to stress the importance of sustainability in the CE. As discussed in our literature review, circularity does not mean sustainability. Extremely isolated communities may contribute to plastic waste streams, however, transporting that waste to processing facilities leads to a net negative environmental impact. Similarly, recovery, defined as recycling and incineration under the CE, could become problematic as carbon emission concerns grow. Energy recovery through incineration is a valuable process, but our data shows that countries who incinerate at highest rates often perform the worst in overall scores. The correlation could be worrying. These kinds of concerns represent opportunities for further research in CE.

In general, data is difficult to come by, incomplete, and often aggregated at levels that make analysing individual waste streams complicated. As a result, data collection must be given significant time within the research process. Primary data gathering should be anticipated. The CE is still relatively young in the EU, so existing databases are far and few between. Likewise, variation of data availability between countries means researchers will have to get creative, utilizing only a handful of countries to create metrics for application on a broader scale. Given the complexity and comprehensiveness of the CE in Europe, we suggest maximizing the data captured. Finally, our main output was a scorecard that compared countries to each other. Therefore, country performance is mostly relative. Future research would support the advancement of the CE if they were to focus on more objective performance analysis. For example, seeing the effect of certain indicators on the overall recovery rate would help EU Member States to better target areas of their economy to increase performance in the most efficient manner. Though this may be difficult given current data restrictions, we hope that this report will assist in future efforts for empirical analyses of the circular economy.

The results of our comparative analysis show variation between individual indicator scores and aggregated CE performance. The CE is highly stratified, meaning that comparative performance is best achieved by comprehensive outlooks. This includes producers, consumers, and governments that can perform together on an institutional level, in addition to the physical infrastructure metrics from our benchmark section. Responses to low scorecard outputs are not trivial. To address societal, and even global, problems will require market-wide actions by all actors analysed in this report. The CE is still in early stages of its final development, and research should respect it as such.

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Appendix A: Indicators Considerations

Indicator ID	Name	
		Note: Populations used for scaling purposes come from World Bank 2018 Estimates
1	Plastic Recycling	Indicator shows percentage of plastic packaging waste recycled at country level per year
2	Plastic Packaging Waste per Capita	Indicator shows the mass of plastic packaging in kilograms disposed of, scaled to 1 million country inhabitants
3	Share of incinerated post-consumer plastic waste	Indicator shows the percentage of plastic waste that was disposed of by incineration, irrespective of whether or not incineration is done for energy recovery purposes. For this indicator, lower incineration levels were given higher score to indicate the negative impact of incineration on the environment, as well as the removal of material from the CE
4	Share of landfilled post-consumer plastic waste	Indicator shows the percentage of plastic waste that was disposed of by landfill. For this indicator, lower landfill levels were given higher score to indicate the negative impact of landfilling on the environment, as well as the removal of material from the CE
5	Net Trade of recyclable Plastics per capita 2018 (Import divided by export)	Indicator shows a ratio of imports to exports for recyclable plastics. The amounts of imports/exports were taken at a per capita level for the year 2018, then divided to reach the ratio.
6	Circular Material Usage	Indicator shows the circular material use rate (CMU rate), which measures, in percentage, the share of material recovered and fed back into the economy - thus saving extraction of primary raw materials - in overall material use. The CMU rate is thus defined as the ratio of the circular use of materials (U) to the overall material use (M).
7	Climate Strike Attendees	Indicator shows the estimates of people at climate strikes. Specifically, the indicator uses numbers reported by “Fridays for Future” for the “Week for Future”. This data was chosen as it had the highest reporting rate for the organization’s website (40%).

		Values were then normalized to provide country levels per million inhabitants
8	Electronic Mass Media Mentions	Indicator shows the number of text articles that mention CE per country, scaled to per million inhabitants. Data was sourced from 2016 measures from the European Commission's Eco-innovation Index
9	Eco-industry revenue, in % of total revenue	Indicates the share of revenue from eco-industry in total revenue across sectors in a specific country. Total revenue is aggregate revenue in all companies across sectors in a specific country. Data have been sourced from the Orbis database (Giljum, Lieber & Gözet, 2018)
10	Bought a remanufactured product	Indicator represents survey results from 2013 study undertaken by the European Commission (Eurobarometer). Results are given as percentages of respondents per country. They describe used products that have been repaired to the quality and guarantees of new products.
11	Leased or rented a product instead of buying it	Indicator represents survey results from 2013 study undertaken by the European Commission (Eurobarometer). Results are given as percentages of respondents per country. They describe temporary transfers of ownership of goods.
12	Used sharing schemes	Indicator represents survey results from 2013 study undertaken by the European Commission (Eurobarometer). Results are given as percentages of respondents per country. They describe systems like car sharing where goods are rented or shared instead of bought. This differs from Lease/Renting in terms of time used. Sharing schemes are typically single-use activities.
13	Patents	Indicates the number of patents granted for innovations in CE-related fields as defined by Eurostat. Values were then scaled to per million inhabitants
14	Difficulty to implement	Indicator shows a Eurobarometer survey study on perceived business difficulties for implementing CE. Responses are in percentages and can go over 100% if respondents chose multiple facets of business to represent difficulties.

15	Employment in Circular Economy related fields	Indicator shows the share of employees who work in CE related fields compared to all workers in that same country. Values are given as percentages.
16	Circular activities of Small and Medium Companies	Indicator shows survey results from a Eurobarometer report. It measures, as a percentage of total companies, how many small and medium companies have taken part in at least one circular economy related activity in the time period 2012-2015.
17	Amount of self-Financing for circular economy activities by companies	Indicator shows survey results from Eurobarometer report. It measures firm survey estimates of the percentage of financing CE related activities that was paid for by the firm itself. If a firm has a high level of self-financing, that is given lower scores as it indicates a lack of private financial or governmental support.
18	Bottle Deposit Schemes	Indicator shows amount of money received for returning plastic bottles. Specifically, the level is determined as an average of the refunds for all bottle sizes. The level is then adjusted to current PPP values in Euros for each country level.
19	Plastic Recycling Centres per Million Inhabitants	Indicator shows the amount of facilities that turn plastic waste into resellable plastic pellets. The number of facilities is then scaled to the population of the country (per million inhabitants). The metric does not address quality or processing power of the facility.
20	Plastic Bag Tax Rates & Bans	Indicator shows the consumer cost of a plastic bag as imposed by a tax, producer-imposed cost, or a ban on bags. Data was largely collected through a report by the European Environmental Agency. Where standardized costs were absent, country specific measures were pulled from media publications that reported average consumer costs. Furthermore, the methodology behind how bans were costed is in the next section of this appendix.
21	Publication Mentions	Publication mentions were pulled from the Web of Science database. Our search terminology was "(Circular Economy OR Recycling OR Recovery AND Plastic) Document Types: Article OR Book OR Book Chapter OR Correction OR Correction, Addition OR Data Paper OR Discussion OR Excerpt)". Values are reported at

cumulative publications over the time period 2000-2017. Furthermore, no language specifications were made. Often times, there are separate abstracts written in English, even if the rest of the publication is in another language, and we wanted to capture those works as well. The cumulative numbers under this criteria were then scaled to per million inhabitants.

Appendix B: Plastic Bag Ban Methodology

When addressing the tax levels levied on plastic bags, we ran into the problem of what to do about bans as there isn't an apparent monetary value for a ban. We decided to estimate a tax level that would be essentially as effective as banning the bag. In other words, what is the tax that prices bags out of the market for nearly every consumer. To do this, we compared the outcomes of bag taxes in Ireland and the UK. These taxes were studied by researchers to determine the effectiveness in consumption reduction. Utilizing the data points discovered in these studies, we created our estimate for a tax-ban level.

For comparisons, we used 2019 PPP US dollars. Our conversions related historical tax values to current 2019 US values by first converting Euros or pounds to dollars based on historical exchange rates for the months when the taxes were imposed. Then PCI conversions from the US Bureau of Labor Statistics were used to compare these historical levels to current ones.

Ireland began their tax in 2002, imposing a 25 cent charge in 2019 PPP dollars (Helping the Hoarders, 2015). For the UK, their 2008 tax equaled $0.12 (Malkin 2008). The resulting reductions in consumption were estimated at 90% and 70%, respectively. This result means there is some non-linearity in how consumers respond to price changes. This follows literature that claims most consumers simply need a small push to dramatically change their consumption habits, with minimal effects on tax increases thereafter. Utilizing these data points, we drew a natural logarithm line through the data points to mimic the apparent non-linearity. The math for calculating the logarithmic function is as follows.

$70=a+\ln(0.12)$
$90=a+\ln(0.25)$
$70-\ln(0.12)=90-\ln(0.25)$
$70+2.12b=90+1.39b$
$0.73b=20$
$b=27.40$

$70=a+27.40\ln(0.12)$
$70=a-58.09$
$a=128.09$

$100=128.09+27.4\ln(x)$

-28.09=27.4ln(x)
-0.69=ln(x)
e-0.69=x
x=0.51

From this math, we concluded that a tax of about 50 cents would effectively price out plastic bags from the economy. Initially, we were worried because we see some countries that are at or above this tax level. We concluded that, due to tax revenues, a ban could receive a lower score than a high tax. While bans would be perfectly effective in reducing consumption, there is no revenue generation. Tax revenue could be used to mitigate other environmental problems, meaning that there actually may be a net benefit to a high tax instead of an outright ban.

Appendix C: Detailed Scorecard Methodology

Steps	Formula	Explanation
1. Data insertion		Adding sorted data per country into excel
2. Create descriptive statistics	Average Standard Deviation Standard Deviation*3 High = Average + Standard deviation*3 Low = Average - Standard Deviation*3 3rd Quartile 1st Quartile	In order to get a better understanding and prepare the data for further analysis descriptive methods were applied.
3. Determine Outliers	If the value of an observation is lower than the Low (Average - Standard Deviation*) or higher than the high (Average + Standard deviation*3) label it as “Outlier”	To get an overview of countries that have extreme outliers in their observation (either low or high) the value of the observation is compared to the high and low values.
4. Determine Quartiles	If the value of an observation is higher than the 3rd quartile or lower than the 1st quartile label it as “Outlier”	By determining the countries in the upper (above 3rd quartile) and lower fences (under first quartile) of the observations “extreme” values are specified and labeled as outliers

5. Determining the average of first and third quartile	Add the values of the first and the third quartiles and divide them by 2 (take average)	By taking the average of the first and third quartile we receive a median value that can be used to normalize the data to a range between 1 and 10
6. Normalize Data	Divide observation by average of first and third quartile and multiply by 5	Dividing the observation by the before calculated average scales the data to a range that puts the observations in relation to each other. By multiplying the resulting number by 5 the range is expanded. This allows the scorecard to have values between 1 and 10
7. Restrict Data	Adjust values higher than 10 to 10	In order to restrict the range of the data to values between 1 and 10 any number higher than 10 is changed to 10.
8. Equal Weights	Take the average of sub-categories	The scored results of each indicator are grouped into sub-categories (Benchmark, social, industry and regulatory). Afterwards the average of each sub-category is taken. This gives every country a score in the respective sub-category.
9. Calculate final Score	Take average of sub-category scores	The average of the individual scores of each sub-category is taken resulting in the final overall score for each country. We take an equal weight of each sub-indicator.
10. Determine External Validity	Run a pearson-correlation on the resulting final scores and established indicators.	By correlating our scorecard with established indicators we can check for external validity. The correlation is calculated at 1% significance.

Appendix D: Survey Results

Country	Average	Consumer	Business	Regulatory
Austria	8.666667	9.5	7	9.5
Belgium	7	8	6	7
Bulgaria	6.333333	7	6	6
Croatia	-	-	-	-
Cyprus	6.333333	6	5	8
Czechia	-	-	-	-
Denmark	-	-	-	-
Estonia	5.666667	6	6	5
Finland	-	-	-	-
France	5.666667	6	5	6
Germany	-	-	-	-
Greece	-	-	-	-
Hungary	5.666667	6	6	5
Ireland	-	-	-	-
Italy	-	-	-	-
Latvia	5.666667	6	5	6
Lithuania	5.166667	5.5	4.75	5.25
Luxembou	-	-	-	-
Malta	-	-	-	-
Netherlan	4.333333	5	3	5
Poland	4	5	5	2
Portugal	3.666667	4	5	2
Slovenia	3.666667	3	4	4
Spain	3.166667	4.5	2.5	2.5
Sweden	3	3	3	3
UK	2.333333	4	2	1

Plastics Circularity Index (PCI) 2020 - The EU Edition - addresses how EU countries perform relative to each other in their circular management of plastics and related waste products. A circular economy, encompassing plastics, is extensive and entails several decisions and actions of actors. PCI analyses such activities undertaken by governments, businesses and consumers that stimulate the circular usage of plastics. PCI EU Edition covers each stakeholder category with a collection of indicators to gain an initial view of the state of plastics circularity in EU countries. In addition to the indicators per actor category, the index also considers country profiles on plastics and circularity. This index is prepared by the authors in the scope of Policy in Emerging Markets co-training by Economics and Strategy in Emerging Markets programme, School of Business and Economics, Maastricht University and UNU-MERIT.