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The European Union Plastic Policy

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Abstract

In January 2018, the European Commission has adopted an "European Strategy for plastics in a Circular Economy" with the aim of improving economics of recycling and reducing the waste of plastics. The strategy wants to increase plastic sustainability in the EU, to encourage environmental friendly behaviours and also to compensate the lost in the EU budget due to the UK withdrawal. This thesis has the objective to analyse the policy proposed by the European Commission in order to understand if the plastic tax will foster circular economy within the EC circular economy plan.

The first part of this thesis is devoted to explain and clarify the concept of "Circular Economy" as well as the process of recycling of plastic. The second part, provides an empirical analysis using the Multiple Regression Model applied to some sample EU countries in order to examine the relationship between the amount of non-recycled plastic packaging waste and some other relevant independent variables. The results show a problem of heterogeneity within EU countries, which may be an issue in obtaining good results applying a policy for every Member State.

Abstract in Italian

A gennaio 2018, la Commissione Europea ha adottato un pacchetto di misure sull'economia circolare, tra cui una strategia sulla plastica: "European Strategy for plastics in a Circular Economy" con l'obiettivo di migliorare l'economia del riciclo e ridurre i rifiuti plastici. La strategia mira ad aumentare la sostenibilità e ad incoraggiare i comportamenti rispettosi dell'ambiente nel contesto della plastica; così come compensare la riduzione del budget europeo come conseguenza dell'uscita dall'UE del Regno Unito. Questa tesi ha l'obiettivo di analizzare la politica sulla plastica, che comprende una tassa su di essa, con lo scopo di chiedersi se effettivamente la stessa incoraggerà comportamenti coerenti con il concetto di Economia Circolare.

La prima parte della tesi espone il concetto di Economia Circolare, come anche il processo di riciclo della plastica. La seconda parte fornisce un'analisi empirica usando il modello della Regressione Multipla applicato ad alcuni paesi dell'UE con lo scopo di esaminare la relazione tra l'ammontare di rifiuti plastici non riciclati nei Paesi ed alcune altre rilevanti variabili indipendenti. I risultati mettono in luce l'eterogeneità tra i paesi Europei. Che potrebbe risultare un problema nell'ottenere buoni risultati applicando una politica univoca per ogni stato membro.

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Introduction

On 18th of January 2018, with the aim of improving economics of recycling and reducing the waste of plastics, the European Commission adopted an "European Strategy for plastics in a Circular Economy"[1]. It is stated it will contribute to increase plastic sustainability and encourage environmental friendly behaviours. On March the 22nd, the EC organized a roundtable with stakeholders to discuss how the EU budget can contribute to the Plastics strategy. Consequently, in May the 2nd 2018, the European Commission published a Proposal[2] for a Council Decision on the system of Own Resources of the European Union. It states that United Kingdom withdrawal from EU led to a political priority on EU budget reforming. Nowadays, there is a need to diversify the sources of revenue for the EU budget to create a benefit for every Member State. In this context, the Commission proposes a "basket of new Own Resources"[3] to contribute to EU budget where a tax on plastic is proposed. In particular, it is a tax on the amount of non-recycled plastic packaging, as it is the major component of plastic waste. The EC estimate the Own Resources, on average, may cover approximately 12% of the budget over the period 2021-2027.

In the first part, the thesis provides a focus on what is plastic and which are the categories of plastic concerned by the tax. Plastic is a cheap useful product which changed the industry from the beginning. It can be modelled as desired and it is resistant, versatile and can be produced in a huge sort of colours. Those are some of the characteristics and of the reasons why its demand is really high and so, its waste as well.

In the EU, the 26% of total volume of plastics is represented by plastic packaging. This is due to the fact that in Europe, demand of plastic in the packaging segment accounts for 39.9%. Moreover, Europe is one of the major producer, amounting to the 17.9% of the worldwide plastic production. In this context, the recycling rate of plastic packaging

[1] COM(2018)28 final.
[2] COM(2018) 325 final; 2018/0135; EC Proposal for a Council Decision on the system of Own Resources of the European Union; {SWD(2018) 172 final}
[3] "The 'basket' approach introduces genuine Own Resources which are linked to key EU policies, specifically climate change, environmental policy, plastics strategy, the circular economy and the Single Market. It displays a strong link to EU policies and EU value added."

amount only to 40.3% respect to the total plastic packaging in the EU. This work continues explaining that even if plastic is recycled, its recycling is not an infinite process, so concerning plastics, it is preferable to say that is a down-recycling process. Anyhow, it is always better to recycle because, according to the data provided in this thesis, huge amounts of plastics are landfilled and incinerated.

The European Commission, with its proposal, would face those problems transforming the economy in a more circular one. This thesis shows that, in fact, this is quite problematic in the sense that a down-recycling process may not be easily transformed in a circular and infinite one.

In the second chapter, an empirical analysis is provided with the usage of Multiple Regression Models. Some sample countries are analysed to see the relationship between the amount of non-recycled plastics in a country, which is the basis to calculate the tax contribution that a country will pay, and some variables that potentially may influence it. The most important result is that a heterogeneity problem rises within EU countries. This fact makes more difficult to create homogenous policies which work effectively for every Member State.

In the last part of the thesis, it is stated that the tax may not be completely sufficient to transform the economy in a circular one. It continues analysing some existing policies which had concrete effects and gives some conclusions.

1. Plastic economy

Nowadays, plastics seems to be fundamental in our economy. Plastic products are cheap, important to our everyday life and, unfortunately, they seem to be the most wasteful product of our linear, "take-make-dispose" economy.

1.1 What is the plastic problem?

Plastics are petrochemicals derived products produced from fossil oil and gas.[4] They are cheap, not heavy, durable materials which can be moulded in various shapes, and so they can be find in a wide range of products. There are two main categories of plastics: Thermoplastics and Thermosets. Following *PlasticsEurope* definition, the first is "a family of plastics that can be melted when heated and hardened when cooled. These characteristics, which lend the material its name, are reversible. That is, it can be reheated, reshaped and frozen repeatedly." And the second "a family of plastics that undergo a chemical change when heated, creating a three-dimensional network. After they are heated and formed, these plastics cannot be re-melted and reformed." Moreover, thermoplastics have a certain recycling capacity, while thermosetting plastic materials are those which cannot be recycled. In the *Table 1,* there are different available thermoplastics and thermosets plastic polymers examples extracted from a paper study[5]. As underlined in the table, thermoplastics are the one used to create plastic packaging products, and so the ones involved in the plastic tax regulation of the EU.
Since the first industrial production of synthetic polymers in 1940, a notable amount of plastic solid waste (PSW) end up in the environment every year. Industries find various advantages on its usage coming from low cost, versatility and high chemical stability; reasons for which plastic production extremely increased during the past 50 years. PSW is being produced on a massive scale worldwide and its production crosses the 150 million tonnes per year globally[6].

[4] British Plastics Federation. Oil consumption. 2008.
See http://www.bpf.co.uk/Oil_Consumption.aspx. (20 October 2008)
[5] Singh N, et al., Recycling of plastic solid waste: A state of art review and future applications, Composites Part B (2016), http://dx.doi.org/10.1016/j.compositesb.2016.09.013
[6] Same as note 5 above.

Table 1 Different available plastic polymers and their application

Thermoplastic	Applications	Thermosetting	Applications
PVC (Polyvinylchloride)	Construction, Medical, Electrical, Automobile, **Packaging**, Clothing, etc.	Bakelite	Electrical systems, non-conducting parts of telephones, radios and other electrical devices, including bases and sockets for light bulbs and electron tubes, supports for any type of electrical components, automobile distributor caps, insulators, billiard balls
PLA (Polylactic acid)	**Decomposable Packaging Material**, **Cups And Bags**, Upholstery, Disposable Garments, Awnings, Feminine Hygiene Products, And Diapers.	Epoxy	Coatings, adhesives and composite materials
ABS (acrylonitrile butadiene styrene)	Drain-waste-vent (DWV) pipe systems, musical instruments (recorders, plastic clarinets, and piano movements), golf club head), automotive trim components.	Melamine	Formica, melamine dinnerware, laminate flooring, and dry erase boards
Polystyrene	Disposable Plastic Cutlery And Dinnerware, CD Cases, Smoke Detector Housings, License Plate Frames	Polyester	Staple fiber (PSF), Bottles for CSD, water, beer, juice, detergents, Technical yarn and tire cord
Polycarbonate	Electrical And Telecommunications Hardware	Polyurethane	Building insulation, Refrigerators and freezers, Furniture and bedding, Footwear, Automotive.Coatings and adhesives.
PET (poly ethylene terephthalate)	**Packaging film, PET Bottle, Carpet yarn, Engineering plastic, Filaments, Non-woven, Packaging stripes, Staple fibre**	Urea - Formaldehyde	Wall cavity filler, agriculture, decorative laminates, textiles, paper, foundry sand moulds, wrinkle resistant fabrics, cotton blends, rayon, corduroy, etc.
Polyamides	Tire, cords, rope, thread, brushes, bearings, gears, cams, hot melt or solution.	Faturan	Umbrellas and Parasols, Prayer Beads etc.
Polypropylene	Bi axially oriented polypropylene (BOPP), **clear bags**, carpets, rugs and mats	Silicon	Sealants, adhesives, lubricants, medicine, cooking utensils, and thermal and electrical insulation, silicone grease etc.
LDPE (low density polyethylene)	**Packaging** for computer hardware, such as hard disk drives, screen cards, and optical disc drives, Trays and general purpose containers.	Vinyl ester	Marine industry, FRP(fibreglass reinforced plastics) tanks and vessels, laminating process, Glasair and Glastar kit planes etc.
HDPE (high density polyethylene)	Toys, utensils, films, bottles, pipe and processing equipment. Wire and cable insulations	Phenol formaldehyde resin	Billiard balls, laboratory countertops, coatings and adhesives, circuit boards, fibreglass cloths etc.

Source: Singh N, et al., Recycling of plastic solid waste: A state of art review and future applications, Composites Part B (2016)

In the European Union countries, in 2016, each individual produced an average of 432 kg of MSW (Municipal Solid Waste), generating in total 24,6 million tonnes with an average growing rate per year of 1% [7]. According to the World Bank[8], "with rapid population growth and urbanization, municipal waste generation is expected to rise to 2.2 billion tonnes by 2025." However, even if plastics are present in all major MSW categories, the highest tonnage is represented by containers and packaging plastics as bags, sacks, and wraps, other packaging, other containers, and soft drink, milk, and water containers[9]. Following Ellen Macarthur Foundation report on plastics, in fact, "plastic packaging can

[7] Eurostat: Municipal waste by waste operations and author's calculation
[8] http://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
[9] S.M. Al-Salem, P. Lettieri, J. Baeyens, "Recycling and recovery routes of plastic solid waste (PSW): A review", Centre for CO2 Technology, Department of Chemical Engineering, School of Process Engineering, University College London (UCL), Torrington Place, London WC1E 7JE, UK, 2009

reduce food waste by extending shelf life and can reduce fuel consumption for transportation by bringing packaging weight down", that is why plastic packaging represents 26% of the total volume of plastic used and so it remains the largest application.[10] In Europe, demand of plastic in the packaging segment accounts for 39.9%[11], followed by building and construction with a 19.7%14 and automotive with 10%[14].

Plastic pollution seems to be a major future environmental crisis. It is a global issue which affects environment and worldwide people health through seas, oceans, rivers and lakes network. According to *PlasticsEurope* (PEMRG) and Conversio Market & Strategy GmbH data, in 2016, 60 million tonnes of plastics were produced in Europe (EU28 plus Switzerland and Norway) showing an increase (of 0.01%) respect to the 58 million tonnes in 2015. Looking at 2016 global data, Europe represented the 17.9% of worldwide plastic production (335 million tonnes produced in the world). According to the World Bank Group document on Agricultural Pollution Plastics, China is the leading producer, followed by EU and US.[12]

One of the reason for plastic production to continuously increase, is the more and more high demand of plastic packaging products. The problem with plastic packaging become even worse: packaging often consists in a mix of various polymer types, meaning more difficulties in recycling. Particularly, plastic bags and films, even if collected, they are not easily sorted by the mechanic process of recycling, meaning a costly and complicated process.[13]

[10] The new plastic economy, Ellen Macarthur Foundation, 2014: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability%20and%20resource%20productivity/our%20insights/rethinking%20future%20of%20plastics/the%20new%20plastics%20economy.ashx

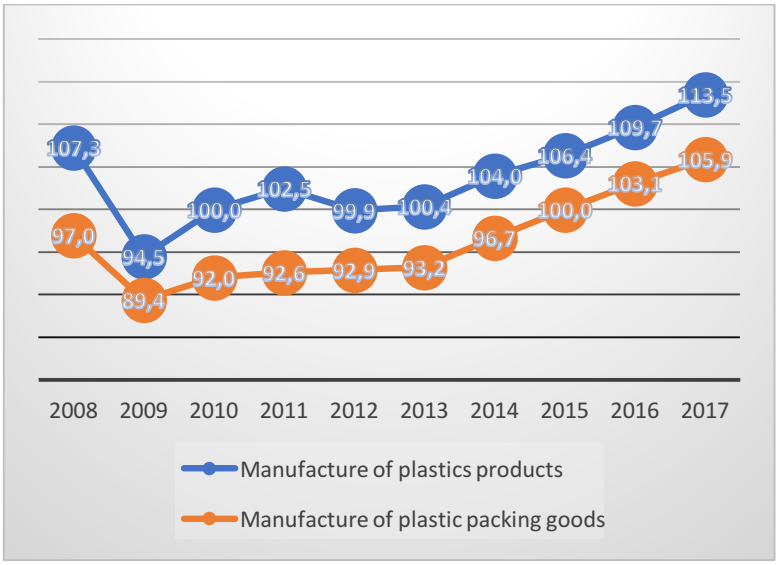
[11] https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf

[12] https://openknowledge.worldbank.org/bitstream/handle/10986/29505/124346-repl-WB-Knowledge-Plastic.pdf?sequence=1&isAllowed=y

[13] BBC: https://www.bbc.com/news/uk-42703561

Figure 1 Plastic Volume Index of Production

(Index, 2015=100)



Source: Author's elaboration from Eurostat

Figure 1 represents a time series from 2008 to 2017 of the plastic manufacture products and plastic packaging goods. It provides a measure of the volume trend in value added over the given reference period (index, 2015 = 100).[14] It is evident the manufacture of plastic packing goods is the major protagonist of the total plastic production in the EU and as previously stated, accordingly to New York Times[15], the increase of plastic packing is the first cause of plastic production increase. "In 2015 packaging accounted for 42% of non-fibber plastic produced. That year, packaging also made up 54% of plastics thrown away". This may probably be one of the reasons why the EU applied a regulation solution focused on plastic packaging. In particular, following *Eurostat* data represented in *Figure* , plastic packing percentage of total production on average over the consider period amount to 92.7% with a variation of 7.8% in differences between total plastic production and packing production. From 2013 to 2017 the correlation between manufacture of plastic products and packing goods is strongly near 1. This means that if

[14] for more information about the reference Metadata: http://ec.europa.eu/eurostat/cache/metadata/en/sts_esms.htm

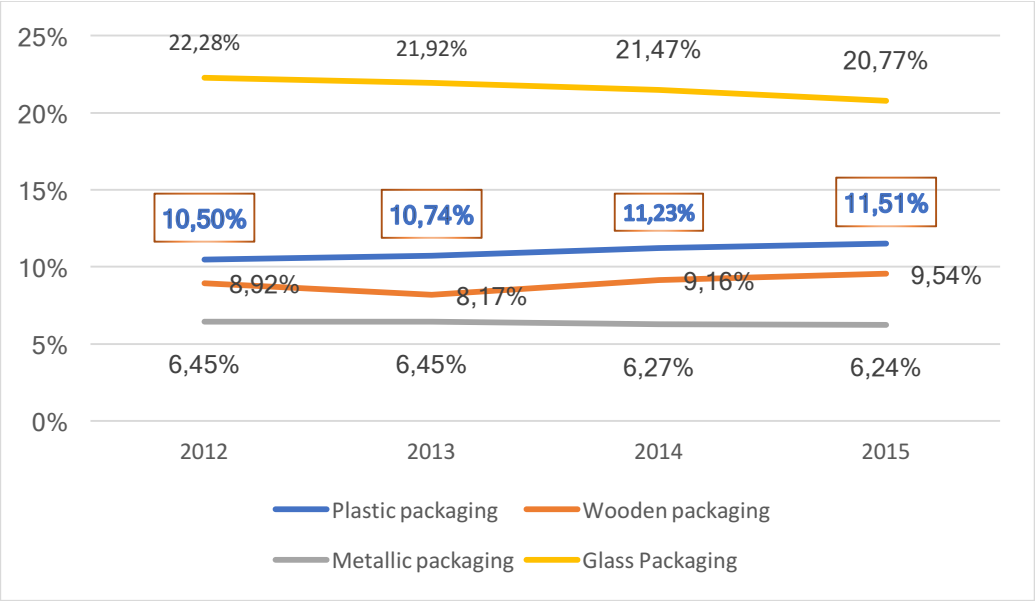
[15] https://www.nytimes.com/2017/07/19/climate/plastic-pollution-study-science-advances.html?mtrref=www.google.com&gwh=89525DBCE85046E32B115A06582007E6&gwt=pay

the demand of one of them increase (and consequently its production), the other increase of the same amount. Currently the European demand for new plastics materials represent 3 million/year, where only 6% is recycled one.[16] Looking at production in terms of tonnes[17], plastic products amounted to 58 million in 2015 and 60 millions in 2016 with an annual average growing rate of 3% (3.4 in 2015, 3.1 in 2016 and 2.8 in 2017).[18]

Almost half century later from the born of the first universal recycling symbol, only 14% of plastic packaging worldwide were collected for recycling.[19] In this context, in 2015, the waste generated from plastic packaging in the EU was 15.9 million tonnes[20], accounting for 37.2% of all plastics consumed in Europe and 35% of worldwide[21]. In 2015, only 6.41 millions of tonnes (around 40% of the total) were collected in order to be recycled.[22] According to *PlasticEurope*, in 2016, this amount increased reaching around 8.4 million tonnes of plastics recycled in Europe (inside and outside).[23]

[16] http://www.circulary.eu/content/uploads/2018/06/2018-06-14-Guidance-document-voluntary-pledges-Plastics-Strategy-updated.pdf
[17] Includes plastic materials (thermoplastics and polyurethanes) and other plastics (thermosets, adhesives, coatings and sealants). Does not include: PET fibers, PA fibers, PP fibers and polyacryls-fibers
[18] PlasticsEurope (PEMRG) / Conversio Market & Strategy GmbH
[19] The new Plastics Economy – rethinking the future of plastics, World Economic Forum, January 2016
[20] Eurostat
[21] Major Obstacles to Sustainability in the Plastic Industry, Bupe G. Mwanza and Charles Mbohwa, Procedia Manufacturing 8 (2017) 121 – 128
[22] Eurostat
[23] https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf

Figure 2 Percentage rate of recycling relative to total packaging recycling in the EU

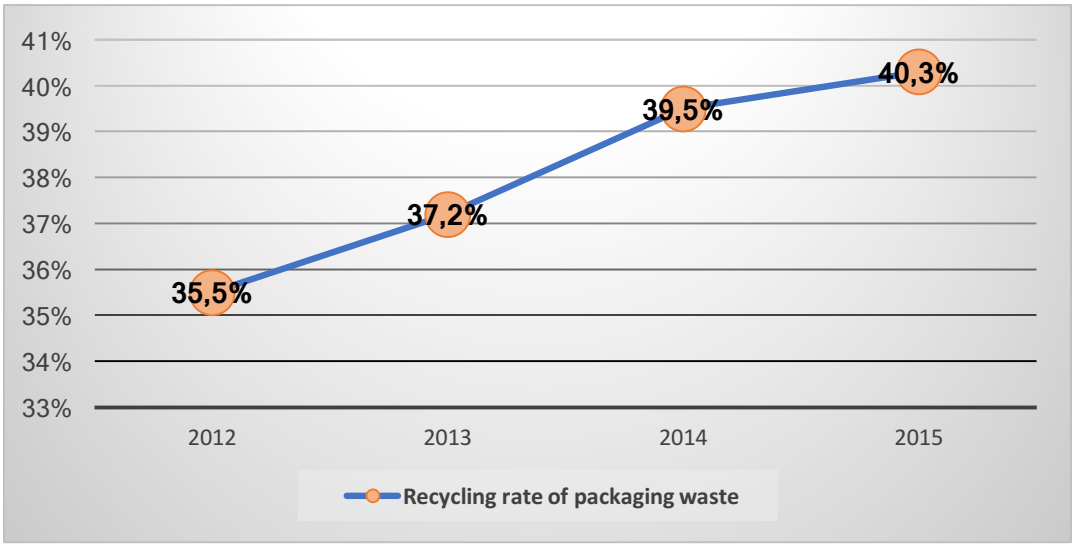


Source: Author's elaboration from Eurostat

Figure 2 represents the percentage recycling rate of packaging waste compared to other packaging (wood, glass, metallic) recycling rates relatives to the total packaging waste recycled from 2012 to 2015.

It is possible to notice that even if plastic packaging is the major product used in packaging sector, its recycling rate amount only between 10.5 and 11.5 percent relative to the total amount of packaging recycled every year. The most recycled within considered products is glass, even if it has a slightly declining trend.

Figure 3 Recycling rate of packaging waste respect to the total packaging waste



Source: Author's elaboration from Eurostat

Anyhow, in the *Figure 3*, it is shown plastic packaging percentage of recycling considering only plastic packing goods.
The recycling rate of packaging waste is increasing every year of 1.5% on average, starting from an increase of 1.2% in 2012 to 2.3% in 2014, to 0.8% in 2015.

As described in this paragraph, the situation of plastics really requires having the attention and actions from any concerned part, as it is become more and more dangerous for our environment and human being health.

1.2 Plastic limits: the down-recycling chains

In this section, it is shown how plastic can be reintegrated to the economy and its limits in not being an infinite recyclable product. Although the recycling of plastic is a limited process that can be done a really limited number of times only, because after every recycling, the strength of plastic material is reduced due to thermal degradation, it is always better to recycle instead of dispersing plastics to the environment. Recycling of plastic depends on some factor, first of all the type of plastic, which is not guaranteed by the collection of waste itself, as in a collection there may be several types. There are then some compatibility issues to be solved before starting the process of recycling. Introduction of one polymer into another may lead to reduction in properties of recycled material because of the different melting points[24]. It exists different techniques to recycle plastic: there are four major categories of recycling process which have advantages and disadvantages. The major existing methods are re-extrusion (primary), mechanical (secondary), chemical (tertiary) and energy recovery (quaternary).[25]

Primary recycling

Also called re-extrusion or closed loop process, the primary recycling refers to the recycling of virgin materials utilizing discarded plastics that have similar characteristics to the original products. After the sorting of contaminated products, it is necessary to have clean plastics before turning them into plastic products of similar quality. This kind of recycling is usually not possible in MSW, as they are excessively contaminated.

Secondary recycling

The secondary recycling is a longer and more complex process for which steps involved includes cutting, separation from contaminated products, flakes separation by floating,

[24] Singh N, et al., Recycling of plastic solid waste: A state of art review and future applications, Composites Part B (2016), http://dx.doi.org/10.1016/j.compositesb.2016.09.013
[25] Singh N, et al., Recycling of plastic solid waste: A state of art review and future applications, Composites Part B (2016), http://dx.doi.org/10.1016/j.compositesb.2016.09.013

etc. Sometimes washing of products is made by the usage of caustic soda. Polymer plastic material is then processed and sold after addition of pigments and additives.[26]
Both primary and secondary recycling processes requires mechanical means, which involve energy consumption and the release of harmful substances in the air for which workers may risk injury and disease while sorting materials[27]. Moreover, the heterogeneity of MSW means contamination of polymer waste, which make it complex to use primary or secondary recycling techniques.

Tertiary recycling

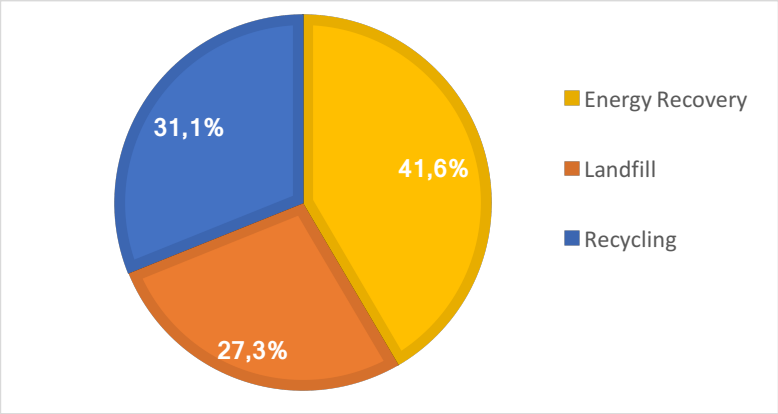
Tertiary recycling method is necessary when the sorting of contaminated materials is not possible anymore (majority of MSW cases). The major types of tertiary recycling techniques available are chemical and thermal recycling.

Quaternary recycling

After a number of recycling cycles of PSW by primary, secondary, tertiary techniques, material starts losing its proprieties. In this phase materials cannot be used again. The only existent solution instead of land filling, is to process the material to recover energy through incineration. The energy recovery method is logical only when another type of recycling is not possible anymore. Plastic materials possess high calorific value, as they are derived from crude oil. This technique also leads to volume reduction of waste which rest is land filled.

[26] Singh N, et al., Recycling of plastic solid waste: A state of art review and future applications, Composites Part B (2016), http://dx.doi.org/10.1016/j.compositesb.2016.09.013
[27] European Commission (DG Environment), Plastic waste in the environment – Final Report, April 2011

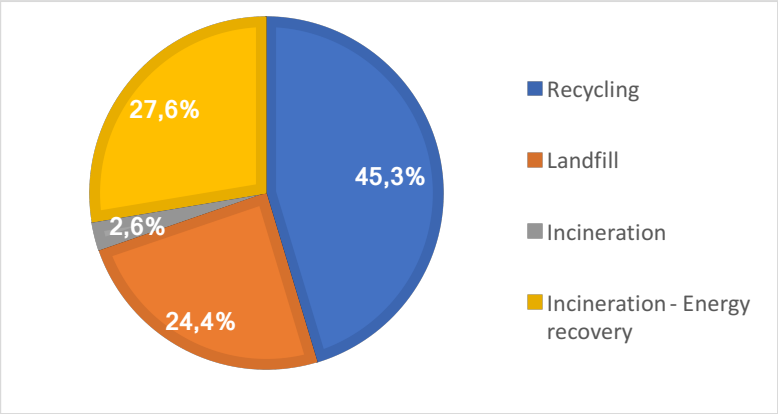
Figure 4 Plastic waste in percentage, 2016[28]



Source: PlasticEurope

Figure 4 represents the percentages of worldwide amount of plastic waste processed in 2016. The first three recycling process represents together the 31.1% of total waste of plastic in 2016; the landfilling of those plastics products amounted to 27.3% and the biggest part concerns energy recovery treatment, amounting to 41.6%.

Figure 5 Recycling rates of Municipal Solid Waste, 2016[29]



Source: Author's elaboration from Eurostat

[28]https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf
[29] Eurostat

It is interesting also to look at recycling rates of MSW represented in the *Figure 5* as plastic is the major component, as stated in the previous paragraph. Looking at Municipal Solid Waste, the recycling rate increase to 45,3% and landfill decrease at 24,4%. This means plastics are less recycled and more landfilled than the MSW, in general. Moreover, as in this statistic energy recovery and incineration are divided, we can see the amount of MSW incinerated amounting at 2,6% and energy recovery at 27,6%.

The next paragraph is devoted to explaining the impacts of plastics in our environment, as well as the impacts of its recycling process.

1.3 Impacts of plastic and recycling

From the previous section, it is clear that the recycling of plastic is not an infinite process, and so that at a certain point, as well as in the whole process of recycling, it leads to serious environmental issues. In fact, the high demand of plastic and consequently its production are generating several environmental problems. The majority of plastics are made from oil, a non-renewable source[30], which is dangerous for the environment, for its composition and for energy consumption for its manufacture. Moreover, since it is necessary to transport oil in order to have the primary raw material, oil spills, tanker accidents, air pollution from transport and oil refineries, are only some of the issues involving environment degradation from the very beginning of the production plastic chain. Furthermore, usually during manufacture process, some chemicals are added to improve plastic proprieties and when plastics are discarded, those chemicals may contaminate the environment in addition to the release of dioxide gas emissions.[31] Ellen Macarthur Foundation report also states over 90% of plastics produced are derived from virgin fossil feedstocks, representing about 6% of global oil consumption (this is equivalent to the whole aviation sector consumption of oil). Following the report, those dates are expected to increase by 2050, reaching the 20% of total oil consumption and involving 15% of the global annual carbon budget (the calculation is based on the forecasted budget required in order to achieve the internationally accepted goal to remain below a 2°C increase in global warming). Furthermore, as most type of plastics are not biodegradable, they are extremely durable (for at least decades, probably centuries or millennia).[32]

As the way of polluting the environment deriving from plastics can be many, the quantification and consequences of the impacts are difficult to estimate. What is sure is that it concerns land pollution, air pollution, animals killing (due to intoxication when

[30] Non-renewable sources do not form or replenish in a short period of time. Non-renewable sources such as crude oil, natural gas, coal, uranium, come out of the ground as liquids, gases, and solids.

[31] Singh N, et al., Recycling of plastic solid waste: A state of art review and future applications, Composites Part B (2016), http://dx.doi.org/10.1016/j.compositesb.2016.09.013

[32] J. Hopewell, R. Dvorak, E. Kosior, Plastic recycling: challenges and opportunities, Philos Trans R Soc Lond B Biol Sci. 2009 Jul 27; 364(1526): 2115–2126

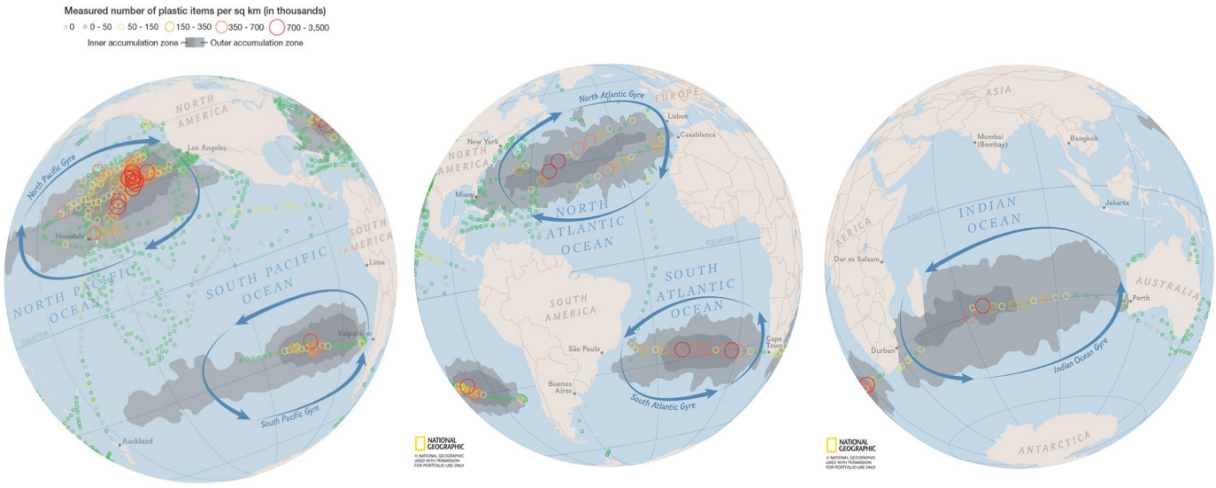
eating plastics or for the toxic substances released into the environment when plastics are landfilled), air pollution, groundwater pollution and consequently human health. Even if plastics can be useful and cheap, the process of cleaning of some affected areas result very expensive. Same result come from the lost in the economy of certain areas in Europe (as well as the whole world), due to the reduction of tourism. However, according to the Independent[33], "a new report released by WWF has revealed tourists cause a 40 per cent surge in waste entering the Mediterranean Sea, 95 per cent of which is plastic." Those evidences, underlined in the mentioned report, show that it is crucial to address the greenhouse gas impact of plastics production and after-use treatment.

Another huge evident problem rises after plastic consumption: the leak of waste in the oceans. According to Ellen Macarthur Foundation report of 2016, each year at least 8 million tonnes of plastic leak into the ocean, which means dumping plastics of one garbage truck into the ocean every minute. In the *Figure* , the five huge garbage islands present in the oceans are represented. The bigger one seems to be in the North Pacific Gyre, where huge amounts of plastic items are present. Furthermore, plastic packaging seems to represent the major share of this leakage in the oceans. Continuing this way, we expect to have more plastics than fish in the oceans by 2050.[34]

[33] https://www.independent.co.uk/environment/plastic-pollution-tourists-mediterranean-sea-increase-microplastics-wwf-a8388296.html

[34] The new plastic economy, Ellen Macarthur Foundation, 2014: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability%20and%20resource%20productivity/our%20insights/rethinking%20future%20of%20plastics/the%20new%20plastics%20economy.ashx

Figure 6 Plastic items in the oceans, January 2015



Source: National Geographic[35]

Even if in the *Figure 6,* the Mediterranean Sea is not represented, as stated before, it also presents huge problems of plastic presence in it. Following the Independent, "levels of microplastics found in the Mediterranean were nearly four times higher than found in the North Pacific 'plastic island' ", Lyndsey Dodds, head of marine policy at WWF. Microplastics are in fact small pieces of plastics, typically smaller than 5mm, which can come from the degradation of bigger pieces of plastics or can also be manufactured and intentionally added to products for specific reasons (for instance in cosmetics). Those pieces can be eaten by fishes instead of food and can be very dangerous for them as well as for humans. In fact, plastics eaten by fishes may accumulate in the chain food and result in health issues for animals and humans. The entire marine ecosystem is being damaged by this phenomena and plastics landfilling is more and more contemning fish we are eating. Being aware of those problems, the European Union, under its sustainability goals, has the aim to reduce by 80-95% greenhouse gas emissions by 2050 and reach zero in the decade thereafter[36]. Therefore, under the Plastic Strategy project, the EC is looking to further action to address plastic marine litter, as stated in the next chapter. The next section is going to describe the concept of circular economy, in the context of plastics, as well as the circular economy package adopted by the European Commission.

[35] https://news.nationalgeographic.com/news/2015/01/150109-oceans-plastic-sea-trash-science-marine-debris/
[36] European Commission, 2011

1.4 The "circular" economy of plastic

The Plastic Strategy launched by the EC is part of the Circular Economy package which includes measures created to help the transition towards a circular economy. This section explains the meaning of this concept in the context of the "European Strategy for Plastics in a Circular Economy" launched by the European Commission in 2018.

The January 2018 strategy should contribute to increase plastic sustainability and encourage environmental friendly behaviours having the aim of improving economics of recycling and reducing the waste of plastics.

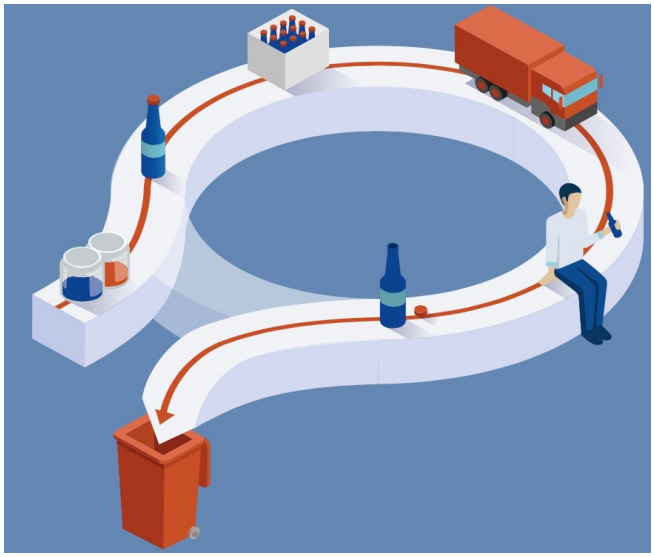
To do so, it is necessary to make some structural changes as, for now, our economy follows a linear "take-make-dispose" model. The circular economy concept is basically a new way of thinking about economy to make it becomes restorative and regenerative by design. Of course, it requires a lot of innovation, having the aim to redefine products in order to minimise waste and negative impacts. This new industrial process starts by using renewable energy sources and it is able to build economic, natural and social capital by creating also new job opportunities.[37]

Following *PlasticsEurope* definition, "in a circular economy, we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of their service life. As a result, a circular economy also offers a way to improve Europe's competitiveness and resource efficiency."[38]

[37] Ellen Macarthur Foundation

[38] https://www.plasticseurope.org/en/focus-areas/circular-economy

Figure 7 Linear Economy Model



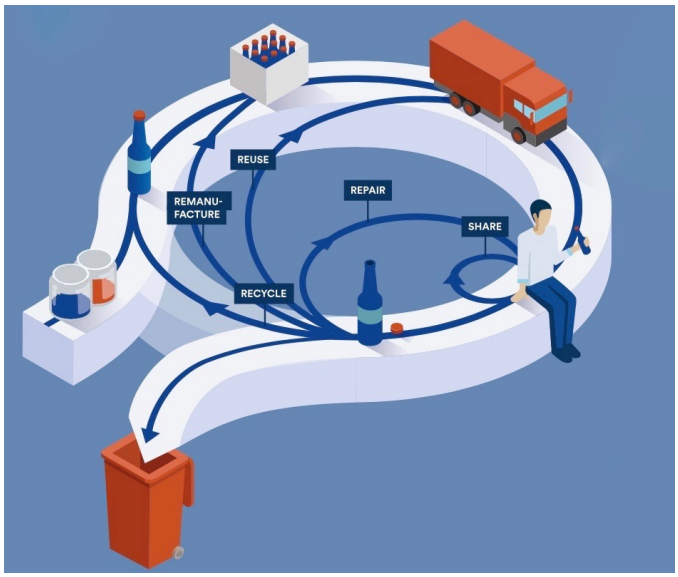
Source: europarl.europa.eu

In the *Figure 7*, a simple example of linear economy model is represented. In the first stage of the production line, raw materials, either extracted domestically or imported, are used. The second phase is the production, usually following low cost strategies (using plastics, for example); the product is then packed up and delivered to be sold. When they are discarded or no longer used, products reach the end of their life. In a linear economy, products become waste at this stage.[39] Looking at the *Figure 8*, it is possible to observe a different way of thinking about the production line. In a Circular Economy Model, the raw materials used to produce come from virgin or secondary sources. The design of product is an important stage of the process, it allows to contribute to a longer product lifespan and a more circular economy, thanks to eco-design and repair-friendly design.[40] Some options to prolong and optimise the lifecycle of a product can be for example to rent, share (car-sharing, car-pooling), borrow the product in order to shift from ownership of products to their usage. At the end of their life, circular economy products can be reused (as it is the case of glass bottles, for instance), remanufactured (such as it can be for electronic products), repaired or recycled. Products such as metals, paper, glass or plastics can be recycled as a source of secondary raw materials. Some problems occur in

[39] http://www.europarl.europa.eu/thinktank/infographics/circulareconomy/public/index.html
[40] http://www.europarl.europa.eu/thinktank/infographics/circulareconomy/public/index.html

the case of plastics. As explained in the previous chapter, plastics has a down-recycling process, which means it can be recycled infinite times, but really less.

Figure 8 Circular Economy Model



Source: europarl.europa.eu

This is why in fact, it could be good to simply substitute plastic with other products, limiting its usage or reuse it. This is unfortunately complicated in large scale terms. As stated before, plastics are cheaper than other products and it would be not easy at all to completely eliminate it. However, to decrease the number of plastic packaging used, and consequently wasted, could be a good starting point.

This last section underlined the definition of circular economy and the limits of plastic on being included in this concept. Plastics recycling is a down-recycling process and so, the quality of the product provided is lower after every process, which normally is one or rarely 2 times possible before proceeding with recovering, generating non-indifferent amount of pollution. This is why in fact, following the Figure 4 Plastic waste in percentage, 2016 every year the 41,6% of plastic is used for energy recovery. This cause pollution and a lot of those plastics are Single Use Packaging one.

As conclusion of this section, it can be said it is always better to re-use (or substitute) plastic instead of recycling it, being aware that, of course, recycling is a better choice than landfilling. Re-using plastic allow fossil fuels to be conserved, lead to reduction of MSW and energy consumption for plastic production as well as reduction of carbon-dioxide (CO2), nitrogen-oxides (NOx) and sulphur-dioxide (SO2) emissions. However, it is necessary to find some innovative ways to reduce the use of plastics and mainly plastic packaging.

2. The European Union solution

As pointed out in the previous chapter, the huge amount of plastic production and its consequent waste, generate several problems to the environment and to human health. The European Union, trying to solve them, discussed some solutions, among which a tax on plastic, to mitigate the plastic demand. In this chapter, an analysis of what the EC proposed to address plastic problems is provided.

2.1 What does the European Commission propose?

After approving an EU Action Plan for Circular Economy in December 2015, the European Commission confirmed, in 2017, the Action Plan would focus on plastic production and use with the aim of making all plastic packaging recyclable by 2030. In January, the 18th 2018, the EC adopted an "European Strategy for plastics in a Circular Economy"[41] with the aim of improving economics of recycling and reducing the waste of plastics. In the document, it is stated it will contribute to increase plastic sustainability and encourage environmental friendly behaviours. In particular, the Circular Economy Package has the following objectives[42]:

- Increase of 55% by 2025 and 65% by 2030 of municipal waste rate of recycling;
- Increase of 50% by 2025 and 55% by 2030 of plastic packaging rate of recycling;
- Reach at least 70% of plastic bottles recycling rate by 2030, where it is not already the case
- Increase of 25% by 2030 of food containers recycling rate

In the plastic strategy information brochure, it is stated "the strategy will also help to achieve the priority set by this Commission for an Energy Union with a modern, low-carbon, resource and energy-efficient economy and will make a tangible contribution to

[41] COM(2018)28 final.
[42] http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

reaching the 2030 Sustainable Development Goals and the Paris Agreement"[43]. In particular, with the Plastic Strategy, a target for all packaging to be recyclable by 2030 has been set. The Plan is very ambitious and it will mobilise private sector, together with national and regional authorities, cities and citizens.

Following the Commission Staff Working Document of the EC concerning "*Financing the EU budget: report on the operation of the own resources system",* "The strategy also recommends introducing measures of a fiscal nature encouraging environmental friendly behaviours. Such measures will contribute to stimulate investment in recycling facilities. They will complement the other measures of the package. Achieving the objectives laid out in this strategy will require major investments in both infrastructure and innovation. Meeting ambitious goals on plastics recycling alone will require an estimated additional investment of between EUR 8.4 and 16.6 billion."[44]

An important fact which concern the Strategy is the EU budget, mostly after the UK withdrawal. In March the 22nd, the EC organized a roundtable with stakeholders to discuss how the EU budget can contribute to the Plastics strategy. Consequently, in May the 2nd 2018, the European Commission published a Proposal[45] for a Council Decision on the system of Own Resources of the European Union. It states United Kingdom withdrawal from EU led to a political priority on EU budget reforming. Moreover, "in the general context of taxation, market integration, free movement of capital and the rise of intangibles […] the adequacy of national taxation frameworks to properly address the development in these fields" is put into discussion. However, taxation is not an EU instrument, taxes can be levied only at national level, apart from some countries where EU provides rules to harmonize the way taxes are applied. In fact, "the introduction of new categories of Own Resources fully respects national fiscal sovereignty". Nowadays, there is a need to diversify the sources of revenue for the EU budget to create a benefit for every Member State. This means that the plastic tax will also contribute to finance the EU and not only to reduce pollution.

[43] http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf
[44] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018SC0172
[45] COM(2018) 325 final; 2018/0135; EC Proposal for a Council Decision on the system of Own Resources of the European Union; {SWD(2018) 172 final}

In that context, in fact, the Commission proposes a "basket of new Own Resources"[46] to contribute to EU budget; the first concerns the creation of a link between financing the EU budget and the benefits enjoyed by companies operating in the Single Market through a Common Consolidated Corporate Tax Base creation; the second concerns a share of revenues from the European Emissions Trading System, which aim to reduce greenhouse gas emissions and costs related to it; and the third concerns a proposal of a tax on plastic waste consisting in:

> *"a national contribution calculated on the amount of non-recycled plastic packaging waste. This will create an incentive for Member States to reduce packaging waste and stimulate Europe's transition towards a circular economy by implementing the European plastics strategy."*

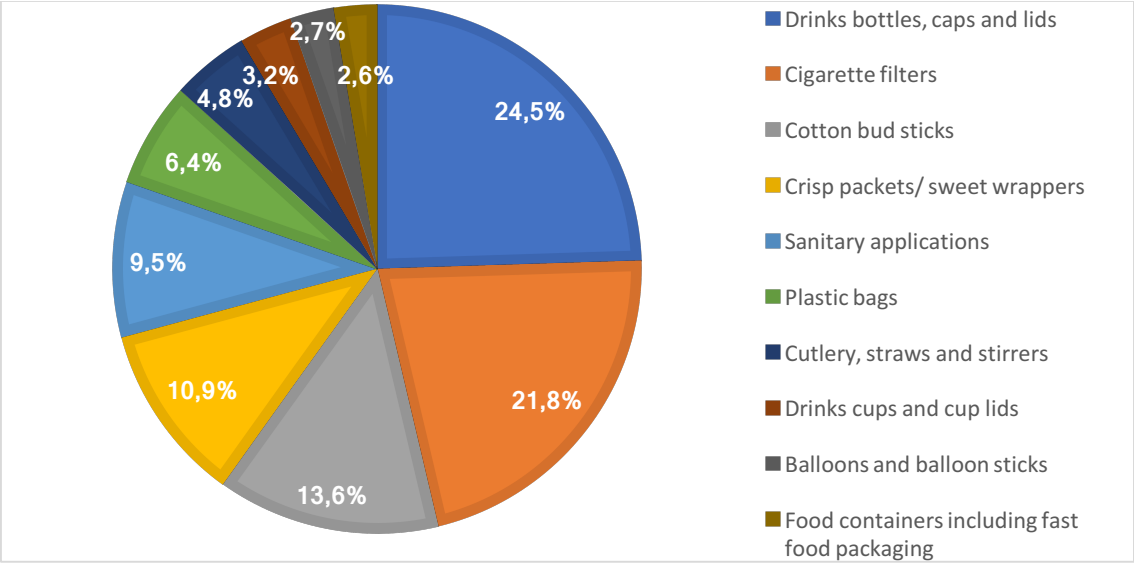
The commission proposal also added it is to "Establish the principle that future revenues arising directly from EU policies should flow to the EU budget". This may lead to provide money that can help manage the impact arising from the withdrawal of UK and also to start a better auto-financing process. The EC estimate the Own Resources, on average, may cover approximately 12% of the budget over the period 2021-2027.

The proposal for single use plastics provided by the EC is based on a study conducted by ICF and Eunomia Research & Consulting Ltd. in order to give the analytical basis for the *Directive of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment*.[47] The study assess some options to reach the *Directive* objectives and it is addressed mostly to single-use plastics (SUP), as those products constitute the 70% of all marine litter items found on Europe's beaches and seas.[48] Those products are mainly 10 and they will be the main objective of the measure.

The major products found in EU beaches are represented in percentage of the total, in the *Figure 9*.

[46] "The 'basket' approach introduces genuine Own Resources which are linked to key EU policies, specifically climate change, environmental policy, plastics strategy, the circular economy and the Single Market. It displays a strong link to EU policies and EU value added."
[47] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf
[48] http://ec.europa.eu/environment/waste/plastic_waste.htm

Figure 9 Top Ten Single Use Plastic Items, by Item Count as reported on Beaches in the EU



Source ICF, Eunomia, EC Directorate-General for Environment May 2018[49]

The study provides different options of policies and analyse the effects, but in the end the effects are still not clear. The policy could bring to a switch in alternative packaging usage, but actually there are no evidence to confirm that.

In order to summarize the objectives of the policy, it is possible to say that they are mainly three:

- to improve the economics and quality of plastic recycling, ensuring a stable market for recycled plastics with clear growth perspectives;
- to ensure new economic opportunities combined with social innovation; and
- to curb plastic waste and littering

[49] http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

Moreover, in June 2018, the European Commission with the aim to help in reaching those objectives, launched a EU-wide voluntary pledging campaign addressed to all its stakeholder, to boost the uptake in recycled plastics in new products on the EU market. In October 2018, the pledges will be used as basis for an assessment by the Commission. In that occasion, the steps to be taken will be determined, and some possible regulatory actions could be considered to promote the uptake of recycled plastics in the EU.

After having analysed, in the previous chapters, what effectively the plastic problems are, and what the EC proposed and it is doing to address the plastic issues, the next chapter is set to analyse in detail the plastic tax content, particularly.

2.2 The European Union Plastic Tax content

The "Own Resources contribution on plastic packaging waste" would be an action proportional to the quantity of Plastic Packaging Waste generated in each Member State which is not recycled. It is essentially a call-rate contribution of 0,80 EUR/KG for all the non-recycled plastic packaging per year. This amount may correspond to around 7 billion/year in the whole EU.[50] The reason for taxing directly the retailer is explained by the fact that a tax on production would have led to negative impacts on industrial competitiveness entailing a risk of leakage of production. Applying the tax on a limited number of plastic items to consumers, instead, would influence their behaviour.

The contribution is calculated as represented in the *Equation 1:*

*Plastic-based Own Resource = call rate * kg of non-recycled plastic packaging waste*

The data required to this calculation are already reported to the Commission (*Eurostat*) pursuant to Article 12 of the European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste[51]. According to the available data on *Eurostat*, some calculations are necessary in order to estimate the effective amount that the EU in total, and each Member State, should have paid if the tax was adopted before. Those calculations allow also to have a forecast of the future amount to pay for each Member State.

In the following *Table 2,* it is already possible to see which countries are the most pollutant in Europe in terms of plastic packaging. Germany is the country who reach the highest level of plastic packaging waste, with an amount of three million of tonnes in 2016. It is followed by France, Italy (data of 2015) and Spain.

[50] COM(2018) 325 final; 2018/0135; EC Proposal for a Council Decision on the system of Own Resources of the European Union; {SWD(2018) 172 final}
[51] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste

Table 2 Tonnes of plastic packaging waste

GEO/TIME	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
European Union	**15.030.076**	**15.016.922**	**14.640.579**	**14.834.333**	**14.995.382**	**15.101.072**	**15.004.579**	**15.405.371**	**15.926.556**	**16.218.454**
Belgium	308.741	301.581	303.532	315.505	315.961	320.423	329.325	329.130	339.690	343.161
Bulgaria	102.093	77.682	95.457	81.978	94.963	96.123	96.547	102.093	99.532	108.247
Czech Republic	217.119	216.156	208.815	209.550	209.414	211.660	215.122	218.871	247.328	236.891
Denmark	191.782	164.838	165.449	165.449	188.261	183.697	190.043	187.472	197.030	214.593
Germany	2.643.800	2.732.400	2.620.800	2.690.100	2.775.800	2.836.700	2.873.300	2.945.600	3.052.200	3.097.700
Estonia	37.341	71.826	52.603	50.884	52.006	47.590	64.657	65.955	61.125	64.601
Ireland	237.685	248.046	224.350	187.617	158.707	168.582	205.310	276.309	282.148	275.510
Greece	295.000	240.000	237.000	221.500	207.770	184.920	181.500	184.400	183.800	:
Spain	1.679.000	1.585.000	1.442.916	1.397.689	1.355.155	1.304.464	1.305.579	1.418.487	1.474.731	1.526.347
France	2.113.930	2.046.728	1.877.058	2.001.571	2.031.859	1.997.820	1.979.160	2.062.443	2.133.626	2.178.758
Croatia	:	:	:	:	:	48.263	48.747	49.094	51.959	54.744
Italy	2.270.000	2.205.000	2.092.000	2.071.000	2.075.000	2.052.000	2.042.615	2.081.947	2.128.496	:
Cyprus	14.710	16.602	15.744	15.786	15.184	15.221	15.728	15.822	:	:
Latvia	39.498	38.460	31.254	35.192	36.186	36.985	40.529	38.703	41.362	40.261
Lithuania	64.483	63.806	54.141	56.522	60.356	59.698	63.207	67.070	65.495	65.611
Luxembourg	25.238	21.728	20.688	22.288	23.800	24.282	27.224	25.548	29.537	30.901
Hungary	218.482	215.254	229.376	210.920	208.662	256.912	275.500	258.560	299.790	308.994
Malta	8.797	14.452	13.299	12.160	11.403	10.846	11.481	11.179	12.475	:
Netherlands	466.000	442.000	427.500	454.000	444.000	459.000	468.000	474.000	492.000	503.000
Austria	244.600	251.569	255.811	264.517	264.152	271.808	288.714	291.968	294.888	297.837
Poland	515.849	669.932	666.406	733.114	784.474	831.919	895.086	896.948	935.755	1.007.369
Portugal	378.412	387.872	378.068	360.918	356.709	350.290	357.175	359.814	369.751	378.505
Romania	375.308	332.600	293.800	281.145	278.810	298.042	290.279	336.818	359.036	:
Slovenia	45.731	47.890	46.603	45.268	44.729	44.841	42.050	44.214	45.090	:
Slovakia	75.045	81.415	91.389	105.779	106.624	104.551	97.784	97.704	106.417	119.409
Finland	98.555	115.373	112.341	116.244	117.126	117.239	117.750	116.792	116.530	122.849
Sweden	191.316	193.150	191.618	198.446	211.901	213.649	222.567	228.390	230.943	238.447

Source: Eurostat

In order to estimate the amount of money corresponding to the contribution, the data on plastic packaging rate of recycling[52] are used and multiplied by the total amount of plastic packaging waste for each country and for the EU in total. According to *Eurostat*, the "'recycling rate' for the purposes of Article 6(1) of Directive 94/62/EC means the total quantity of recycled packaging waste, divided by the total quantity of generated packaging".

So, to obtain the tonnes of non-recycled plastic packaging, it is necessary to follow the *Equation 2*:

52 Eurostat, Recycling rates for packaging waste, code: ten00063

*Tonnes of plastic packaging waste - (Tonnes of plastic packaging waste * percentage rate of recycling)*

= tonnes of non-recycled plastic packaging waste.

Obtaining this result, it is finally possible to apply the *Equation 1*, multiplying the 0,8 EUR/KG *call rate* by 1000KG, as the rate is expressed in kilos. This solution adopted by the Commission is a market-based solution, which aim is to control the market forces in order to reduce the negative externality of non-recycled plastic packaging waste. The tax would lead to some results by exploiting the price mechanism.

In the *Table 3*, the results are gather together.

Table 3 Plastic packaging waste tax estimation

GEO/TIME	2007	2008	2009	2010	2011	2012	2013	2014	2015
European Union	:	:	:	:	:	7.792.153.152	7.538.300.490	7.456.199.564	7.606.523.146
Belgium	152.147.565	145.965.204	138.410.592	147.656.340	148.122.517	149.957.964	160.710.600	153.242.928	155.985.648
Bulgaria	65.747.892	52.450.886	53.455.920	38.759.198	46.190.003	45.600.751	45.338.471	29.321.110	31.213.235
Czech Republic	94.663.884	86.116.550	79.349.700	77.114.400	72.038.416	70.779.104	69.355.333	73.190.462	75.781.299
Denmark	119.978.819	98.375.318	97.416.371	97.416.371	117.023.038	108.895.582	107.792.390	103.934.477	109.548.680
Germany	1.211.917.920	1.151.979.840	1.081.866.240	1.088.952.480	1.143.629.600	1.146.026.800	1.163.111.840	1.173.527.040	1.250.181.120
Estonia	18.461.390	44.819.424	32.529.695	27.110.995	25.129.299	26.726.544	37.190.706	37.304.148	35.305.800
Ireland	147.935.144	141.088.565	114.508.240	90.956.722	66.656.940	80.379.898	98.384.552	142.796.491	148.974.144
Greece	203.668.000	169.152.000	138.976.800	123.862.800	111.364.720	100.300.608	98.300.400	99.133.440	92.929.280
Spain	1.030.234.400	958.608.000	847.280.275	791.651.050	732.867.824	677.277.709	619.366.678	652.504.020	660.679.488
France	1.334.312.616	1.268.971.360	1.126.234.800	1.221.758.938	1.246.748.682	1.197.093.744	1.177.996.032	1.234.165.891	1.271.641.096
Croatia	:	:	:	:	:	21.081.278	21.331.687	24.468.450	22.321.586
Italy	1.302.072.000	1.215.396.000	1.112.944.000	1.085.204.000	1.060.740.000	1.026.000.000	1.032.746.144	1.032.645.712	1.002.947.315
Cyprus	10.085.176	11.315.923	10.302.874	9.193.766	7.531.264	6.721.594	6.882.573	6.759.158	:
Latvia	24.393.965	25.352.832	19.927.550	21.396.736	22.290.576	22.486.880	24.479.516	19.692.086	21.408.971
Lithuania	36.884.276	34.404.195	27.763.505	27.854.042	29.502.013	29.180.382	28.872.958	26.184.128	23.682.992
Luxembourg	12.376.715	12.219.827	12.479.002	12.302.976	12.718.720	12.296.405	14.766.298	12.896.630	15.949.980
Hungary	145.072.048	128.980.197	138.543.104	113.896.800	104.664.859	148.392.371	152.516.800	130.727.936	174.118.032
Malta	6.291.614	9.942.976	5.223.847	7.587.840	6.486.026	5.830.810	7.109.035	6.000.887	:
Netherlands	247.166.400	224.889.600	210.672.000	190.316.800	175.113.600	192.045.600	199.929.600	187.324.800	194.044.800
Austria	131.692.640	131.017.135	137.728.642	138.818.522	137.781.683	141.992.499	151.517.107	155.093.402	156.644.506
Poland	297.129.024	407.854.602	418.502.968	468.019.978	485.746.301	517.786.386	572.855.040	512.336.698	512.045.136
Portugal	256.411.971	251.030.758	225.328.528	217.994.472	210.886.361	195.041.472	184.873.780	172.710.720	168.606.456
Romania	254.308.701	224.837.600	179.100.480	161.489.688	133.159.656	116.117.163	112.163.806	149.547.192	153.092.950
Slovenia	19.572.868	17.010.528	21.623.792	11.842.109	8.766.884	12.627.226	6.156.120	10.823.587	13.202.352
Slovakia	35.000.988	36.669.316	37.067.378	46.288.890	42.734.899	35.965.544	35.124.013	34.469.971	38.820.922
Finland	64.336.704	71.346.663	67.134.982	68.630.458	69.900.797	69.968.235	72.816.600	70.448.934	71.129.912
Sweden	89.229.782	97.347.600	95.809.000	107.319.597	111.714.207	111.268.399	96.861.158	95.923.800	94.224.744

It is fundamental to underline that those values do not consider the country dimension in terms of habitants or meter squared. Analysing the result, weighted by the population, it is possible to see non-indifferent differences.

In the *Table 4,* the 2015 is taken as sample and the *Table* results are weighted by the population amount on 1st January.[53]

Table 4 Plastic packaging waste tax estimation pro-capita, 2015

	Amount of the plastic tax_2015	Population (total) on 1st of January	Amount of the tax per person
Belgium	155.985.648	11.237.274	13,88
Bulgaria	31.213.235	7.202.198	4,33
Czech Republic	75.781.299	10.538.275	7,19
Denmark	109.548.680	5.659.715	19,36
Germany	1.250.181.120	81.197.537	15,40
Estonia	35.305.800	1.314.870	26,85
Ireland	148.974.144	4.677.627	31,85
Greece	92.929.280	10.858.018	8,56
Spain	660.679.488	46.449.565	14,22
France	1.271.641.096	66.456.279	19,14
Croatia	22.321.586	4.225.316	5,28
Italy	1.002.947.315	60.795.612	16,50
Cyprus	:	847.008	:
Latvia	21.408.971	1.986.096	10,78
Lithuania	23.682.992	2.921.262	8,11
Luxembourg	15.949.980	562.958	28,33
Hungary	174.118.032	9.855.571	17,67
Malta	:	439.691	:
Netherlands	194.044.800	16.900.726	11,48
Austria	156.644.506	8.584.926	18,25
Poland	512.045.136	38.005.614	13,47
Portugal	168.606.456	10.374.822	16,25
Romania	153.092.950	19.870.647	7,70
Slovenia	13.202.352	2.062.874	6,40
Slovakia	38.820.922	5.421.349	7,16
Finland	71.129.912	5.471.753	13,00
Sweden	94.224.744	9.747.355	9,67

Analysing the tax in term of contribution pro-capita, it is possible to notice some

[53] Eurostat, Population on 1 January by age and sex (demo_pjan)

differences. The citizens who should pay the most are from Ireland, followed by Luxembourg, Estonia, Denmark, France, Austria, Hungary, Italy, Portugal, Germany, Spain, Belgium, Poland, Finland, Netherlands, Latvia, Sweden, Greece, Lithuania, Romania, Czech Republic, Slovakia, Slovenia, Croatia, Bulgaria.

Those calculations allowed us to have a global view of how this tax is distributed. This show a not obvious result which let us ask ourselves which factors could influence the amount of this contribution. The following paragraph has the aim to analyse empirically the correlations within some factors that may influence the tax level itself.

2.3 Empirical analysis

In line with the available data on *Eurostat*, this section provides a Multiple Linear Regression analysis to capture the variables that explain what the influencing factors of the *Plastic Packaging Waste Tax* are and consequently why some countries are more concerned by this contribution and some are less.

The relationship between the independent variables and the dependent variable is calculated on a time series of 16 years starting from 2000, ending on 2015. In order to run the regression, some sample countries are taken, in particular: Germany, Italy, France, Portugal, Denmark. This do not want to be an exhaustive analysis on all the singular EU Member, but this want to underline the existing tendencies in the countries as well as the heterogeneity within EU Members.

The model is represented by the *Equation 3* which examine by what it is influenced the non-recycled plastic packaging waste; object of the contribution.

Equation 3:

$$Y = \beta_0 + \beta_1 (GDP) + \beta_2 (R\&D) + \beta_3 (Education) + \beta_4 (Unemployment) + \beta_5 (Environmental\ taxes) + \beta_6 (Government\ expenditure\ in\ R\&D)$$

Where:

Y = Non-recycled plastic packaging waste;

β_0 is the intercept which is zero in this case;

$\beta_1(GDP)$[54] represents the Gross Domestic Product per capita (market prices) of the country studied;

$\beta_2 (R\&D)$[55] represents the total expenditure in Research and Development in all sectors of the considered country;

[54] Eurostat, "main GDP aggregates per capita", [nama_10_pc]

[55] Eurostat, "Intramural R&D expenditure (GERD) by sectors of performance", [rd_e_gerdtot]

β_3 *(Education)*[56] represents the number of people from 15 to 64 years old, in the considered country, who has a level of education from 3 to 8 (upper secondary, post-secondary, non-tertiary and tertiary education;

β_4 *(Unemployment)*[57] indicates the total annual average unemployed people by thousand persons;

β_5 *(Environmental taxes)*[58] indicates the total environmental taxes expenditure in the considered country;

β_6 *(Government expenditure in R&D)*[59] represent the percentage of GDP of the total Government expenditure dedicated to R&D in each sector of the selected country.

In order to have a more homogenous result, the data has been transformed in non-linear relationship one, using the log.

In particular, the *Equation 3* is transformed as in the following *Equation 4.* The data is not transformed for the Government expenditure in R&D, as it is a percentage of GDP.

Equation 4:

$$Y = \beta_0 + \beta_1 \ln(GDP) + \beta_2 \ln(R\&D) + \beta_3 \ln(Education) + \beta_4 \ln(Unemployment) + \beta_5 \ln Environmental\ taxes) + \beta_6 (Government\ expenditure\ in\ R\&D)$$

The first country considered for the analysis is Germany, for which data are represented in the *Table 5*.

[56] Eurostat, "population by educational attainment level, sex and age (number) - main indicators", [edat_lfse_03]

[57] Eurostat, "total Unemployment by sex and age - annual average by thousand persons", [une_rt_a]

[58] Eurostat, "total environnemental taxes", [env_ac_tax]

[59] Eurostat, "Intramural R&D expenditure (GERD) by sectors of performance", [rd_e_gerdtot]

Table 5 Time series 2000 – 2015, Germany

Years/ Variables	Y	X1	X2	X3	X4	X5	X6
	Non-recycled plastic packaging	GDP	LN(R&D)	Education	Unemployment	environmental taxes	government expenditure in R&D
2000	13,634492	10,165852	10,832082	17,986682	7,92	10,810677	2,39
2001	13,722224	10,192419	10,859037	17,946330	7,77	10,893252	2,39
2002	13,871163	10,207289	10,884887	17,952566	8,48	10,906268	2,42
2003	13,792524	10,210972	10,906662	17,953120	9,78	10,965315	2,46
2004	14,041585	10,236382	10,914486	17,956875	10,73	10,941341	2,42
2005	14,181577	10,250617	10,928436	17,939864	11,17	10,925849	2,42
2006	14,234901	10,292146	10,981542	17,939896	10,25	10,935960	2,46
2007	14,230858	10,341742	11,026499	17,951936	8,66	10,907001	2,45
2008	14,180136	10,364072	11,105431	17,947994	7,52	10,913596	2,60
2009	14,117342	10,328755	11,112670	17,953166	7,74	10,926136	2,72
2010	14,123871	10,376611	11,156453	17,968340	6,97	10,915179	2,71
2011	14,172861	10,425253	11,232802	18,007414	5,82	10,980042	2,80
2012	14,174955	10,442901	11,278599	18,015163	5,38	10,972911	2,87
2013	14,189753	10,463103	11,286395	18,029571	5,23	10,967284	2,82
2014	14,198668	10,499573	11,341505	18,009171	4,98	10,973220	2,87
2015	14,261942	10,526749	11,393937	18,011896	4,62	10,969301	2,92

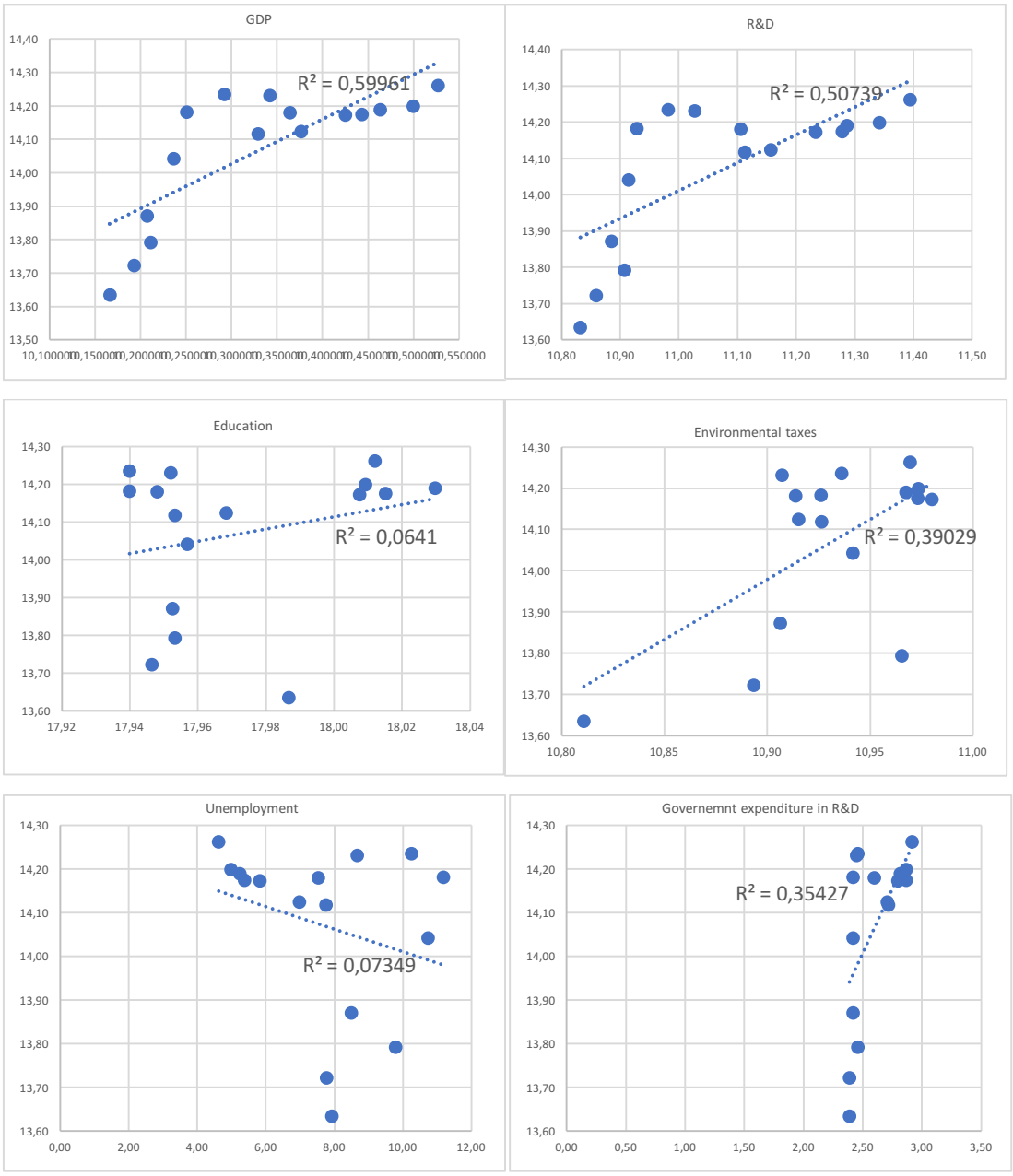
According to the *Equation 4,* the model for Germany results as follow:

$$Y_{Germany} = 11,5184(GDP) - 8,5404(R\&D) - 0,7473(Education) + 0,0841\ (Unemployment) + 0,4926(Environmental\ taxes) + 3,0029(Government\ expenditure\ in\ R\&D)$$

For Germany, an increase of *11,5184 on* GDP, make an increase of one unit in the non-recycled plastic packaging. The same result is for unemployment and for the Governmental expenditure in R&D in percentage of GDP, which with an increase of 0,0841 and 3,0029 respectively, make an increase of 1 unit to the non-recycled plastic packaging of the previous year. It sounds weird that the expenditure in R&D in percentage of GDP is not correlated to plastic recycling, but it may be done by the fact that the R&D give results only in the long term and in any case the investment made is using the short-term resources. R&D, education and expenditure in environmental taxes, having a negative coefficient, gives the opposite results. It means that a decrease of those factors gives more non-recycled plastic packaging. In particular, a decrease of -8,5404 in R&D, -0,7473 in education, -0,4926 in environmental taxes lead to an increase of 1 unit, per each variable, to non-recycled plastic packaging.

In the *Figure 10* the variables are graphically represented. It is possible to notice that some of them are not strongly representing the reality if taken separately, as the R^2 coefficient is relatively low.

Figure 10 Germany: GDP, R&D, Education, Unemployment, Environmental taxes, Government expenditure in R&D



The R^2 coefficient is the relationship between the Sum of Squares (SS) of the regression and the total sum of squares. The more the R^2 is near 1, the better it fits the data.

Running the regression, represented in the *Table 6,* it is possible to notice that the R^2 coefficient is strongly near 1, with a result of 0,99. This means that the 99% of the variables are explained by the model. The same result appears with the adjusted R^2, which consider also how big is the sample and how many variables are present.

Anyway, looking at the results of the regression, it is possible to see that not all the variables are significant. For a coefficient to be significant means to have correlation with the dependent variable. In order to analyze if the variables are significant, it is necessary to run the Null-Hypothesis test and look at *t-Stat* and *p-value*. The null hypothesis states that the estimated value is equal to zero, so that it is not significant. The null hypothesis is accepted when the value is not in the "reject zone" of the t-distribution graph, so the hypothesis that it is equal to zero is accepted. (normally with an *alpha* = 0.05, the *t-Stat* should be bigger that +2 or smaller than -2 to be significant). A further way to see if the estimated coefficient is significant is to look at the *p-value*. The estimated coefficient is significant when the p-value is smaller than a good significance level *alpha*. For example, the coefficient is different to zero if the observed *p-value* is smaller than 0.05.

In the case of Germany, looking at the *Table 6*, the variables GDP, R&D, Education, Unemployment and Government expenditure in R&D are significant.

Table 6 Multiple regression output, Germany

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,99999713
R Square	0,999994261
Adjusted R Square	0,899991391
Standard Error	0,042641964
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	3168,26941	528,0449017	290399,8954	2,89174E-23
Residual	10	0,018183371	0,001818337		
Total	16	3168,287593			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
ln(GDP)	11,51845699	3,023880621	**3,809163929**	**0,003433899**	4,780831091	18,25608288
ln(R&D)	-8,54047482	3,016002465	**-2,831720106**	**0,017799324**	-15,26054709	-1,82040255
ln(education)	-0,747320723	0,24767937	**-3,017290958**	**0,012955264**	-1,299184749	-0,195456696
ln(unemployment)	0,084163865	0,014285551	**5,891537733**	**0,000152789**	0,052333673	0,115994057
ln(environmental taxes)	-0,492600118	0,429835479	-1,146020144	0,278470501	-1,450333249	0,465133014
Government expenditure in R&D	3,002945915	1,103354441	**2,721651178**	**0,021499307**	0,544519017	5,461372812

Looking at the model globally, it is possible to see that the test F has a really small p-value, which means that the model is significant as a whole.

Concerning Italy, for which data are presented in the *Table 7*, the results are different.

Table 7 Time series 2000 – 2015, Italy

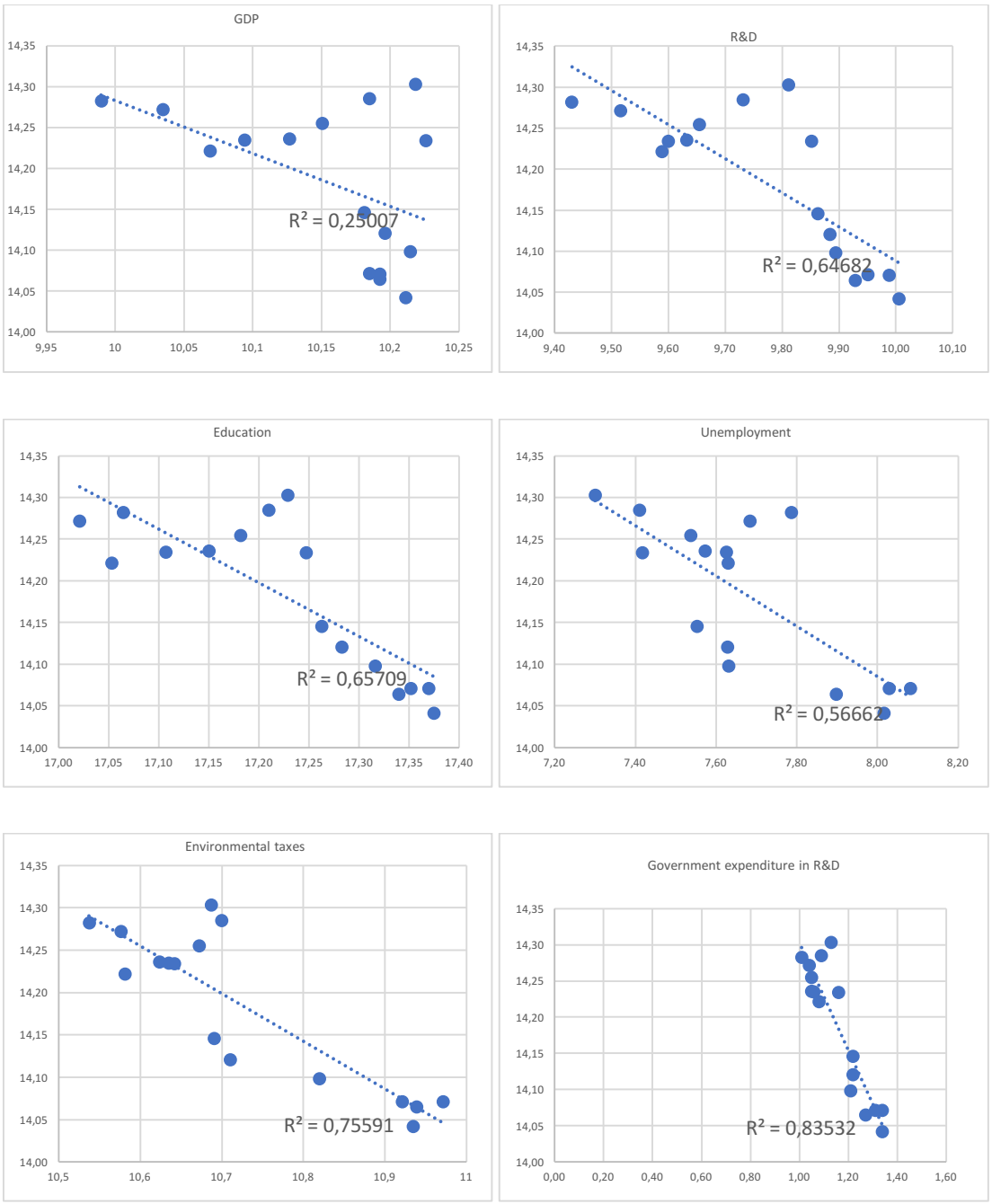
Years/ Variables	Y	X1	X2	X3	X4	X5	X6
	Non-recycled plastic packaging	GDP	R&D	Education	Unemployment	Environmental taxes	Government expenditure in R&D
2000	14,28	9,989665249	9,430302869	17,06456085	7,79	10,53746842	1,01
2001	14,27	10,03451581	9,515778862	17,02092584	7,68	10,57625344	1,04
2002	14,22	10,06900199	9,588742561	17,05281125	7,63	10,58134341	1,08
2003	14,23	10,09410791	9,600285668	17,10703187	7,63	10,63467687	1,06
2004	14,24	10,1266311	9,632531484	17,14999264	7,57	10,6231306	1,05
2005	14,25	10,15034763	9,654949267	17,18192739	7,54	10,67232181	1,05
2006	14,28	10,18490001	9,730995527	17,20986108	7,41	10,69930413	1,09
2007	14,30	10,21829829	9,810900661	17,22878615	7,30	10,68656684	1,13
2008	14,23	10,22557105	9,851815239	17,24720493	7,42	10,64206211	1,16
2009	14,15	10,18111929	9,863134198	17,26294041	7,55	10,69058035	1,22
2010	14,12	10,19615717	9,884554447	17,28283791	7,63	10,71020892	1,22
2011	14,10	10,21464198	9,893972427	17,31584576	7,63	10,8193782	1,21
2012	14,06	10,19241884	9,928302109	17,33963186	7,90	10,93871621	1,27
2013	14,07	10,18490001	9,951472631	17,35172537	8,03	10,92088979	1,31
2014	14,07	10,19241884	9,988805935	17,36971825	8,08	10,97121099	1,34
2015	14,04	10,21097225	10,00590875	17,37488446	8,02	10,93432052	1,34

With those given data, according to the *Equation 4*, the model for Italy is constructed as follow:

$$Y_{Italy} = 6{,}178248151\ (GDP) - 5{,}696822526\ (R\&D) + 0{,}145256858\ (Education) - 0{,}216971146\ (Unemployment) + 0{,}025835521\ (Environmental\ taxes) + 5{,}164644023\ (Government\ expenditure\ in\ R\&D)$$

This means that the GDP, education, environmental taxes and government expenditure in R&D, if increased, they lead to an increase in non-recycling plastic packaging present in a country. Concerning education, environmental taxes and government expenditure in R&D, it sounds quite strange, but the reason, as it was for Germany, can be that it should take longer for education or R&D to show effects on recycling. However, even if the model has a good R^2 and an adjusted R^2, the variables education, unemployment and environmental taxes are not significant in the case of Italy. The variable R&D, instead, is significant and has a positive effect on reducing non-recycled plastic packaging in Italy. In particular, increasing 5,6568 times the R&D may lead to a decrease of 1 unit of non-recycled plastic packaging in the country.

Figure 11 Italy: GDP, R&D, Education, Unemployment, Environmental taxes, Government expenditure in R&D



The significance of the model globally speaking is good, as the F and its p-value are good ones.

Table 8 Multiple regression output, Italy

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,999998777
R Square	0,999997553
Adjusted R Square	0,89999633
Standard Error	0,028062131
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	3218,724419	536,4540698	681226,0576	6,23505E-25
Residual	10	0,007874832	0,000787483		
Total	16	3218,732294			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
ln(GDP)	6,178248151	1,043072196	**5,923126101**	**0,000146429**	3,854138465	8,502357836
ln(R&D)	-5,696822526	1,094271622	**-5,206040634**	**0,000397809**	-8,135011641	-3,258633412
ln(education)	0,145256858	0,325809461	0,445833763	0,665214791	-0,580691861	0,871205577
ln(unemployment)	-0,216971146	0,14892384	-1,456926885	0,175808912	-0,54879414	0,114851848
ln(environmental taxes)	0,025835521	0,20089057	0,128604947	0,900219968	-0,421776563	0,473447605
Government expenditure in R&D	5,164644023	1,280427957	**4,033529567**	**0,002385923**	2,311672745	8,017615302

Concerning France, the *Equation 4*, is modified as follow:

$$Y_{France} = 2{,}548988171\ (GDP) - 2{,}770002736\ (R\&D) + 0{,}663064127\ (Education) - 0{,}098176249\ (Unemployment) + 0{,}464596416\ (Environmental\ taxes) + 0{,}76585391\ (Government\ expenditure\ in\ R\&D)$$

And it is given by the data represented in the *Table 9*.

Table 9 Time series 2000 – 2015, France

Years/ Variables	Y	X1	X2	X3	X4	X5	X6
	Non-recycled plastic packaging	GDP	R&D	Education	Unemployment	Environmental taxes	Government expenditure in R&D
2000	14,27334	10,09823	10,34024	17,42796	7,74327	10,37421	2,08
2001	14,25043	10,13062	10,40084	17,45141	7,65634	10,31358	2,13
2002	14,27497	10,15425	10,44950	17,47215	7,68294	10,39234	2,17
2003	14,30831	10,17351	10,45072	17,50025	7,75705	10,38056	2,11
2004	14,30624	10,21097	10,48270	17,51785	7,80751	10,47266	2,09
2005	14,30143	10,23996	10,49758	17,53600	7,81521	10,47534	2,04
2006	14,32935	10,27849	10,54282	17,54907	7,81682	10,49615	2,05
2007	14,32707	10,31890	10,57906	17,56912	7,72665	10,50364	2,02
2008	14,27686	10,34174	10,62294	17,58909	7,65964	10,51129	2,06
2009	14,15753	10,30561	10,66511	17,60259	7,87169	10,49681	2,21
2010	14,23895	10,33202	10,67980	17,61490	7,89357	10,53728	2,18
2011	14,25919	10,35774	10,71689	17,63032	7,88796	10,58694	2,19
2012	14,21855	10,36722	10,74762	17,64965	7,95683	10,62001	2,23
2013	14,20247	10,37661	10,76558	17,68767	8,01500	10,66656	2,24
2014	14,24905	10,38591	10,77726	17,71216	8,01500	10,68045	2,23
2015	14,27896	10,40426	10,81656	17,72241	8,02355	10,76395	2,27

In the case of France, the model has the same coefficient sign as it is for Italy. Anyhow, looking at *Table 10*, any of them result to be significant. This model is not good to represent France and need to be reviewed considering the specificity of the country. Just analyzing three EU countries it is possible to immediately notice that they are not homogeneous and it is not easy to find a Regression Model who can represent them simultaneously.

Table 10 Multiple Regression output, France

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,999998582
R Square	0,999997165
Adjusted R Square	0,899995747
Standard Error	0,030385254
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	3256,228898	542,7048164	587811,3033	1,21082E-24
Residual	10	0,009232637	0,000923264		
Total	16	3256,238131			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
ln(GDP)	2,548988171	2,224824839	1,145702856	0,27859578	-2,408230491	7,506206833
ln(R&D)	-2,770002736	1,560594163	-1,774966742	0,106292274	-6,247223222	0,707217749
ln(education)	0,663064127	0,550937095	1,203520571	0,256491668	-0,564500219	1,890628473
ln(unemployment)	-0,098176249	0,19910759	-0,4930814	0,632602733	-0,541815607	0,345463108
ln(environmental taxes)	0,464596416	0,255248337	1,820174121	0,098748821	-0,104132319	1,033325152
Government expenditure in R&D	0,76585391	0,875097953	0,87516364	0,402015957	-1,183985839	2,715693659

The data for Portugal are gather in the *Table 11*. The analysis for this country result to be quite interesting as four of the concerned variables are significant and, in particular are GDP, R&D, education and environmental taxes.

Table 11 Time series 2000 – 2015, Portugal

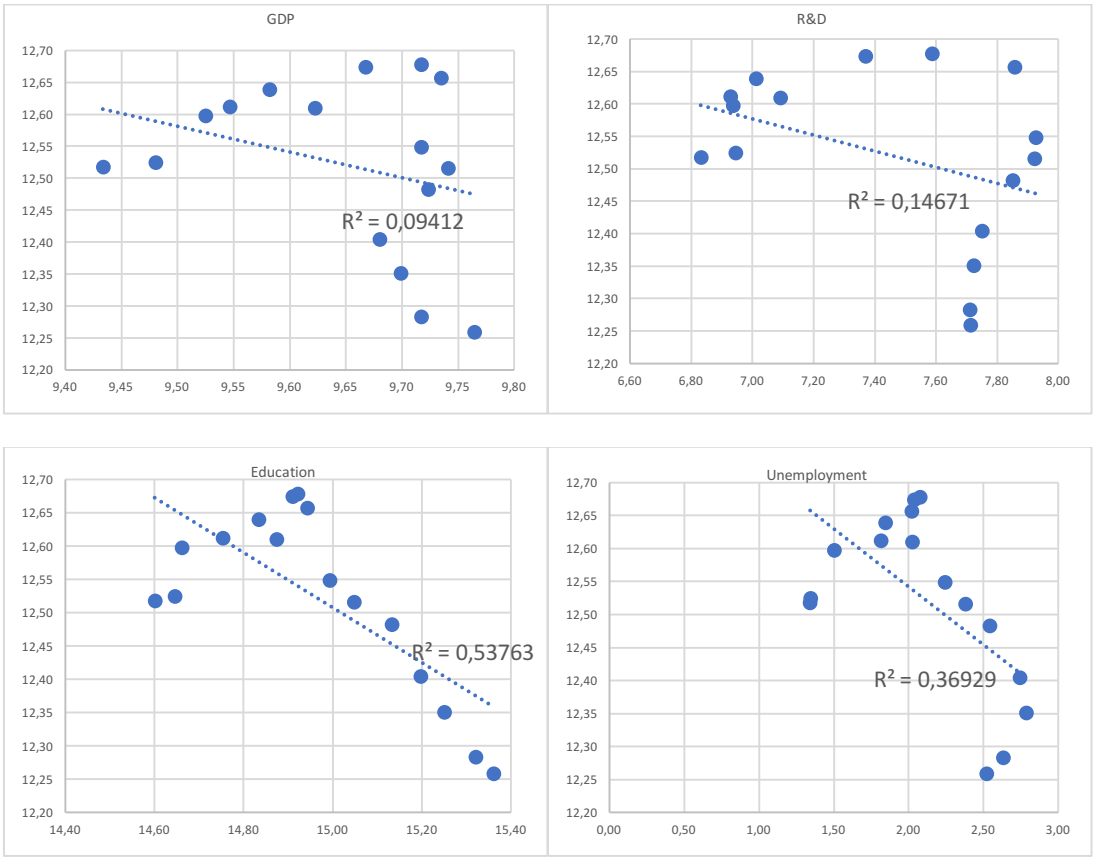
Years/Variables	Y	X1	X2	X3	X4	X5	X6
	Non-recycled plastic packaging	GDP	R&D	Education	Unemployment	Environmental taxes	Government expenditure in R&D
2000	12,517703	9,433484	6,831511	14,600947	1,340250	8,113897	0,72
2001	12,524090	9,480368	6,945467	14,645632	1,342865	8,253694	0,76
2002	12,597270	9,525151	6,936349	14,661300	1,504077	8,358000	0,72
2003	12,611438	9,546813	6,927147	14,753333	1,813195	8,367328	0,70
2004	12,638919	9,581904	7,012427	14,834383	1,843719	8,407813	0,73
2005	12,609783	9,622450	7,091003	14,873669	2,025513	8,428965	0,76
2006	12,673667	9,667765	7,369552	14,910561	2,034706	8,442047	0,95
2007	12,677684	9,717158	7,587175	14,922096	2,074429	8,479375	1,12
2008	12,656473	9,735069	7,857510	14,942786	2,021548	8,397585	1,45
2009	12,548459	9,717158	7,927180	14,993260	2,243896	8,360818	1,58
2010	12,515368	9,740969	7,922100	15,047879	2,376765	8,379078	1,53
2011	12,482218	9,723164	7,850279	15,132716	2,540026	8,313421	1,46
2012	12,404112	9,680344	7,749380	15,197780	2,742774	8,199077	1,38
2013	12,350571	9,698920	7,722443	15,250257	2,783776	8,232552	1,33
2014	12,282515	9,717158	7,710765	15,320761	2,631169	8,277387	1,29
2015	12,258466	9,764225	7,711715	15,361520	2,520917	8,376003	1,24

The model is represented by the following equation:

$Y_{Portugal}$ = *5,387294282 (GDP) -0,921686158 (R&D) -1,626810728 (Education) + 0,156456941 (Unemployment) -1,06160952 (Environmental taxes) + 0,252664308 (Government expenditure in R&D)*

GDP, unemployment and Government expenditure in R&D are influencing positively the amount of non-recycling plastic packaging. In particular, an increase of those variables leads to an increase in the amount. However, unemployment and Government expenditure in R&D are not significant for Portugal, meaning that they are not influencing the dependent variable. It is quite interesting to see that GDP, R&D, education and environmental taxes are significant and, particularly, a part for GDP, an increase of those variables may lead to a decrease in non-recycled plastic packaging.

Figure 12 Portugal: GDP, R&D, Education, Unemployment, Environmental taxes, Government expenditure in R&D



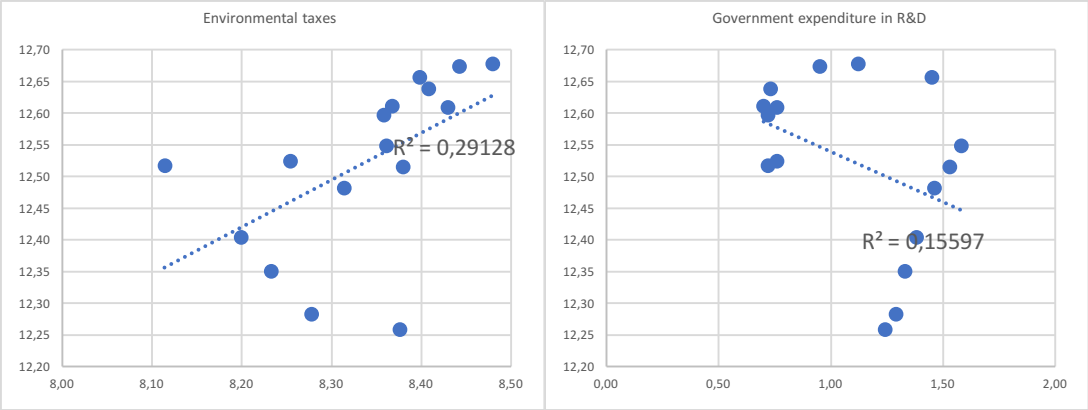


Table 12 Multiple Regression output, Portugal

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,99999572
R Square	0,999991441
Adjusted R Square	0,899987161
Standard Error	0,046341035
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	2508,977357	418,1628928	194721,56	1,74692E-22
Residual	10	0,021474915	0,002147491		
Total	16	2508,998832			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
ln(GDP)	5,387294282	0,706322734	**7,6272418**	**1,78394E-05**	3,813509156	6,961079408
ln(R&D)	-0,921686158	0,376399259	**-2,448692804**	**0,034334497**	-1,760355972	-0,083016344
ln(education)	-1,626810728	0,267434823	**-6,083017577**	**0,000118319**	-2,222692647	-1,030928809
ln(unemployment)	0,156456941	0,08558389	1,828112043	0,09747622	-0,034235851	0,347149732
ln(environmental taxes)	-1,06160952	0,373157495	**-2,844936882**	**0,017400481**	-1,893056232	-0,230162808
Government expenditure in R&D	0,252664308	0,398241756	0,634449563	0,540029663	-0,634673621	1,140002238

Looking at R^2, the model is representing the reality at 99% and, it is also a good model globally, as the F test is high with a low associated p-value.

Table 13 Time series 2000 – 2015, Denmark

Years/Variables	Y	X1	X2	X3	X4	X5	X6
	Non-recycled plastic packaging	GDP	R&D	Education	Unemployment	Environmental taxes	Government expenditure in R&D
2000	11,831830	10,413313	8,266637	72,200000	1,499623	9,061352	2,19
2001	11,769875	10,445812	8,361344	77,300000	1,425515	9,090267	2,32
2002	11,797224	10,471638	8,441119	77,300000	1,451614	9,157951	2,44
2003	11,758425	10,488493	8,487724	74,200000	1,686399	9,136750	2,51
2004	11,890451	10,532096	8,496362	74,700000	1,648659	9,220032	2,42
2005	11,904129	10,578980	8,535794	74,300000	1,574846	9,256732	2,39
2006	11,932037	10,633449	8,597763	74,600000	1,360977	9,263631	2,4
2007	11,918217	10,661954	8,677704	67,700000	1,335001	9,311437	2,52
2008	11,719688	10,691945	8,810019	67,100000	1,232560	9,218016	2,77
2009	11,709889	10,643041	8,863032	67,800000	1,793425	9,130869	3,06
2010	11,709889	10,687389	8,866905	68,200000	2,009555	9,186952	2,92
2011	11,893271	10,703244	8,895520	69,300000	2,024193	9,206072	2,94
2012	11,821285	10,725468	8,934534	70,200000	2,018895	9,220146	2,98
2013	11,811102	10,738568	8,947143	70,500000	1,945910	9,279168	2,97
2014	11,774659	10,760028	8,954709	71,800000	1,885553	9,270646	2,91
2015	11,827269	10,774781	8,991885	72,700000	1,819699	9,291682	2,96

$$Y_{Denmark} = 1{,}406007393\ (GDP) - 1{,}166847178\ (R\&D) - 0{,}001794659\ (Education) + 0{,}149705571\ (Unemployment) + 0{,}705680103\ (Environmental\ taxes) + 0{,}154011629\ (Government\ expenditure\ in\ R\&D)$$

It can be noticed that the sign of the variables in the model for Denmark are the same as for Germany.

Table 14 Multiple Regression output, Denmark

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,999994539
R Square	0,999989078
Adjusted R Square	0,899983616
Standard Error	0,049400036
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	2234,25712	372,3761867	152590,4553	5,23308E-22
Residual	10	0,024403636	0,002440364		
Total	16	2234,281524			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
ln(GDP)	1,406007393	0,457805626	**3,071188543**	**0,011816848**	0,385952891	2,426061894
ln(R&D)	-1,166847178	0,480671159	**-2,427537323**	**0,035599814**	-2,237849262	-0,095845094
ln(education)	-0,001794659	0,005515613	-0,325378026	0,751600593	-0,014084212	0,010494893
ln(unemployment)	0,149705571	0,076527606	1,956229637	0,078928546	-0,020808561	0,320219702
ln(environmental taxes)	0,705680103	0,460237153	1,533296691	0,156208703	-0,319792178	1,731152384
Government expenditure in R&D	0,154011629	0,306571353	0,502367972	0,626285852	-0,529071913	0,837095171

A comment on the GDP variable deserve to be given. The GDP if increased lead to an increase of non-recycled plastic packaging, this is a behavior that every analyzed country has. It is worth to mention the *Environmental Kuznets Curve (EKC)* to explain the reason why this behavior is in fact normal. The EKC is an inverted-U curve which explain the relationship between GDP and pollution in a country. Normally, countries when industrialized, tend to be more pollutant. This tendency is true until a certain point (the maximum of the curve); after that, an increase of GDP lead to a decrease of pollution. There is then probably a relationship between non-recycled plastic packaging and its waste, and GDP in a country which may be similar to the one between pollution and GDP. This needs deeper studies to be verified, but this is not the purpose of this thesis.

3. Will it foster circular economy?

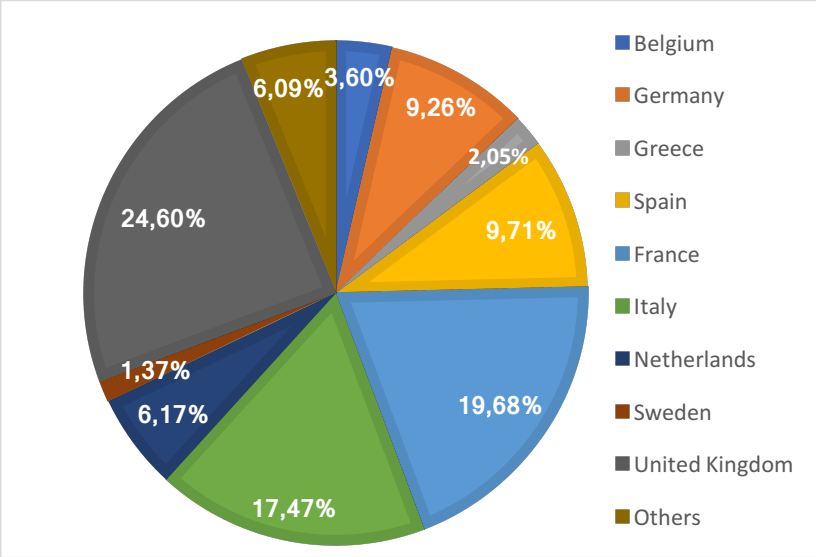
In the previous sections, an explanation of the circular economy concept is provided, as well as the European Commission measures proposed. In particular, the plastic tax is supposed to do not be an indifferent change in the costumers and producers' behaviour.
However, in the analysis provided, the effectiveness of the tax is not so evident. The European Union Member States still have slightly, or more evident, different cultures, approaches and behaviours respect to the environmental issues.
Anyway, the tax could be a good starting point to adapt more and more measures to fight against plastic pollution. By contrast, this seems not to be sufficient to foster circular economy.
As clarified in the first chapter, plastics are not recyclable an infinite number of times, which means that to associate the concept of circular economy to plastic is not easy at all. The classic process of recycling plastics cannot be entirely called a circular economy process, as plastics are not able to come back to the economy exactly with the same quality as it was at the starting point of the cycle.
Plastics can be reused more times, even if after a certain point of their usage, their quality level starts to decline. So, the reuse of plastics might be called a circular economy process, which is not the case for recycling.
As in a circular economy the resources are kept in use for as long as possible before being regenerated at the end of their life cycle, plastics also should be kept in use for as many time as possible and then regenerated; but the problem is that with plastics, and mostly with plastic packaging, this is not possible. Plastic packaging after the first use become waste and then they are recycled, giving a less quality product. Plastic packaging cannot be a product part of a circular economy system, at the moment. This means that alternative packaging solutions and products must be put in place to foster circular economy. The tax is a starting point as disincentive against their usage but it is not a complete solution. However, it may be good as resource of founding for the EU budget in order to adopt alternative solutions and investing on it. It is also good to encourage the Member States to adopt solutions to reduce plastic packaging landfill and incineration. It is, by the way, important to underline that those solutions will come by the Member States themselves

and so will be different in every EU country, this rise again a heterogeneity problem within the states.

The problem of heterogeneity in the EU is another theme that merits to be analysed, but this is not the propose of this thesis. In the next paragraph, this problem rises again looking at the plastic packaging measures already adopted or that are going to be adopted in the EU states and/or regions.

In the *Figure 13*, an overview of the countries that invest the most on waste management is provided.

Figure 13 General government expenditure on waste management, 2016[60]



Source: Author's elaboration from Eurostat

In fact, the tendency of giving importance to the management of the waste is not the same in every country, as well as it is not the same waste situation in every EU Members. For example, countries that already have a good waste management invest less in its management. At the same time, there are countries that invests less because they have other priorities. The countries that invest the most in the waste management for one reason or for the other are UK, France, Italy, Spain, Germany, Netherlands and then the others.

[60] Eurostat, "General government expenditure by function (COFOG) [gov_10a_exp]"

3.1 Plastic tax solutions adopted in the world

This paragraph has the aim to give an overview of the existing actions taken by the EU countries concerning Single Use Plastics. Moreover, it also lists extra EU countries actions on SUPs.

As the issue of marine plastic pollution is growing and it regards the whole world, the number of actions taken in the EU, as well as globally, is constantly increasing. Unfortunately, those actions are taken at regional or country level, mainly, and this may influence the effectiveness of the policies or have less effect respect to a decision taken by groups of countries together, or better, but this is utopia, at global level.

In the *Table 15*, a list of measures taken or that will be taken is provided concerning the EU Member States.

Table 15 Summary of existing measures regarding SUPs across EU Member States[61]

EU Member State / Region	Measure	Item Addressed / Detail	Year
Belgium - Brussels Region	Ban	A decree has been enacted which bans ultra-lightweight plastic bags.	September 2018
Denmark, Island of Samsø	Ban	All plastic bags	2018
France	Ban	Plastic cups, glasses, plates and cutlery. Includes plastic coffee cups, which will instead be delivered in compostable containers.	2020
France	Ban	Plastic cotton buds	2018
France	Ban	Ultra-lightweight plastic bags "produce bags" e.g. those used to pack fruit and vegetables, meat and fish. Compostable bags are exempt.	2017
France	Ban	Oxo-fragmental bags	Date not listed, in law
Italy	Ban	Non-biodegradable cotton buds	2019
Italy	Ban	Ban on ultra-lightweight bags e.g. those used to pack fruit and vegetables, meat and fish. These are to be replaced with biodegradable or compostable alternatives which a charge will be applied to.	2019
Portugal	Ban	Ban on the import and placing on market of disposable plastic utensils.	Proposed Bill – would have three years to adopt20
Scotland	Ban	Plastic cotton buds – Proposal to introduce a ban will be put to public consultation.	2018 (proposed)

[61] http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

Scotland	Ban	Plastic straws – Investigating the potential for banning straws in Scotland under devolved powers.	Proposed ban
Scotland	Ban	SUPs – Ensure plastic is reusable or recyclable by 2030. Have committed to this measure regardless of Brexit and UK position with respect to EU policy.	2030
Spain - Balearic Islands	Ban - Regional	All single use consumer plastics – items will have to become "easily recyclable" or switch to biodegradable alternatives.	2020
Spain - Balearic Islands	Law - Regional	Wet wipes will be required to be clearly labelled so as to prevent flushing.	2021
Spain - Balearic Islands	Law - Regional	Law will address plastic bottles by requiring restaurants to provide tap water free of charge.	In discussion

For the consistence of the problem, the actions put in place are maybe still not sufficient. Furthermore, it is clear that the SUP products actions in the EU are taken at country level and not in the whole EU, this create again a problem of fragmentation within EU.
In the *Table 16*, an overview on the non-EU countries actions is provided. It is possible to notice that the measures are taken at both regional and country level, as it is for the EU.

Table 16 Summary of existing measures regarding SUPs in non-EU countries [62]

Country / Region	Measure	Item Addressed / Detail	Year
Asia			
Bangladesh	Ban	Total ban on polyethylene (PE) plastic bags.	2002
Bhutan	Ban	Total ban on plastic bags.	2009
China - Jilin Province	Ban - Regional	Total ban on non-biodegradable plastic tableware (and bags) in the Jilin Province	2015
Indonesia - Badung	Ban - Regional	Ban on the use of Styrofoam in the city of Badung.	2016
India - Karnataka	Ban - Regional	All plastic – covers sale of plastic carrier bags, plastic plates/cups/spoons, and cling film.	2016
India - Delhi	Ban - Regional	All plastic – covers sale of plastic carrier bags, plastic plates/cups/spoons, and cling film.	2017
Philippines	Ban	Ban on the sale and use of non-biodegradable plastic bags in >59 municipalities.	2011
Sri Lanka	Ban	Ban on Styrofoam containers.	2017
Taiwan	Ban	Ban on beverage cups, straws, plastic bags and single use tableware.	2030
America			
USA - San Francisco	Ban - Regional	Plastic water bottles on city properties	2014

[62] http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

USA - New York City	Ban - Regional	Ban on single use Styrofoam containers in New York. The ban was challenged by a coalition of recycling firms and plastic manufacturers who claimed the material is recyclable. The ban was lifted in 2015, and reintroduced in 2017.	2013, lifted in 2015 and reintroduced in 2017
USA - Washington D.C.	Ban - Regional	On wet wipes labelled as flushable, unless it can be proven that they break down in normal sewer conditions.	2018
USA - Seattle, Washington, Portland, Oregon, Westchester, Berkeley and Malibu	Ban - Regional	Ban on Styrofoam food ware.	Date not listed
USA – Laguna Beach and Santa Monica	Ban - Regional	Ban on polystyrene (PS) food ware.	Date not listed
USA - Seattle	Ban - Regional	Ban on plastic straws and plastic utensils.	2018
South and Central America			
Costa Rica	Ban	All single use plastics.	2021
Antigua and Barbuda	Ban	Total ban on the importation and use of plastic utensils and Styrofoam containers.	2019
Chile, Punta Arenas and coastal regions	Ban - Regional	Total ban on PE bags in Punta Arenas. Total ban on the sale of plastic bags in 102 coastal villages and towns.	2014, 2017
Columbia	Ban	Ban on disposable plastic bags smaller than 30x30cm.	2016
Guatemala, San Pedro La Laguna	Ban - Regional	Total ban on plastic bags and Styrofoam containers in San Pedro La Laguna.	2016
Guyana	Ban	Ban on the import and use of Styrofoam items	2016
Haiti	Ban	Ban on the import and production of plastic bags and Styrofoam containers.	2013
Jamaica	Ban	Ban on all non-biodegradable plastic bags below 50-gallon capacity and on Styrofoam containers.	2018
St Vincent and the Grenadines	Ban	Ban on the import of Styrofoam products, VAT removed from biodegradable alternatives to lower their costs.	2017
Australia/Oceania			
Australia, Hobart, Tasmania	Ban - Regional	Ban on plastic takeaway containers.	2020
Australia, Coles Bay	Ban - Regional	Ban on all non-biodegradable plastic bags.	2003
Australia, South Australia	Ban - Regional	Ban on lightweight plastic bags.	2009
Vanuatu	Ban	Ban on polystyrene takeaway boxes.	2018
	Potential Ban	Considering the introduction of a ban on the use and import of single use plastic bags and bottles	2018
Africa			
Benin	Ban	Total ban on import, production, sale, and use of non-biodegradable plastic bags.	2018
Cameroon	Ban	Total ban on non-biodegradable plastic bags.	2014
Cape Verde	Ban	Total ban on the sale and use of plastic bags.	2017
Eritrea	Ban	Ban on the import, production, sale and distribution of plastic bags.	2004
Guinea Bissau	Ban	Total ban on the use of plastic bags.	2016

Kenya	Ban	Ban on the import, production, sale and use of plastic bags.	2017
Mali	Ban	Total ban on the production, import, possession, sale and use of non-biodegradable plastic bags.	2012
Mauritius	Ban	Ban on the import, manufacture, sale or supply of plastic bags.	2016
Morocco	Ban	Ban on the production, import, sale and distribution of plastic bags.	2016
Rwanda	Ban	Total ban on production, use, import and sale of all PE bags.	2008
Tanzania	Ban	Total ban on all plastic bags.	2018
Zimbabwe	Ban	Total ban on Styrofoam products - was temporarily lifted after introduction to allow businesses time to replace Styrofoam containers with reusable, recyclable or biodegradable ones	2017

It is interesting to see that some "total ban" actions have already been taken in some countries or regions. However, a diversified behaviour is globally present. Each country or region have its proper measure. In fact, in the European Union, according to ICF and Eunomia "there is some concern that unilateral action taken by Member States could fragment the Single Market. In part, the rationale for EU action stems from the desire to respond to the problem of marine plastic pollution whilst also, as far as possible, maintaining the integrity of the Single Market."[63]. So, the EU should also consider trying to make the policies more similar in every country, still respecting the particular cases. But this is not so an easy objective. However, the awareness of the underlying issue of marine plastic pollution is growing globally, as well as the pollution itself and, in response to this, the measures taken are increasing.

[63] http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

3.2 How to encourage replacing and reduce plastic pollution?

In the previous paragraph, it is shown that a lot of measures ban the plastic packaging usage and in some countries, other SUP products are totally banned as well. Nowadays there is an always increasing demand of packaging, as the population in some countries is growing as well as the demand and the variety of goods which requires a packaging to be transported and protected. This would require a lot of innovation in order to create new packaging products or give them an "Eco-design", in order to ensure its longevity. In the recent years, one idea that has increasingly raised is the development of new technologies to create bio-based products and plastics. However, those products offer a lot of challenges even if hold much promises. Furthermore, in the long term it may lead to resource scarcity and competing uses of biomass and lands[64]. It might be not a complete solution to use bio-based plastics, also because the degradation process in most of those kinds of plastics only starts under certain conditions, for example after heating it of only if exposed to sun.

Another point to consider regarding plastic production and in founding alternatives to it, is the pollution caused by the production process, and so, it would be better to go for alternative fossil-free options for producing plastics. The usage of renewable electricity for example, as well as water and carbon dioxide as feedstock through Carbon Capture Utilisation (CCU). Following the European Commission website[65], CCU is a way to use CO_2 as source of carbon. This method is still on development-to-demonstration phases but it will be a new economy for CO_2, used as raw material. Following the EC website "CO_2 utilization may delay carbon emissions to the atmosphere while reducing the consumption of the original feedstock and avoiding the emission of other substances associated to them. Enhanced oil and gas recovery (EOR, EGR), as well as CO_2 mineralization, result in permanent storage, while in the other utilization cases, CO_2 is emitted later in the product chain, i.e. when the CO_2-product based is consumed.

Due to its inherent potential, CCU is considered a complementary alternative to geological CO_2 storage […]. The market for CO_2 utilisation is relatively small, and future

[64] Mülhaupt, 2013; Tsiropoulos et al., 2015
[65] http://s3platform.jrc.ec.europa.eu/carbon-capture-and-utilization

markets for CO2 will have to map and prioritize points of CO_2 emission with utilisation opportunities, advocating for tailor-made and local solutions [Global CCS Institute & Parsons Brinckerhoff 2011]."

Furthermore, improving the efficiency of resources and its recycling, may decrease the demand for virgin plastic products and so, its production. This may help to maintain its production level at least stable.

However, as stated in this thesis, in order to foster circular economy, it is good to control plastic production and try to reduce its waste, but for the future, alternative products to plastics are necessary.

In the following *Table 17*, extracted from ICF and Eunomia study[66], some possible measures concerning SUP are underlined.

Table 17 possible SUP products measures

Product	Information campaigns	Labelling	Voluntary agreements	Specific Requirements on Product Design	Setting enhanced technical standards for WWTW and CSOs	EPR – for flushed items	DRS for beverage containers	EPR – full cost of litter	Sales restrictions / measures for adoption by public authorities	Consumption levies	Reduction targets (SUP)	Reduction targets (all SU)	Ban (of SUP items)	Ban (of all SU items)
Cigarette filters		Packs												
Drinks bottles												Water + soda only		
Cotton bud sticks		Packs												
Crisp packets														
Sweet wrappers														
Wet wipes		Packs												
Sanitary towels		Packs												
Cutlery		Packs												
Straws		Packs												
Stirrers		Packs												
Drinks cups / lids														
Food containers														

Source : http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

[66] http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

Information campaigns in order to improve consumers' understanding of the environmental impacts related to the products might be applied to all the listed SUP. Concerning labelling, a mandatory labelling of the listed SUP products could help to deliver the message more directly to their consumers. Voluntary agreement, as well as voluntary commitments and pledges, concerns every kind of action to reduce the usage of the product, through campaigns, discounts, etc. Following the Study[67], they are "generally those actions taken by industry to bring about changes without the need for changes in policy. At a European level, voluntary agreements typically involve a specific industrial sector, or category of producers; some formal recognition can be given through gaining approval from the European Commission." Voluntary commitments and pledges are usually made individually by individual companies. This measure can be applied to every listed product. Specific requirements on product design concerns drinks bottles, stirrers and drinks cups/lids. Those kinds of measures aim to integrate the smaller items with larger items in order to reduce littering. The enhance of the setting can be applied to cotton bud stick, cutlery and drinks cups/lids. A huge amount of those products is landfilled and they flush into the rivers and seas. Some options can be put in practice to mitigate the flow of the items, for example, following ICF and Eunomia study "Control at source; build bigger sewer systems including with larger overflow tanks; take surface water out of combined sewers; and reducing screen size from 6mm to 3mm, and install more screens at CSOs and WWTWs". EPR for flushed items may also be applied to cotton bud stick, cutlery and drinks cups/lids and is related to the previous point. It concerns a plan to give the responsibility to the producer to, for example, clean the items litter. EPR with full cost coverage of litter collections can be applied to every listed product. The implementation of Deposit Refund System (DRS) for beverage containers concerns and can be applied to drink bottles, cups and food containers. The DRS is a way to provide to consumers an incentive to bring back their bottles and food containers and be refund. This system is already applied in some Member States. Sales restrictions concern the ban of certain products under certain situations, for example in some big events etc. This measure can be applied to drink bottles, cotton bud sticks, drink cups/lids and food containers. Consumption levies can be applied to every listed item. Following ICF and Eunomia, "levies' are considered to be any economic instrument implemented

[67]http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

at the Member State level that increases the cost of SUP items placed on the market, and incentivise non-use, or substitution by SUNP and MU items." Reduction target (SUP) measure can be applied to every listed item a part for crisp packets and sweet wrappers. This measure concerns the set of a target on consumption of those items and has the aim to make it reduce every year, based on the consumption rate. The same case is for all SU products. Concerning the ban, it can actually be applied to drink bottles, cotton bud sticks, wet wipes, cutlery, straws, stirrers, drinks cups/lids and food containers. The listed products already have existing alternatives in the market.

It is certain that the above summarized measures may require efforts from every subject involved: the EU, governments, citizens, institutions, producers. However, as stated in the ICF and Eunomia study, some measures are already being put in place within EU and globally. This can confirm the feasibility of the approach in many cases.[68]

[68]http://ec.europa.eu/environment/waste/pdf/Study_sups.pdf

Conclusion

This thesis has analysed the EU plastic policy, in order to understand if the plastic tax proposed is going to foster Circular Economy. Moreover, Multiple Regressions Models are provided, in order to examines the relationship between the dependent value, the amount of non-recycled plastic packaging, and the independent variables: GDP, R&D, Education, unemployment, environmental expenditure, government expenditure in R&D.
The first part of the thesis presented some facts related to plastics: In the European Union countries, in 2016, each individual produced an average of 432 kg of Municipal Solid Waste and the major component of the waste is plastic, particularly plastic packaging. Moreover, in the EU the demand of plastic in the packaging sector amount to 39,9%. The work continues explaining the concept of Circular Economy, in order to clarify the intention of the "European Strategy for Plastics in a Circular Economy" launched by the European Commission in 2018. Circular Economy means a switch from a linear "take-make-dispose" model to a more restorative and regenerative one that allows the reuse of resources. It showed that this concept cannot be easily associated to plastic, as plastic experience a down-recycling process after its life circle. Recycled plastics has not the same quality as at the beginning of its life.
Within the EU Strategy for Plastics in a Circular Economy, the EC proposed a call-rate contribution of 0,80 EUR/KG for all the non-recycled plastic packaging per year in every Member State. The results that will take place on consumers behaviour is still not certain. However, an analysis of what are the variables influencing the amount of non-recycled plastic packaging is provided, through a Multiple Regression Model applied to some sample Member States as Germany, Italy, France, Portugal, Denmark.
The results for Germany shows that GDP, R&D, education, unemployment and government expenditure in R&D influence the amount of non-recycling plastic packaging in the EU. Concerning Italy, the significant variables are GDP, R&D and government expenditure in R&D. For France, any of the studied variables is sufficiently significant. Regarding Portugal, GDP, R&D, education and environmental taxes are variables that influence the amount of non-recycled plastic packaging. Concerning Denmark, the variable that are significant are GDP and R&D.

The major result of the Multiple Regression model is that the EU presents a problem of heterogeneity. The reasons of a bigger or smaller amount of non-recycled plastic packaging are different in the sample countries used for the Regression; which means that within all the EU countries, the difference can be even bigger. Some countries are slightly similar, but other are significantly different. This fact rises a problem in term of policies, as it may be difficult to apply a European policy that can be effective in the same way, in every country.

Concerning plastics, in particular, it is evident that there is a lack of coordination and on standards within the EU, as well as globally. The economy of plastics is fragmented, as it is for innovation as well. Following Ellen Macarthur Foundation report[69] "many innovations and improvement efforts show potential, but to date these have proved to be too fragmented and uncoordinated to have impact at scale. Today's plastics economy is highly fragmented. The lack of standards and coordination across the value chain has allowed a proliferation of materials, formats, labelling, collection schemes and sorting and reprocessing systems, which collectively hamper the development of effective markets. Innovation is also fragmented. The development and introduction of new packaging materials and formats across global supply and distribution chains is happening far faster than and is largely disconnected from the development and deployment of corresponding after-use systems and infrastructure. At the same time, hundreds, if not thousands, of small-scale local initiatives are launched each year, focused on areas such as improving collection schemes and installing new sorting and reprocessing technologies. Other issues, such as the fragmented development and adoption of labelling standards, hinder public understanding and create confusion." It is clear that in order to have effective policies, the problem of heterogeneity within EU states cannot be forgot in order to provide solutions that have also the aim to harmonize the measures results within the Member States.

[69] The new plastic economy: rethinking the future of plastics & catalysing action (https://www.ellenmacarthurfoundation.org/assets/downloads/publications/NPEC-Hybrid_English_22-11-17_Digital.pdf)

List of Acronyms

CO_2 Carbon-Dioxide

CCU Carbon Capture Utilisation

CSO Combined Sewer Overflows

DRS Deposit Refund System

EC European Commission

EPR Extended Producer Responsibility

EU European Union

GERD Gross Domestic Expenditure on R&D

GDP Gross Domestic Product

MSW Municipal Solid Waste

NOx Nitrogen-Oxides

PSW Plastic Solid Waste

R&D Research and Development

SO2 Sulphur Dioxide

SS Sum of Squared

SUP Single-Use Plastics

WWTW Waste Water Treatment Works

UK United Kingdom

US United States

WWF World Wildlife Fund

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