Life in Plastic, It's not Fantastic

The Economics of Plastic Pollution

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ABSTRACT

Since the 1950s, the production of plastic surpassed the production of almost every other material. If the trends in plastic production - and oil consumption - continue at its current rate, estimates are that by 2050 there will be about 12 billion tonnes of plastic litter in the environment and the plastic industry will be responsible for 20% of the world's total oil consumption. Globally, management of the increasingly large quantity of plastic waste has been challenging, with only 9% of plastic being recycled and almost 80% of plastic being either dumped, disposed in landfills or littered in the environment, resulting in an estimated 4 to 12 million metric tonnes (Mt) of plastic waste in the oceans annually. The improvement of solid waste management systems has not accompanied the rapid growth of plastic production, creating market inefficiencies with serious downstream effects on human health, quality of life and the environment – in particular marine life. Ultimately, there is no "one size-fits-all" solution to the current plastic problem. Governments, businesses and individuals all have a major role to play in paving the way for a circular economy with more sustainable patterns of consumption and a more efficient design of plastic products.

KEYWORDS: Plastic, Solid Waste Management, Environmental Economics, Asia

1 INTRODUCTION

Currently, one of the most serious and widespread environmental problems is plastic pollution. For many years after its creation, society only perceived the benefits of plastic and knew little about the damaging consequences its use could have to human health, ecosystems and the climate. Current mainstream methods of disposal are not entirely environmental efficient - this is particularly problematic in areas of rapid economic development and population growth such as the South East Pacific region. In China, for example, the cost to regulate plastic bag pollution is up to $ 2.6 million per year (Worldwatch Institute, 2019). However, not only China, but other governments and international organizations have felt the pressure to introduce tougher policies to control plastic pollution, ranging from economic instruments to regulatory ones, including bans, levies, voluntary agreements and a combination of both types of legislations, which has proved to have different effects in different countries.

2 RESEARCH AIM AND METHODS

For many years after its creation, society only perceived the benefits of plastic and knew little about the damaging consequences its use could cause to our health, various ecosystems and the climate. For a better understanding of the severity of this situation, this paper aims to analyse strategies in an empirical context that are used to in the field of environmental and natural resource economics to target this problem. For this purpose, the report has been organized into three main parts: (1) a literature review on plastic pollution, its characterization and evolution; (2) a theoretical and empirical background of the positive and negative externalities of plastic production and consumption, as well as the exemplification of different types of regulation that combat negative externalities and finally (3) a case study on China's implemented regulation in order to analyse the policy instrument's efficiency in targeting plastic pollution. The report closes with an overall conclusion to the current plastic crisis and a suggestion for a new production system is provided.

3 PLASTIC POLUTION

3.1 Characterization and Evolution

Plastic pollution is an accumulation of plastic products in the environment that adversely affects wildlife, wildlife habitat and humans (Parker, 2018). Although the first synthetic plastics, such as Bakelite, appeared in the early 20th century (1907), they only caught people's attention and became more common in the 1960s. Up until 2015, the annual production of plastics increased from nearly 200-fold to 381Mt (Geyer et al. 2017), due to its advantages.

Between 1950 and 2015, nearly 6,300Mt of plastic waste has been generated. Of this amount, around 600Mt (9%) had been recycled, 800Mt (12%) was incinerated, and approximately 4,900Mt (60%) of all plastics ever produced were discarded and are presently accumulating in landfills or in the natural environment. If the production continues on this path, assuming consistent use patterns and projecting current global waste management trends to 2050, only 9,000Mt of plastic waste will have been recycled, 12,000Mt incinerated, and 12,000Mt discarded in landfills or in the natural environment (Geyer et al. 2017).

3.1.1 Components of Plastic, Types of Plastic

Plastic is the term commonly used to describe a wide range of synthetic or semi-synthetic polymers that are used in a huge and growing range of applications. The polymer used to make a plastic is almost always mixed with additives, including colorants, plasticizers, stabilizers, fillers, and reinforcements. These additives affect the chemical composition, chemical properties, and mechanical properties of a plastic and also affect its cost (Murphy, 1996). While plastics may be made from just about any organic polymer, most industrial plastic is made from petrochemicals. More than 99% of plastics are produced from chemicals derived from oil, natural gas and coal — all of which are dirty, non-renewable resources. According to the UN's "*The state of plastics: World Environment Day Outlook 2018*", if the current trends continue, by 2050 the plastic industry will account for 20% of the world's total oil consumption. In today's market, numerous different types of plastics are available, all of which are constructed differently and vary in their recyclability. Nowadays, the serious plastic pollution is mainly due to the slow decomposition rate of plastic, as it has strong chemical bonds that simply make it last. According to the Ocean Conservancy (2017) the simplest plastics, such as the ones used in grocery stores, i.e. plastic wrappers and containers, take at least 50 years to break down while the most complex ones take between 100 and 600 years to decompose.

3.1.2 Plastic pollution Worldwide

Plastics are the most affordable and easily available items in the current world. This material is cheap, easy to make and (equally) durable and it can also get discarded easily. The increasing urbanization along with the population growth rate are responsible for an unaccountable amount of plastic pollution (Hoornweg and Bhada-Tata, 2012). With this increase in population and urban growth, the demand for cheap and readily available materials has also increased. As a result, in

recent decades, their production has tripled to reach out to the ever-rising consumer demands. In 2010, Portugal produced, on average, about 0.27kg plastic waste per person, while the Netherlands produced 0.42kg and India produced 0.01kg. Tackling plastic pollution is a challenge for all countries, yet sixteen of the top twenty countries responsible for mismanaged plastic waste are low to middle income countries (Altenburg, T. and Assmann, C. (Eds.), (2017). The largest generator of mismanaged plastic waste in 2010 was China, producing 8.8 million Mt of waste per year (27% of world total) and Indonesia producing 3.2 million Mt of waste per year (10% of world total) (Matsangou, 2018). Furthermore, developing economies are in a phase of development where wealth creation is accelerating, which is perceived as incompatible with environmental conservation – UNEP (2018) estimates that 57%, 40% and 32% of plastic in Africa, Asia, and Latin America respectively, is not even collected.

The shipping and fishing industry are one of the main sectors that contribute to plastic pollution, especially in oceans. Remote rural beaches tend to have plastic rubbish accumulated by the shores, coming from ships, sea accidents, and from nets used for fishing. The nets used for large-scale fishing operations spend long periods submerged in water leaking toxins, but they also get broken up or lost, left to remain wherever they fall (Watson et al., 2006). This not only kills and harms local wildlife, but also results in pollutants entering the water. The sector of plastic packaging for food, beverages, and tobacco products, constitutes over 60% of global beach litter. An estimated 1 to 5 trillion plastic bags are consumed worldwide each year –about 2 to 10 million bags per minute. Packaging has a very short 'in-use' lifetime - typically under 6 months - in contrast to building and construction plastics – which are used for a lifetime of 35 years. Packaging is, therefore, the dominant generator of plastic waste, responsible for almost half of the overall total by 2015 (Geyer et al. 2017).

4 EMPIRICAL ANALYSIS OF PLASTIC POLLUTION

The notion of hetero-regulation of the environmental system is often defended, i.e. the regulation of the environment is regarded as a function of the powers outside market rules calling for government intervention. While the countries that generate more plastic waste per year are not always the same as the countries that can be identified as the main sources of mismanaged plastic waste, and while some nations are better equipped to tackle plastic pollution through waste management systems, this is a problem that affects the entire human population (Ritchie and Roser, 2019). The rising of the internationalization of economic law comes as a huge consequence of the phenomenon of globalization. The interdependence of the ecological system is a very unique characteristic which explains the importance that international legislation has in regulating and harmonizing the various domestic regulations implemented by different countries.

Market failure happens when the prices of products or services are not properly considered, i.e., when external costs are not considered in the final price, meaning there's a need for market intervention. If externalities are present, the competitive markets will not necessarily result in Pareto efficient provision of resources - thus intervention is recognized as necessary to define rules and create mechanisms that cope with the market failures. In addition, since the damage caused to the environment is sometimes hard to attribute to a single certain agent, only though public action can an equitable distribution of abatement costs be achieved. In this sense, the government should not only prevent future plastic pollution, but also take action in order to solve the major issues related to the excessive usage of single-use plastics and mismanagement of plastic waste (Dos Santos et al., 2006).

4.1 Plastic Production Externalities

The side effects of production externalities can be positive, negative or a mixture of both. A positive production externality happens when a third-party gains as a result of production, and since they are not charged, there is only an incentive to supply. Production externality occurs when a firm's production process causes a decrease in utility to a third party – these externalities are usually unintended and can have economic, social and environmental impacts and can be measured in terms of the difference between the actual cost of production and the cost of the production to society (social costs). Additionally, if the externality is not accounted, inefficiencies will appear in the marketplace creating a market failure (Varian, Hal R., 2014).

4.1.1 Positive Externalities

The global plastics market was valued at 522.66 billion US$ in 2017 and, in Europe alone, the industry gives direct employment to more than 1.5 million people (Plastics Europe, 2018, pp.12). The European plastic industry had a trade balance of more than 17 billion euros in 2017 and contributed to 32.5 billion euros to public finances and welfare in the same year, ranking 7th in industrial added value contribution. However, the plastic market is highly fragmented with a larger share of the market occupied by medium and small enterprises (SME's) involved in plastic manufacturing. Some of the key manufacturers are Evonik Industries AG, BASF SE, Saudi Basic Industries

Corporation (SABIC) and DowDuPont Inc., and their main implemented strategy is an increased focus on high margin products. Companies are investing heavily in capacity expansion as well as with research and development and the market is projected to grow due to an increase in plastic consumption in the construction, automotive and electronics industries (Plastics Market Size & Trends Industry Analysis Report, 2019).

The plastic industry not only contributes to job creation and economic welfare, but in terms of social impacts, plastic helps to reduce food waste since it stores and keeps products fresh for longer, it comprises a lot of health care equipment, it is used in many renewable energy technologies such as wind turbines, solar cells and its treatment can generate energy (Plastics Europe, 2018).

4.1.2 Negative Externalities

Within the plastic industry, production externalities exist because a profit maximizing polluting firm will not pollute at socially efficient levels when left to its own choices. As seen before, the production of plastic exploits finite and non-renewable resources since plastics involve the synthetization of petroleum and natural gas derivatives. The production of plastic products can inflict a vast range of damages to third parties, including but not limited to: solid waste production, low levels of noise pollution, deterioration of air quality, greenhouse effect by emission of CO_2, stratospheric ozone pollution and spreading of toxic substances (with negative effects on the food chain). Taking the example of CO_2 emissions, since it is common to the production of all plastic products and thus the market fails in general terms, i.e., not specific to a single product, it makes sense that this problem would be addressed by a general economic /regulatory instrument[1]. Plastic production and the incineration of plastic waste originate approximately 400 million tons of CO_2 per year. GHG emissions from solid waste management accounts for almost 5% of total global GHG emissions. Methane alone, in landfills, represents 12% of total global methane emissions - this level of methane varies by country as it depends on the waste composition, the region's climatic conditions and waste disposal practices. The use of recycled plastics can help reduce the dependence on the extraction of fossil fuels thus curbing CO_2 emissions, and, the recycling of all global plastic waste could potentially save the equivalent to 3.5 billion barrels of oil per year (CIEL, 2017). On the other hand, taking solid waste production as another example and having in mind that 36% of plastic production in 2015 was plastic packaging, it would be best to target this externality by the use of a specific economic/regulatory instrument, such as but not limited to: bans or levies on single use plastics (UNEP, 2018).

4.2 Negative Consumption Externalities

When the provision of public goods is left to private individuals some inefficiency problems may arise since private costs, given that firms follow a utility maximizing behaviour, may differ from social costs. An issue that arises with the case of public goods is the incentive to free ride, i.e., the expectation that another party will account

[1] This is already in place, for example, in the European Union with the marketable emissions permit system and through a carbon tax which is a tax levied on the carbon content of different fuels.

for the good in cause. Moreover, we found no evidence showed positive consumption externalities of plastic, hence the lack of a section on this topic. Thus, considering the negative consumption externalities have effects on public goods - these are goods that if made available to one person, automatically become available everyone - the consumption of plastic products, if inappropriately disposed of, can affect commodities that possess public good characteristics, including the natural environment – through ineffective waste management systems - and biodiversity.

4.2.1.1 Loss of Biodiversity

As seen before, marine litters and microplastics can be found in all oceans of the world (UNEP 2011). From the smallest corals to the biggest wales, over more than 170 marine species are known to be killed either by the ingestion of plastic or by bioaccumulation, suffocation, strangulation or starvation (Verlis et al. 2013). These impacts are known to affect any taxa of animals, such as mammals, seabirds, which tend to consume plastic debris directly and also feed it to their chicks; sea turtles, which tend to confuse plastic bags with their prey – the jellyfish, all kinds of fish and a scope of invertebrates. Species that have a lack of adaptation to regulating ingestible dietary items are more vulnerable to the effects of cumulative ingestion (Vegter et. al, 2018).

The accumulation of plastic debris has altered the key physic-chemical processes, such as oxygen availability and light as well as temperature and water movement. Plastics may also change the temperature and permeability of sediments on sandy beaches, affecting animals with temperature-dependent sex-determination, such as reptiles (Carson et al. 2011). The biodiversity of habitats is locally changed by large plastic debris through an alteration of the availability of refugia and by providing hard surfaces for taxa that would otherwise be unable to settle in such habitats (Andrady, 2011).

4.2.1.2 Waste Management Systems

The open dump disposal method poses highly harmful consequences to the environment. The trash and its components suffer chemical changes - due to the mixture of substances and the direct effect of the sun - that generate toxic components which pollute the soil and the underground water. Consequently, this disposal method degrades soil that could be used for plantation, which in turn directly affects crop production in these areas and the population that is forced to consume polluted food (Yazdani et al., 2015).

Another negative environmental impact of the plastic industry is improper garbage disposal. When disposed of, plastic enters in the ocean from coastlines, rivers, shores, spreading into different locations, but originating giant islands that float on coastlines or the ocean basins. The biggest accumulation ever seen is the Great Pacific Garbage Patch (GPGP) - located between Hawaii and California, covering an estimated surface area of 1.6 million square kilometres. Even though there are huge garbage islands, there are several records about beaches covered in garbage, for instance, in Bali. Plastic litter on beaches has increased 140% since 1994. Looking through an economic lens, plastic pollution causes loss of benefits to society together with the costs of clean-up to townships as the marine industry sectors and coastal tourism suffer most. For the 21 countries belonging to the Asia-Pacific region, damages related to the marine debris for the fishing, shipping and tourism industries was estimated at $1.3

billion per year. In Europe, cleaning plastic waste from coastlines and beaches costs about $720 million per year. It was estimated that the cleaning the townships in the UK, Netherlands and Belgium costed approximately 18 million euros and 10.4 million euros respectively (Law, 2016; Matsangou, 2018; UN Environment, 2018).

4.3 Correcting Negative Externalities

There are two main types of legislation that policymakers usually opt for to tackle this issue: command and control (regulatory) instruments and market based economic instruments. The first one includes mitigation measures such as bans (ex: on microbeads, on personal care products, on single use plastics) while the second type of legislation aims to influence human behaviour through economic incentives or disincentives through levies on suppliers, retailers and/or consumers (ex: a container deposit legislation (CDL) [2], charges for certain items and disposal taxes). It's also possible to opt for a combination of regulatory and economic instruments that can be translated into bans and levies and extended producer responsibility (UN Environment, 2018; Szura, Katelyn, et al., 2018).

4.3.1 Bans

According to UNEP (2018), bans are a prohibition of a specific type or a combination of products, in this case, the single use plastics – some examples include, but are not limited to plastic bags, cutlery, foamed products and packaging. Moreover, the ban can be partial, meaning that it only targets certain specifications of a plastic product (ex: thickness of plastic bag) or the ban can be total, thus including all specifications of a particular type of plastic product (ex: all plastic bags).

4.3.2 Levy

To levy describes the act of imposing or collecting a charge, in this case, a levy would work as a tax. Levies are incentive taxes which aim to change the economic agents' behaviour in order to reduce environmental damage and focus on efficient resources use. The value of the tax must be fixed taking into account the environmental costs and the cost of control structure of the agents. Governments can impose levies on suppliers, retailers and consumers in order to reduce the domestic production, imports, distribution and use of plastic products (Varian, Hal R., 2014). A levy paid by plastic products suppliers can be an effective tax when it comes to inducing behavioural change but only if it is fully passed on from suppliers to retailers whom will in turn be tempted to impose some kind of measure on the consumers: either the retailer charges the consumer for the plastic products, or it can offer those consumers, who do not use plastic products - such as a plastic bag - a reward, incentivizing the use of reusable materials. Thus, a plastic levy on retailers is a tax that must be paid when purchasing plastic products, however, the retailers are not obliged to convey the tax on to the consumers. Finally, a plastic levy on consumers, is a charge on each plastic

[2] This is when, the buy purchaser pays a deposit fee for the item their buying, which is returned when the item (usually plastic bottles) is returned.

product sold – this is a standard price defined by law (UNEP, 2018).

4.3.3 Negotiation Solution and Property Rights

The externality problem arises because the polluter faces a price zero for the output it produces, even though people would pay to have that output reduced. When a resource is open to unrestricted access, there is no way of ensuring that its level is kept to the level that will maximise its overall value, hence the problem lies in the fact that there are undefined property rights - in this case regarding the quality of the environment. The clear definition of properties rights and the possibility to establish negotiation between the agent causing the externality and those affected by it, leads to a social optimum by one of two mechanisms: (1) the polluting agents compensates the affected party, in which case the affected party holds property rights; and (2) the affected party pays the polluting agents to not pollute anymore – in this scenario the pollutant agent holds property rights. The Coarse Theorem implies that with a clear definition of property rights and with no transaction costs, the negotiation on property rights leads to the socially efficient level of production regardless of who holds property rights - thus, the optimal pattern of production is independent of the assignment of the property rights (Varian, 2014). However, even if property rights are not well defined, the outcome of the economic interactions will undoubtedly involve inefficiencies (overexploitation of resources). Generally, there are two solutions proposed for resolving environmental problems: specifying property rights in environmental goods by "privatizing" them, or to control the access and use of the environmental goods through government regulation. In situations where law is non-existent or ambiguous, the tragedy of the commons [3] arises (Varian, 2014). However, according to Ostrom, such a tragedy only occurs when external groups exert their self-interest-based power to gain an advantage from the resources, since common resources can be well managed by people and communities in close proximity to said resource (CGIAR, 2015). The difficulties in assigning private property rights to the environment pose a challenge in the application of this strategy. So, when agents cannot make voluntary agreements, it's the government's duty to intervene and internalize the externality, but this can only be effective when supported by individuals and communities.

4.3.4 Worldwide Regulation

The economic damage caused by plastic waste is immense and varied and the economic, environmental and health reasons to take action are clear (UN Environment, 2018).

As apprehension about the effects of plastic on the environment and human health increases, so does pressure on policymakers to introduce tougher policies. There is an increasing range of global and national strategies emerging to phase out single-use plastics including but not limited to: (1) the European Union has approved a single use plastic ban *"avoiding 3.7 Mt of carbon dioxide emissions by 2030, eliminating 46 billion*

[3] The Tragedy of the Commons is an economic problem in which every individual tries to gain the greatest benefit from a given resource.

bottles, 36 billion straws, 16 billion coffee cups, and 2 billion plastic takeout containers each year"; (2) the Indonesian government has assured up to $1 billion a year with the aim of lowering the amount of marine litter; (3) in 2002 Bangladesh initiated a prohibition of polyethylene bag manufacture and distribution in its capital city; (4) Rwanda prohibited the use of plastic bags under 100 microns thick and (5) India has promised to eliminate all single use plastics by 2022 and had previously implemented a bag prohibition with a penalty of imprisonment for up to 7 years and a fine of €1240 (UNEP, 2014).

4.3.5 Social Movements

In the past decade, the zero-waste movement has gained particular recognition. Consumers are not only actors but rather drivers for a behavioural change, creating a sustained pressure not just for policymakers but businesses themselves, i.e., pressure in the upstream and downstream. Individuals have begun to turn down plastic bottles, straws and cutlery, they have begun cleaning beaches and second guessing their overall purchasing habits. New businesses have emerged, offering biodegradable and ecological alternatives to plastic products – such as bamboo toothbrushes, metal straws, razors, hairbrushes, bags and bioplastics – and even supermarkets in countries such as the UK and the Netherlands are implementing plastic free aisles (Bodkin, 2018). Thus, informed consumers are also part of the promotion of a more sustainable production of plastic products and the shifts for more eco-friendly alternatives. Nonetheless, individual choices will prove to be most effective in an economic system that can provide feasible, environmental options for the masses and not just an elite – plastic pollution must primarily be addressed through power and politics. Hence, this will require governments, international institutions, manufacturers and retailers to ensure that the management of the material across its lifecycle is done efficiently and help pave massified way for alternatives to plastic products. (UN Environment, 2018).

5 CASE STUDY: CHINA'S REGIONAL AND NATIONAL PLASTIC BAG BAN AND PLASTIC WASTE IMPORT BAN

China is one of leading countries in terms of plastic waste so much so that plastic litter in China has become known as "white pollution". Particularly, the contribution to plastic debris in the oceans, China is responsible for an estimated 28% of the plastic into waterways (Worldwatch Institute, 2019). As the Chinese economy grows, its demand for repurposed plastic does as well.

The case of China's bans on plastic bags and plastic waste import illustrate through an economic perspective the costs of plastic pollution for governments and the need for government intervention. Of the possible types of regulations, command and control policies' efficiency is analysed in targeting plastic pollution.

5.1 Temporary and Permanent Plastic Waste Import Bans

Regarding another policy initiative, in 2013, the Chinese Green Fence operation resulted in a reduction of plastic waste accepted at the Chinese border. Since it began reporting in 1992, China has imported 106Mt of plastic waste, and collectively with Hong Kong they have imported 72.4% of all plastic waste. China accepts materials believed to be recyclable and sorts them by recyclables, for profit, and waste. For the exporting countries, the shipment of processed plastic waste to China has provided an outlet for managing their plastic waste, i.e., preventing it from being disposed to a landfill or by incineration. In 2013, China introduced a temporary restriction (Green Fence Operation) on waste imports to reduce the amount of non-recyclable waste entering the country. Quality controls implemented by Green Fence highlighted the fragility of global dependence on a single plastic waste importer as direct upstream implications were felt for the waste management industries of the exporting countries – a 446 million US$ and 298 million US$ reduction in export and import trade values occurred respectively from 2012 to 2013 (Brooks, A.L., Wang, S. and Jambeck, J.R., 2018.).

China has increasingly implemented more rigid waste import policies and while the Green Fence campaign was temporary, more recently, on January 1, 2017, China announced a new import policy that permanently bans the import of nonindustrial plastic waste starting from 2018, because contaminated recyclables pose a threat to China's public health and environment. If taken collectively, then the EU-28 would be the top exporter (leading countries: Germany, UK, and Netherlands), contributing to 32% (27.6 billion US$) of all exports, followed by the United States and Canada contributing to 14% (14.3 billion US$) of all exports. This suggests that collectively, higher-income countries in OECD have contributed to 64% (57.4 billion US$) of all exports to lower-income countries in the East Asia and Pacific (EAP) and thus the trade of plastic waste is largely occurring between OECD and EAP countries. According to the International Solid Waste Association, there is indirect evidence that points to the majority of plastic being reprocessed by family-run, low-tech businesses with no environmental controls. Nevertheless, through its Green Fence Operation and the recent ban on imported plastic waste, the Chinese government has started to work towards reduce unregulated facilities. As a result of this new policy, plastic is piling up in the U.K., the E.U. and the U.S.A. until officials find a solution. Meanwhile, an estimated 111Mt of plastic waste will be displaced with the new Chinese policy by

2030 (A. L. Brooks, S. Wang, J. R. Jambeck, 2018).

6 CONCLUSION

As stated initially, plastics are found in many different sectors including transportation (shipping), fishing, health care, packaging (especially in the food industry), telecommunications, and consumer goods (Worldwatch Institute, 2015). The plastic industry makes a revenue of about 600 billion US$ per year worldwide and in Europe alone it gives direct employment to more than 1.5 million people. This industry contributes to public finances and welfare, ranking at the same level as the pharmaceutical industry and very close to the chemical industry in terms of industrial added value contribution. Furthermore, plastic helps to reduce food waste since it stores and keeps products fresh for longer, it makes up a lot of health care equipment, it's used in many renewable energy technologies such as wind turbines, solar cells and its treatment can generate energy. Nevertheless, the increase in plastic litter, debris and microplastics in the oceans, and toxic additives in plastic products, resulted in a matter of concern for both consumers and countries.

The main issue lies on the mismanagement of plastic waste and a global dependence on a single plastic waste importer – China, which receives 56 % of the total global weight of plastic waste. Much of the plastics collected for recycling in high income countries - Europe being the main exporter of plastic waste intended for recycling - are exported to developing countries – mostly in the EAP region – which have less robust waste management systems and lower environmental standards, which puts the balance between environmental protection and economic growth at stake. More than 60 countries worldwide have introduced policies to curb plastic pollution – depending on what the major issue regarding plastic is and whether it's tackled at a regional or global level, different legislations have shown different effects, with generally positive impacts. Bans and levies on plastic bags and, single use plastic products have been the main focus of government action so far, proving to be an effective way to counter some of plastic overconsumption. Another solution to close the gap between private and social benefits would be to price the use of environmental goods and governments have mainly opted for environmental taxes – such as the Pigouvian Tax - and levies on resource consumption. These taxes are directly set by the government, so it creates a double dividend as it reduces environmental impacts and ends up raising revenue for the government. As a market instrument that incites a cost-effective allocation, environmental taxes are increasingly being implemented worldwide. However, for various reasons, pricing environmental goods is not sufficient since there may be other market failures hindering the ecological transformation. The right combination of policies depends on different country conditions including - ultimately, there is no "one size-fits-all" solution to the current plastic problem. Alongside a reduction in plastic overconsumption, finding more environmentally friendly alternatives, and improving product design to use less plastic, should be done. Governments usually have a preference for policies that boost economic growth over ones that tackle environmental objectives, defending that the income generated can be used to clean up at a later stage. These discounting attitudes may put at risk future generations, as the mismanagement of production and consumption of plastic "today" is already showing its costs to the environment, countries and populations and the preferences of future generations are not reflected in market prices. All in all, transitioning to more environmentally

appropriate alternatives to plastics will be a lengthy process where governments, business and individuals have a major role to play.

6.1 Rethinking the Economic System – Towards a Circular Economy

The main reasons for governments to accelerate structural change in their economies is the fact that economic growth has been attained at the cost of the overexploitation of natural resources and this has been proven to be unsustainable. According Altenburg and Assmann (2017), the reconstruction of the industrial systems requires a cross-sector approach. A circular economy model is a proposed alternative to the linear economic model presiding in our society, in which the most important aspect is the increased capture and recovery of materials at the end of their service life so that they can be recycled and reused. (UNEP, 2018). In terms of plastic production, the problem ultimately lies in its design – in a linear global economic model the manufacturing, distribution, consumption and trade system for plastic is designed for its products to be thrown away immediately after use. Hence the importance in ensuring that decisions regarding plastic production are based on the sustainability of the entire life cycle of the product instead of just based on the resource efficiency at the end of the life cycle. For this to happen, governments must hold plastic manufacturers accountable for the life cycle of their products while the private sector should adopt business models that reflect a social and environmental responsibility for the downstream effects of their product. Because plastic is so cheap, transitioning to alternative materials can be costly, especially in the production and transport of stages of the lifecycle and, the overall costs and costs by stages varies per region of the world. However, if these targets were implemented in Europe and North America, the result would be a reduction of 7.9 billion US$ in net terms, in what concerns environmental cost of plastics (Altenburg, T., and Assmann, C. (Eds.), 2017).

Despite mismanaged plastic waste being a big source of concern, other methods of disposal such as landfills and incinerations also pose externalities. Energy recovery processes, such as incineration, are more desirable to disposing in landfills or unofficial site of disposal, like dumps. Recycling [4] delivers a social and environmental return on investment because not only it recovers the economic value the materials but also the environmental benefits by a reduction of littering. *"In the waste management hierarchy, prevention of waste should always take first priority"* (UNEP, 2018, pp. 6). For this to happen, plastic products must be redesigned to be as durable as possible (as to increase their reusability), to reduce chemicals added (which would make recycling less difficult and less costly) and to start incorporating in its composition more biodegradable materials. In this way, a circular economy strategy lays the grounds for a new plastics economy, where the design and production of plastics products fully respects the reuse, repair and recycling needs of a XXI century society, and more sustainable materials are developed. (UNEP, 2018; Lord, 2016).

[4] Recycling can also lead to unintended consequences and about 80% of recycled PET (from bottles) is used for fiber production in the clothing industry and fibers are lost from these fabrics during wear and washing, generating a significant source of microplastics in the environment.

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