IS THE PLASTIC MARINE DEBRIS WELL ASSESSED? ANALYSIS OF THE SOURCES AND THE INTERNATIONAL LEGISLATION RELATED

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ABSTRACT

Plastic marine debris has become of major concern due to the lack of knowledge about its sources and the possible ineffectiveness of its related international policies. Research has shown that albeit there exist many different origins, international legislation may fail to cover them due to methodological limitations, excess of qualitative monitoring processes or the governments' lack of implication. This study aims to determine, apart from the main plastic ocean sources, the evolution of international policies regarding such issue – what has been achieved, which pollutants have been handled and which are the future call-to-actions. To do so, a deep study on the main marine debris legislation texts is performed, followed by the construction of a regression model able to explain the tons of plastic floating in the Earth's oceans. Once having the statistical results, it is demonstrated that the country's surface area, population growth, municipal solid waste generation per capita, gross domestic product per capita growth, aquaculture production and the container port traffic are the factors that better explain the marine litter amount. In relation, it is proved that prior 2010 policies did not well cover marine debris sources and that posterior 2010 just treat a few of them. On the basis, it is recommended to enhance a circular economy model based on information-sharing practices and well-designed and defined data gathering methods, proper waste management systems particularly in developing countries, consumer behaviour regulation or on increasing plastic value, among others.

Keywords: plastic, marine debris, plastic oceans, international policies, sources, circular economy

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1. INTRODUCTION

Plastic is considered to be one of the main big problems of this century. Born in 1855 and designed to be useful and cost-effective for industrial activities, it could also satisfy the materialistic behaviour of consumers in terms of quick solutions. That is why *throw-away* or single-use goods such as plastic bags, food wrappers and containers, beverage bottles and cans, cutlery, straws, cups, lids and even cigarette filters became very successful (Scott E. Rupp, 2018). During the 1930s and 1940s, the plastic industry experienced a great increment mostly because of packaging, and from 1975 to 2012, its production grew by 620% ("Plastics Europe", 2013). Throughout its evolution, natural resources have run out for future generations and waterways have been polluted, which is related to the fact that individuals have always seen nature as something to use and consume rather than something to protect (Cotter. B, 2019).

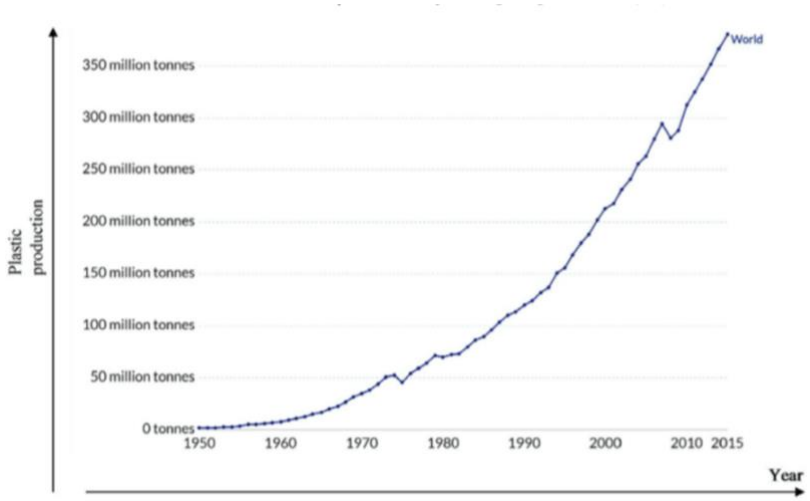


Figure 1: Evolution of global plastics production measured in metric tonnes per year (Source: Geyer et al. 2017)

Then, albeit marine debris[1] is not a new phenomenon, it has recently become more important due to its increasing production over time. Mismanaged plastic waste is estimated to triple by 2060 if individuals keep consuming plastics as now. By the same year, the ocean will have more plastics than fish in terms of weight (MacArthur Foundation, 2016).

[1] Any human-created manufactured or processed solid waste material which has been disposed or abandoned into the marine and coastal environment, directly or indirectly (Coe & Rogers, 1997). It is estimated that between 60% and 80% of such materials are made of plastic (Algalita Marine Research Foundation, 2008).

Specifically, about 9.2 billion tons of plastic has been produced since its invention. If this amount was be transformed into clingfilm, it would be enough to wrap the whole globe, with some of it leftover (Berners-Lee, 2019). From such amount, 6.3 billion tons have never been recycled, and what is more, 5.3 million to 14 million tons are estimated to end up in the ocean each year (Parker. L, 2018).

Special attention is given to microplastics[2], which are estimated by the UN Environment Programme to be around 51 trillion. While bigger plastic items can be easily removed, microplastics are not visible – they can be smaller than the diameter of a piece of hair – so they cannot be properly identified. They are latterly found in food chains or pharmaceutical products which lead to human health issues due to their toxic chemicals and carcinogens. These microfibres mostly come from the beauty industry and wastewater treatment, but they can also be created when washing clothes or using fishing nets (Matsangou, E., 2018). As plastic is a non-biodegradable material, these small fibres cannot be absorbed by the natural system due to its high molecular weight. In fact, plastic degradation at sea has been ranged from 450 to 1.000 years, even though some items such as foamed plastic cups only take 50 years to be disintegrated (Le Guern, C. 2009).

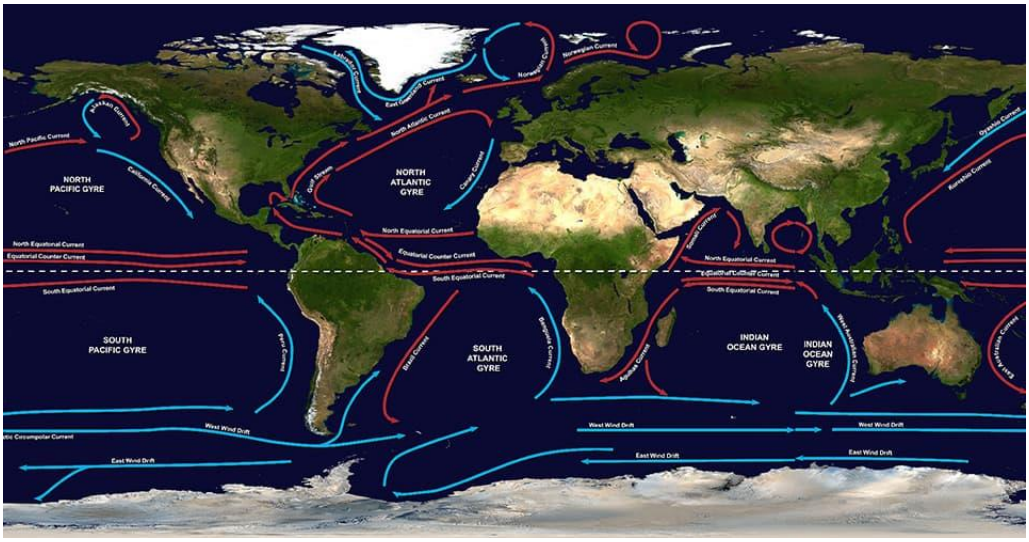


Figure 2: Map of the five major ocean gyres
(Source: National Oceanic and Atmospheric Administration, 2017)

[2] Small fragments and particles coming from broken up plastic items and that become smaller over time (Matsangou, E., 2018).

There are specific areas in the ocean called gyres[3] where these amounts of macro and micro-plastics are being accumulated. There are 5 important gyres worldwide, and the biggest one, the North Pacific Gyre (also known as the Great Pacific Garbage patch), which is formed by plastics coming from North America and Japan, occupies twice the size of Texas. It was first mentioned in 1988 and it was described as a large area in the ocean concentrating around 1.8 trillion microplastics across 617.000 square miles, both suspended or beneath the ocean surface (Akpan. N, 2018). It is also characterized for being toxic for the marine environment as it contains *bisphenol A* and *PS oligomer*[4] (Le Guern, C. 2009).

Some countries have undertaken numerous analysis to know the sources of marine debris in their territorial waters[5], and some international organizations and entities have also estimated the global primary plastic production by industrial sector or, for instance, the total plastic waste per country. The environmental, social and economic consequences of such phenomenon can be easily observed and they become fundamental when assessing public behaviour, legislation, governance, industry or commerce (Pahl et al., 2017). Firstly, environmental impacts involve marine fauna injury or death due to microplastic ingestion or entanglement, which leads to a reduction in the provision of fisheries and habitat damage. Plastics is also a risk for vessels and for non-native species which end up in far-away habitats. Overall, it represents a biodiversity loss and a long-term ecosystem deterioration. Secondly, social impacts include coastal contamination and a consequent decrease in recreational opportunities. People can also suffer from plastic ingestion or heritage lost. Social aspects are also related to the loss of aesthetic value and non-use value of ecosystems. Finally, economic impacts include different associated financial losses such as in shipping activities, tourism, cleaning activities, coastal agriculture, control and eradication of non-native species or power station costs. Details about all the impacts mentioned can be found in **Appendix 1**. Indirect costs must also be borne in mind. The 98% of plastics come from fossil fuel feedstocks and its management process is energy-intensive and carbon-emitting, for which CO2 emissions could grow 76% by 2050. Also, keeping with the same pace of production and incineration practices would lead to 287 billion tonnes of carbon by 2100,

[3] Large-scale circular mass of water featured by spiral currents around a central point which can be found both in the Northern Hemisphere and Southern Hemisphere. There are 5 gyres in total which represent 40% of the ocean (Le Guern, C. 2009).

[4] Toxic chemicals of major concern as they can totally modify animals' hormones.

[5] Area of the sea immediately adjacent to the shores of a state and subject to the territorial jurisdiction of that state ("Territorial waters | International law", n.d.).

which is a third of the whole carbon budget (Birkbeck, 2010). Low plastic prices do not reflect all these costs. Fossil fuel feedstocks and infrastructure for plastic manufacturing are being heavily subsidized and the huge production of such material allows economies of scale, resulting in small prices for most plastic products (Birkbeck, 2010). Contrarily, the costs of damaging the marine ecosystem are estimated to be of $13 billion per year (Matsangou, E., 2018).

Governments and citizens have a lot to do to mitigate such consequences. On the one hand, governments along with other institutions should elaborate policies according to the prevention of plastic oceans as well as guidelines to cover its consequences. The problem with these policies or agreements is that, after implementing them, their evaluation and tracking processes are usually based on qualitative data rather than quantitative, which would enable to proof the effectiveness of such policies in a more straightforward way. Another problem, as mentioned, is that if the real plastic sources are not properly identified, so they cannot be taken into account when designing international policies. On the other hand, it is the responsibility of citizens and shareholders to stop the throwaway plastic culture by supporting a circular production and consumption model to reduce or even eliminate the plastic accumulation (McDermott & Kristin L., 2016).

2. OBJECTIVES

The main goal of this thesis is to prove the effectiveness of international regulatory policies by involving all possible countries and sources of marine debris and using 2010 for all statistical calculations. Comparing the legislation previous to 2010 to the statistical results, as well as comparing these statistical results to the legislation after 2010, will offer a clear snapshot of the evolution and effectiveness of the international organisms, associations and governments when elaborating the correct policies regarding plastic oceans. The objectives, then, are the following ones:

1. Finding and analysing the corresponding international agreements regarding plastics in the ocean.

2. Finding indicators with a direct impact on marine plastic pollution:
    a. Selecting possible variables included in international policies and previous related studies.
    b. Observing which are the most relevant ones based on statistical results.
    c. Observing which type of relationship these factors have with plastic ending up in the ocean.

3. Evaluating the effectiveness of international legislation:
    a. Studying if policies set before 2010 were effective based on statistical results.
    b. Studying if the posterior policies handle the most pollutant sources (variables) found in 2010.

4. Determine the future investigation lines as well as proposing some solutions once having studied the effectiveness.

3. THEORETICAL FRAMEWORK

3.1 Countries and marine debris: contextualization

Before starting to analyse both the international policies and studying the other similar literature, it is crucial to explain the different sort of countries regarding the waste management industry, and consequently, the marine debris.

As mentioned, the numbers are very worrying. In 2016, almost 310 million metric tons of plastic waste were generated, but just 63% of them passed a controlled waste management process (World Wide Fund For Nature, 2019). In fact, from 1950 onwards, only 9% of primary plastic has been recycled (Birkbeck, 2010). Waste and recycling industries are highly related to countries' income. In developing countries[6], the impact of unworkable waste systems is huge due to their limited recycling capacity and their poor waste infrastructures. There, 90% of litter is disposed of in openly landfills which creates health, safety and environmental problems as well as contributes to climate change ("*Solid Waste Management*", 2019). For example, in India and Cambodia people could just throw their garbage out their homes with no institution penalizing them for which they have no incentive to start recycling or paying a waste management service. This could explain the 59.130 plastic tonnes in the Indian Ocean (Kaza S., 2018).

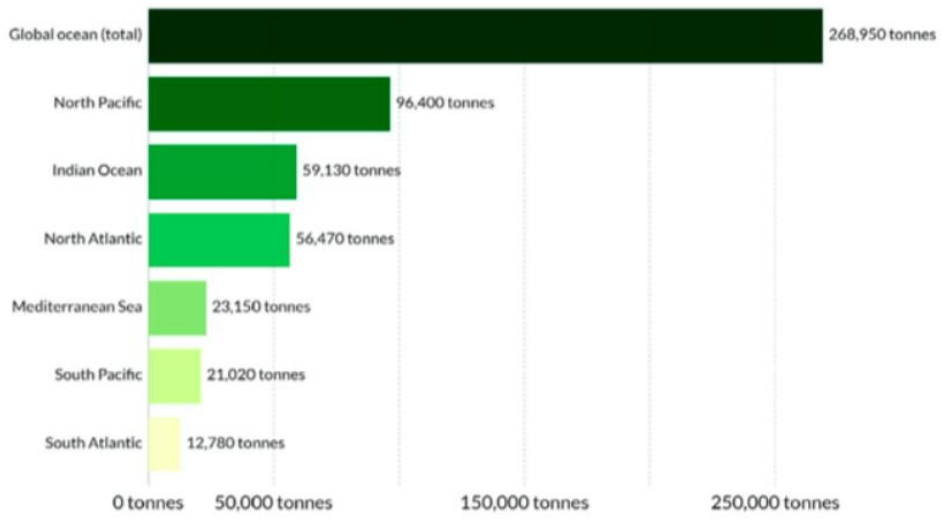


Figure 3: Quantity of plastic floating at ocean surface within reach of the world's ocean or marine basins (Source: Eriksen et al. 2014)

[6] Any country having a standard of living or level of industrial production well below that possible with financial or technical aid (Dictionary.com, 2020).

Conversely, high-income countries often have the correct infrastructure and means for which the probability of plastics ending up in the ocean is lower. For instance, countries such as Norway or Switzerland can reuse more than 80% of their plastics due to their integrated and well-designed waste framework and resource strategy to address each waste stream with the best option (National Oceanic and Atmospheric Administration, 2018).

Many debates have been created around which countries have the fault of the current situation. It has been proven that, even if they counted on better infrastructures, richer countries would waste more plastic than poorer ones (Niranjan, 2019). For instance, Germans and Americans throw away plastic items 10 times more compared to Indians or Kenyans. Furthermore, countries such as Australia or Japan have been exporting great amounts of litter to Southeast Asian countries for recycling, which exceeds the waste capacity management of these regions. Fortunately, Vietnam, China and Malaysia have finally banned such imports. This study is intended to clarify that the current situation is all countries' responsibility. As mentioned, low-income countries, while becoming richer, should invest in proper waste infrastructures and focus on recycling centres and secure dumping sites. On the other hand, richer ones should start dealing with their litter without having to export it, as well as reducing the waste infrastructures operating costs, which currently are of €924 per metric ton (Niranjan, A., 2019).

Nowadays, each country is applying some policies according to their current situation, possibilities and needs (Birkbeck, C. D., 2020). By creating or modifying the corresponding policies – or by strictly applying the current ones – sustainable waste frameworks will be created, which must also be complemented with the support of local institutions, financial sustainability and citizen engagement related to deep ecology[7]. It is estimated that implementing all these policies and practices with proper strong enforcement would lead to a reduction of 57% in global plastic litter and a decrease of half of the total virgin plastic production from business activities, as well as it would lower single-use plastics demand by 40% and would create jobs in plastic recycling and manufacturing industry (World Wide Fund For Nature, 2019)**.**

[7] Philosophy recently created by ecologists which aims the legal recognition and protection of nature by recognising it as a subject of law (Le Guern, C. 2009).

3.2 International policies related to plastic oceans

The United Nations created the United Nations Environment Program (UNEP) in 1972, which was designed to set the global environmental agenda and to control the implementation of programmes around the globe. Specific programs for plastic were added a few years ago, and in the Environment Assembly celebrated in 2019, they agreed on jointly tackling pollution on single-use plastics. An Expert Working Group was also created to strengthen the international cooperation regarding marine debris through sharing best practices, instruments and experiences (Birkbeck, 2010). The most important UNEP conventions, sub-organisations and agreements regarding marine debris are:

- The *United Nations Convention on Oceans and the Law of the Sea (UNCLOS)*. It was signed in 1982 and it replaced the Geneva Convention of 1958. Part XII specifies the policies regarding the conservation of the marine environment.
- The International Maritime Organization was established in the *London Convention on the Prevention of Marine Pollution by Dumping of Wastes*, which was carried out in 1972 and involved 87 states. Its goal was the effective control of all sources of marine pollution as well as implementing some prevention measures. In 1996, it was modified with the introduction of new duties for member parties and with some points related to plastic, which entered into force in 2006.
- The *International Convention for the Prevention of Marine Pollution from Ships* (1973) and *the Protocol of 1978 relating thereto (MARPOL 73/78*) is the main framework to prevent and reduce pollution from vessels by both assessing the items which accidentally end up in the sea as well as the regular pollution from shipping operations. Annexe V deals with plastic items, which entered into force in 2013.
- The *Convention on Biological Diversity* entered into force in 1993 and it focused on preserving biological diversity through the sustainable use of its components and the sharing of its benefits among all members.
- As commented above, specific plastic waste and marine litter policies have recently been incorporated. They involve different programs such as the *Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA)*, the *Global Partnership on Marine Litter (GPML)* guided by the Honolulu Strategy or the *Global Partnership on Waste Management*.

- The *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* was undertaken in 1989 and it was aimed to assess the management of hazardous wastes and their disposal. In 2019, members extended the original text with an amendment dedicated to marine debris and plastic waste, in which 187 states agreed that unrecyclable plastic will require the prior consent from importing countries before being exported. Also, several partnerships on plastic waste in support of this new amendment were created with members of private companies, civil society and other stakeholders (Birkbeck, 2010).

Apart from the United Nations, the International Solid Waste Association (ISWA), which was founded in 1970, also aims to enhance waste management practices and meet the Sustainable Development Goals[8]. Its projects include keeping waste out of oceans, building a circular economy infrastructure, building a resource management infrastructure and assessing the waste management worldwide. In 2017, a report called *Task Force on Marine Litter* was included (Velis C, Lerpiniere D, Tsakona M, 2017). Finally, the World Trade Organization (WTO) has also been promoting the economic transition towards a free-plastic economy through the removal of subsidies that promote plastic trade, new environmental standards, new policies and producer responsibility schemes (Birkbeck, C. D., 2020). Other conventions and programs related are the Stockholm Convention, which is intended to reduce or even eliminate the production of persistent organic pollutants some of which are additives used in plastic industry, the Paris Agreement, aimed to assess the CO_2 emissions and to regulate the growing plastic industry relying on fossil fuel feedstocks and carbon-intensive production processes, the 2015-G7 Action Plan to Combat Marine Litter and the G20 Implementation Framework, which contain different regional actions, the World Bank Project, which supports sustainable projects with financial aid, the Global Environment Fund (GEF), which issues alternative assets related to green energy, the World Customs Organization (WCO) or the International Organization on Standardization (ISO), both of which relate to plastic trade and social responsibility .

[8] They are different call-for-actions in which countries are committed to tackling plastic pollution through targets on sustainable consumption and production patterns

3.3 Other similar studies

Some regional and partial studies have been examined. The first country-by-country estimate for coastal emissions of plastic appeared in 2015, in which it was proved that between 4.8 and 12.7 million tonnes entered the oceans in 2010 (Jambeck, J. R. et al, 2015). Such estimation was done taking into account countries' population density, waste generation rates, countries' economic status and specific waste data. This 2010 study is the most recent one regarding the amount of plastic littered. The results show that China, Europe and North America are the ones in charge of the greatest share of littered plastic due to their consumption and disposal practices (Birkbeck, 2010):

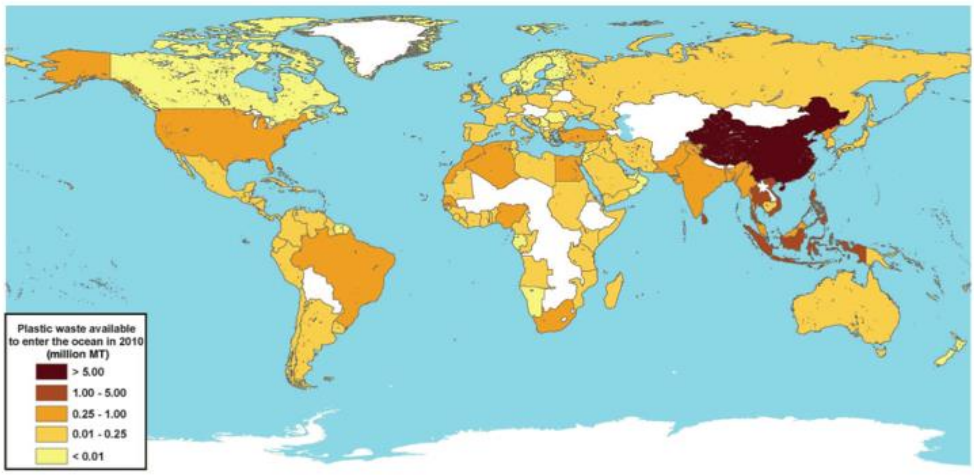


Figure 4: Countries with their estimated mass of mismanaged plastic waste (in millions of metric tons) generated in 2010 by populations living within 50 km of the coast (Source: Jambeck, J.R. et al, 2015)

Studies regarding agricultural and land sources have proven that the 80% of marine debris is originated in land, coming from both common litter and materials in poorly managed landfills which end up in the ocean through conduits, outpourings and wind (Sonam et al, 2019). Some articles point out the 10 largest rivers of the world are the responsible of the 90% of marine pollution as they are potential connectors between garbage generated on land and marine debris (Schmidt et al., 2017). Waterways, even in developed countries, are very sensitive to rain as they can be easily polluted when the rain level exceeds the sewage treatment facilities' capacity. For instance, about the Yamuna River in India, it was estimated that 80% of its pollution is the result of sewage, and that combined with industrial toxic releases, they represent 3 billion litres of waste per day that end up in the ocean (Le Guern, C. 2009). On the other hand, Greenpeace also stated that abandoned fishing gears are great contributors of plastic pollution in the sea (Laville, 2019) and that food production is responsible for the vast majority of single-use plastics littered

(Westwater, 2018). Finally, human activities concentrated in coastal regions are less able to assimilate high amounts of plastic consumption which have more possibilities to end up in the sea ("*Europe's seas and coasts*", 2019). Nevertheless, since 2010, the marine protected area coverage has raised over 14 million ̃Ω ά, which represents an increment of 6,4% ("*Explore the World's Marine Protected Areas*", n.d.).

Studies regarding population and urban development pollutants link marine debris with those nations with a growing population rate close to coastlines and with poor waste administration frameworks (Jambeck, J. et al, 2015).

Rank	Country	Econ. classif.	Coastal pop. [millions]	Waste gen. rate [kg/ppd]	% plastic waste	% mismanaged waste	Mismanaged plastic waste [MMT/year]	% of total mismanaged plastic waste	Plastic marine debris [MMT/year]
1	China	UMI	262.9	1.10	11	76	8.82	27.7	1.32–3.53
2	Indonesia	LMI	187.2	0.52	11	83	3.22	10.1	0.48–1.29
3	Philippines	LMI	83.4	0.5	15	83	1.88	5.9	0.28–0.75
4	Vietnam	LMI	55.9	0.79	13	88	1.83	5.8	0.28–0.73
5	Sri Lanka	LMI	14.6	5.1	7	84	1.59	5.0	0.24–0.64
6	Thailand	UMI	26.0	1.2	12	75	1.03	3.2	0.15–0.41
7	Egypt	LMI	21.8	1.37	13	69	0.97	3.0	0.15–0.39
8	Malaysia	UMI	22.9	1.52	13	57	0.94	2.9	0.14–0.37
9	Nigeria	LMI	27.5	0.79	13	83	0.85	2.7	0.13–0.34
10	Bangladesh	LI	70.9	0.43	8	89	0.79	2.5	0.12–0.31
11	South Africa	UMI	12.9	2.0	12	56	0.63	2.0	0.09–0.25
12	India	LMI	187.5	0.34	3	87	0.60	1.9	0.09–0.24
13	Algeria	UMI	16.6	1.2	12	60	0.52	1.6	0.08–0.21
14	Turkey	UMI	34.0	1.77	12	18	0.49	1.5	0.07–0.19
15	Pakistan	LMI	14.6	0.79	13	88	0.48	1.5	0.07–0.19
16	Brazil	UMI	74.7	1.03	16	11	0.47	1.5	0.07–0.19
17	Burma	LI	19.0	0.44	17	89	0.46	1.4	0.07–0.18
18*	Morocco	LMI	17.3	1.46	5	68	0.31	1.0	0.05–0.12
19	North Korea	LI	17.3	0.6	9	90	0.30	1.0	0.05–0.12
20	United States	HIC	112.9	2.58	13	2	0.28	0.9	0.04–0.11

*If considered collectively, coastal European Union countries (23 total) would rank eighteenth on the list

Figure 5: Plastic waste input study which analyses the coastal population as well as administration frameworks and percentages of mismanaged waste per country (Source: Jambeck, J. R. et al, 2015)

These countries have low waste collection rates as they have limited investment for it. In relation, the quick creation of *megacities* and urban regions could also explain such phenomenon. Almost 70% of the city development occurs in the city surroundings and ghettos, areas in which administration of waste disposal is slightly worst that in the city centre. In relation, plastic waste generation per capita has been studied to proof the relationship between plastic usage and its recycling process (McAdam, 2017), as well as the renewable energy usage, which has been proven that could reduce plastic pollution in some particular developed areas (Folk, 2019). Also, a recent study by Toyota has claimed that business activities can have an impact on water pollution in consumption's disposal phase, and therefore countries should enhance their social responsibility frameworks to avoid it ("*How Businesses Can Reduce Plastic In Our Oceans*", 2020).

Other articles take into account economy and growth-related variables such as the gross domestic product (McAdam, 2017). Industrial activities also generate plastic trash through packaging, construction and textiles activities ("*What Is Plastic Used For In*

Society, & What Sectors Use & Waste The Most Plastic?", 2019). In fact, some producers are expecting to increase their production capacity to 75% by 2022, which would be followed by a demand increase for disposable plastics (Day K. and Hodges T., 2018). Single-use plastics are also widely mentioned. Their dependency on natural gas has made fuel feedstocks really available and cheap worldwide, for which plastic production is expected to increase by 50% in the next 10 years. It would triple the plastic exports amount by 2030 (Day K. and Hodges T., 2018). Some governments have started to introduce bans and levies to stop such situation. The first country to ban plastic bags was Bangladesh in 2002, followed by Ireland which got a 90% reduction in single-use plastic items, and the money gathered was used to promote plastic recyclability programmes. In 2003, Taiwan introduced a small charge in plastic purchases both for businesses and citizens. Lately, in 2018, the European Commission put pressure on its 28 member states to approve bans on such plastics, which would avoid 3.7 million tons of carbon dioxide emissions by 2030 (Amadeo, 2020). Plastic trade has recently become relevant for governments, especially since China banned its plastic waste imports in 2018 and for which some European countries had to rearrange their plastic waste exports to other developing countries (Gray, 2018):

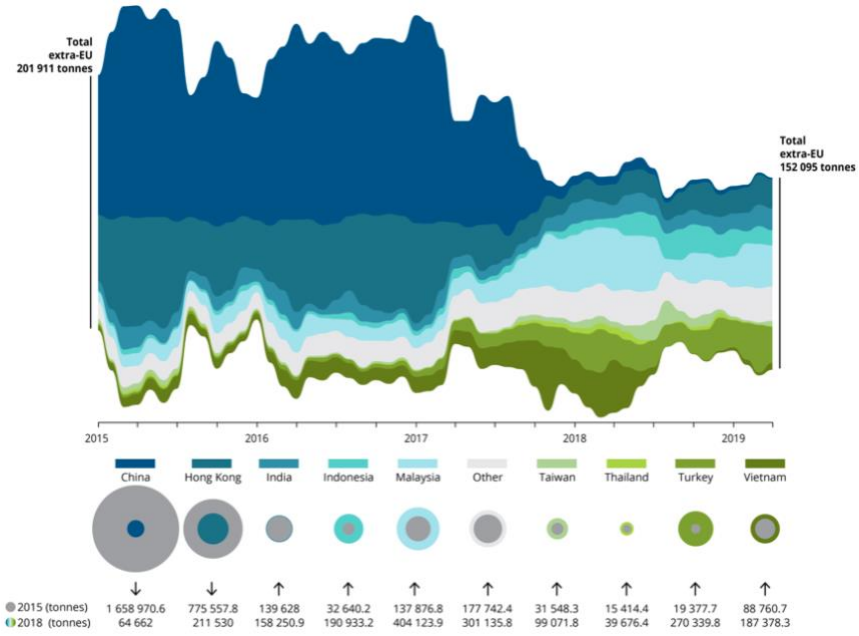


Figure 6: Extra-EU-28 plastic waste trade by receiving country (Source: Eurostat, 2019)

Finally, it has been seen that international and national policies play an allegedly important role in the behaviour of governments regarding environmental policies and

waste management, so those countries with more regulatory policies are expected to have less probability to throw litter away their oceans.

Another factor frequently studied is education. According to Chow, Winnie So, Cheung & Yeung (2017), people's behaviour towards plastic consumption can be modified through different education programs, which should be boosted by governments. Then, it becomes fundamental to analyse the relationship between government resources in terms of education and marine debris. For instance, in 2004, the Australia government promoted the plastic waste proper disposal in all schools, and the Indonesian government engaged citizens with enhancing the waste management to prevent plastic pollution in the Java Sea. Both campaigns succeeded in reducing the amount of plastic littered. Besides, a 2018 research at the University of Plymouth proved that innovative and systematic tools for teachers can make a significant positive contribution to students' willingness to change their behaviour regarding plastic consumption. Then, teachers can improve the public understanding of environmental issues as well as can provide solutions through different programmes and workshops (Scott E. Rupp, 2018). Wages and waste are also related because, as commented before, the per capita share of plastic inadequately disposed is highly related to the countries' income. Finally, even though it is not quantitatively proven, experts believe there is a linkage between those individuals and organizations involved in clean-up activities and the reduction of plastics in shores and seas (Sonam et al, 2019). Clean-ups are straightforward and effective to perform as they represent the starting point of cultural change towards new behaviours. However, special attention must be put into the machines used as they can absorb the plankton needed for marine species to do the photosynthesis (Le Guern, C. 2009). The first massive coastal clean-up was carried out in 1986 by the Ocean conservancy. In 2008, the organization reported that 104 different regions had participated and that the percentage of debris collected had risen by 126% since 1994, which is so worrying.

In terms of countries' infrastructure, shipping activities often create waste from commercial vessels which is deliberately or accidentally dumped into the sea (Scott E. Rupp, 2018). In fact, according to the World Shipping Council, the shipping industry loses 10.000 containers per year at sea, which represents a flux of 6.4 million tons of items discharged (Cambel, 2018). It was also estimated that 20% of debris come from dumping activities on the ocean such as sailboats, large transport ships, offshore drilling rigs and fishing piers (Le Guern, C. 2009). According to Blok (2019), it is also necessary to focus on internal freshwater sources to explain the ocean pollution, as microplastics

are often thrown away in such water flows and channels, mainly in developing regions. New studies have concluded that the role of wastewater treatment plants is crucial at filtering microplastics, albeit their implication is not as effective as it should be ("*Wastewater Treatment Status by Countries and Economies*", 2020).

Finally, many articles blame tourism for polluting the ocean. People using beaches for recreation and leisure constitutes one of the most plastic pollutants ("*What Causes Marine Litter?*", n.d.). In fact, around 80% of tourism chooses coastal areas, which disrupts the local infrastructure and habitats. For instance, shoreline activities account for 58% of marine litter in the Baltic Sea Region and 67% in Jordan. This phenomenon is of particular concern in East Asian regions where from 1.8 billion people, 60% live in coastal cities (Le Guern, C. 2009). According to Eagle, Hamann & Low (2016), tourists' behaviour must be changed to minimize the plastic environmental issues.

4. RESEARCH QUESTION AND HYPOTHESIS

The 4 main research questions are highly related to the specified objectives:

1. Which were the variables with the highest relationship with marine debris in 2010?
2. Which variables taken into account in previous 2010 policies were not relevant anymore by that year?
3. Which of these variables were not included in the international agreements set before 2010?
4. Do the posterior 2010 policies handle 2010 results?

From these questions, the hypothesis presented are the following ones:

1. Pollutants included in previous 2010 international policies keep having a positive relationship with marine debris in 2010, demonstrating that policies were not well-designed.
2. Regarding specific variables for 2010:
    a. Plastic exports and industrial activities were highly related to marine debris.
    b. Waste management frameworks were not effective enough, which means that waste production had a positive relationship with marine debris.
    c. Education had not so much to do in terms of plastic in the ocean because there was no consciousness among citizens.
    d. Tourism and recreational activities were highly related to marine debris.
    e. Single-use plastic bans were significant as they prevent countries from polluting the oceans.
3. Many relevant variables were not significant for marine debris due to their correlation with other significant variables.

5. METHODOLOGY

5.1 Overview

To accomplish the objectives, an analysis of international policies and a regression analysis to determine which variables have a direct impact on plastic ending up in the sea are done. This second action is a standard approach when facing macroeconomic variables, even though there is no other study with so many countries and possible regressors. To get the final regression function, some prior steps are undertaken to assure data validity and reliability. It has been verified that other similar studies use the same procedure to observe the causal relationships among variables.

5.2 Qualitative analysis: International legislation

As mentioned, a deep analysis of the international policies regarding plastic oceans has been done. It is useful for verifying the effectiveness of international organisations and governments when assessing plastic debris. All official texts and amendments of organisations, conventions, protocols or agreements have been read to extract relevant information about policies' current performance, goals and monitoring practices. The analysis can be found in **Appendix 2.** From it, many conclusions can be set. First of all, it is needed to pay special attention to developing countries and other regions with vulnerabilities such as South Asia, East Asia, Pacific and Sub-Saharan countries as well as small islands. The commented differences among low-income and high-income countries are observed in data gathering tools, lack of prevention policies and frameworks or practices regarding the elimination of waste. In many regions, information cannot be systematically collected, so the real situation in terms of waste remains unknown. Secondly, the analysis evidence that the way in which these policies and agreements are being monitored relies on reports and other types of qualitative analysis. Even though reports are very detailed and complemented with audits and meetings, they are not as effective as numerical data would be in giving objective information. Finally, even though all policies mention many marine debris sources that must be taken into account, all of them agree that there is limited information available for debris prevalence by source and pathway.

5.3 Qualitative analysis: pollutant variables

5.3.1 Data gathering tools

Data about variables included in the international policies' texts and previous literature articles are mostly extracted from *The World Bank*, which has a specific development data group that coordinates, gathers and reports statistical data for every country. The institution works closely with most of the world's regions, and all its processes are guided by professional collection, compilation and dissemination standards to ensure data quality and integrity ("*The World Bank – About us*", n.d.). However, some specific data such as the Municipal Solid Waste are extracted from other sources also linked to international organisations – in this case, it was from *The International Solid Waste Association*.

5.3.2 Data selection

As what it is aimed to study is the amount of plastic waste that ends up in the sea for each country, the *share of plastic waste that was littered in 2010* (measured in tonnes) is used as the dependent variable. It captures the uncollected street waste that enters sewage systems and has more probability to end up in the oceans, which is assumed to be an extra 2% on top of the national mismanaged waste (McCarthy, 2019). This variable has also been used in many other marine debris studies as it is the closest approximation to the real marine debris amount per country. Regressors' data are widely explained in **Appendix 3.** An Excel datasheet which grouped such variables into groups – agriculture, population and urban development, economy and growth, education, environment, infrastructure and tourism – has been done and latterly exported to JMP, the statistical software that will perform all the statistical calculations needed. Doing such study with 2010 data will enable to see whether countries were correctly applying the previous 2010 policies and whether the posterior 2010 policies properly cover the results. Thus, it will be possible to see the evolution and the effectiveness of such international agreements.

5.3.3 Data limitation and the final population sample

Data about littered plastic waste only consider countries with coast. Also, as some small islands and some countries with political and social conflicts present no data for certain variables, they have been deleted too. Overall, the deleted countries represent 0.374% of the total population of countries with coasts and their surface area is 0.094% of the total surface of countries with coasts. These calculations are found in **Appendix 4.**

There are no data about tons of vessel waste discharges, seaside population, fishery subsidies, countries with incentives for recycling, the number of environmental non-profit firms per country or the total waterway lengths. There are no neither 2010 data about forest or agriculture protected areas, the number of volunteers for coastal clean-ups or the average wage per country. OECD countries indeed have information regarding the number of passengers on vessels and cruises, incineration rates, landfill or dumping areas, waste collection rates or about wastewater treated over the total wastewater generated. However, OECD only includes data for the 36 member states. In any case, it has been intended to find missing data by looking at specific country reports where 2010 information can be found. It has required a great amount of time, but several data gaps could be finally found. With such limitations, thus, there are a total of 52 possible explanatory regressors and 162 coastal countries to be analysed.

5.3.4 Data analysis

Normality test

With data in a JMP datasheet, the first step is performing a normality test for the dependent variable. An observation is normal when it has frequent behaviour, which can be easily seen through a histogram. As the sample of this study is smaller than 200 countries, which is the value from it is assumed the distribution starts to be normal, it is fundamental to perform it.

Correlation

The next step is related to collinearity, which appears when one regressor can be written as a linear combination of another one, so they are correlated and cannot predict the value of the dependent variable. In a multiple regression model, multicollinearity is quite common, which is when there are associations among two or more explanatory variables. Then, all regressors included in the model must be exogenous[9]. Through correlation analysis, it will be possible to quantify the strength of the linear relationship between the regressor and the dependent variable as well as between regressors. A correlation matrix with all variables is done, and the ones with more correlation with the other regressors

[9] Regressors must follow the ceteris paribus criteria in which when one regressor varies, if no other regressors which also affects the dependent variable vary systematically, then we can use this regressor to explain the effect of such variation.

are omitted. Then, individual correlations for each mentioned group of variables - agriculture, population, economy, education, environment, infrastructure and tourism - are done, also adding the dependent variable. Those variables with correlations between 0,3 and 0,6 were picked up. To reduce the noise of the model, the maximum number of variables were picked up. However, as correlations only explain the relationship between two variables, it will not give proper multicollinearity information. Then, to further analyse multicollinearity, the Variance Inflation Factor (VIF) will be used, which indicates how much the standard error of the coefficient estimation is inflated due to the existence of multicollinearity. Thus, once having the regression analysis, variables with a VIF greater than 5 will be deleted.

T-test for dummy variables

The next step is performing a t-test for dummy variables – *single-use plastic bans* and *Basel Convention members*. It is crucial because it will be possible to see if means differ from each other and then observe if they are both significant for the model.

Regression analysis

The final step, as mentioned in the beginning, is the regression analysis with the final variables to obtain the explanatory model[10]. When doing so, other assumptions must be met ("*Regression model assumptions*", n.d.):

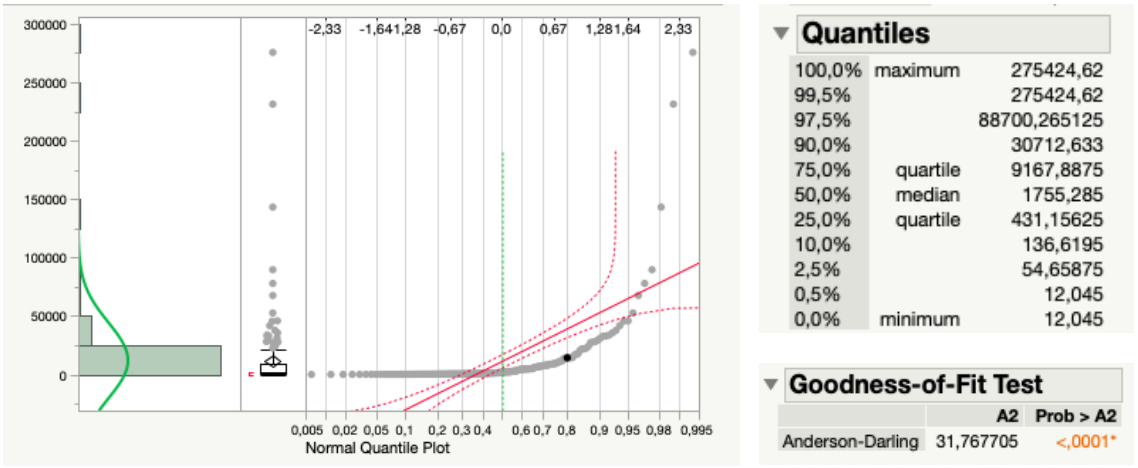
- The relationship between regressors and dependent variable has to be linear.
- Errors must follow a normal distribution, they must be independent from one another and they must present homoscedasticity[11] - they must have a constant variance. This is analysed through a residual predicted plot.
- Outliers may appear, which are data observations that differ significantly from the other data points. If its source cannot be found, they can be not taken into account. They can be seen through a scatter plot.

[10] The regression determines which variables have an effect on the dependent one or help explain the response. It is intended to identify the predictors that better explain the response to understand the magnitude and direction of the model coefficients. Overall, it is aimed to know how the response values change as the values of a given predictor change ("*Interpreting Results in Explanatory Modelling*", n.d.)

[11] Homoscedasticity is the assumption that there is no systematic change in the spread of residuals over the range of measured values (Frost J., 2019)

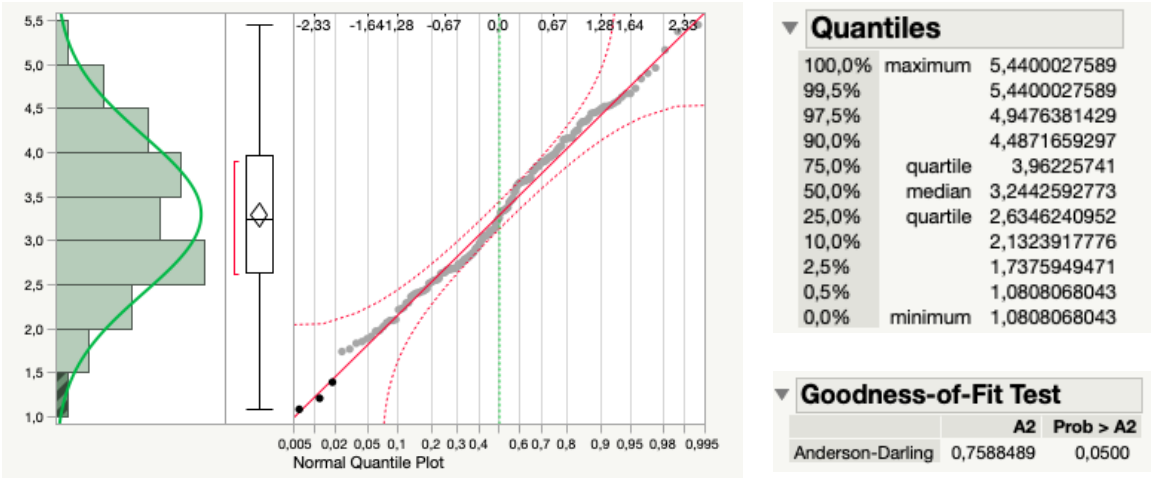
6. RESULTS

6.1 Normality test



Graph 1: Histogram of the dependent variable normality test with its quantiles table and goodness-of-fit Computed by the JMP software

The results show that three-quarters of countries emit below 9.167 tones of plastic while the top 1% of counties reunite around 275.000 tones. This means that few countries contribute to the vast majority of plastic pollution. To solve such asymmetry, the dependent variable must be transformed into a logarithm. The normality test obtained by doing such transformation gives the following results:



Graph 2: Histogram of the dependent variable logarithm normality test with its quantiles table and goodness-of-fit Computed by the JMP software

As data more or less follow a straight line, they are reasonably approximated by a normal distribution. Furthermore, the p-value of the test (indicated by *Prob> A2*) is of 0.05,

which suggests that there is not sufficient evidence indicating that the underlying distribution is not normally distributed.

6.2 Correlation analysis

The whole correlation matrix is attached in **Appendix 5**. The first variables omitted due to their high level of correlation with many other variables are *Land area*, *Total municipal solid waste generation, GDP, GDP per capita, Plastic exports* and *imports*, *Wage and salaried workers* and *Tourism expenditures and receipts*. Then, regarding agricultural variables, first of all, *Surface area* and *Forest area* are highly related, so just the first-mentioned one will be chosen as it is the most related one with the logarithm variable. *Water area* will also be included and its VIF will determine whether it has to be deleted or not. *The % of land area*, the *Agriculture, Forestry and Fishing value-added* and *Food production index*, even though they have a weak relationship with the logarithm variable, will be included because they are not related among them and can also be relevant.

	LOG	% of land area	AFF value added	Surface area	Forest area	Water area	Food production index
LOG	1,0000	0,2178	-0,1468	0,3406	0,2700	0,1613	0,1274
% of land area	0,2178	1,0000	0,3154	0,0001	-0,0691	-0,0778	0,1535
AFF value added	-0,1468	0,3154	1,0000	-0,0824	-0,0763	-0,0143	0,3363
Surface area	0,3406	0,0001	-0,0824	1,0000	0,9290	0,7162	0,0680
Forest area	0,2700	-0,0691	-0,0763	0,9290	1,0000	0,6997	0,0751
Water area	0,1613	-0,0778	-0,0143	0,7162	0,6997	1,0000	0,0580
Food production index	0,1274	0,1535	0,3363	0,0680	0,0751	0,0580	1,0000

Table 1: Correlation test for Agriculture variables
Computed with JMP software

Regarding population variables, just *Renewable energy consumption* will be deleted as it highly related to the *Renewable electricity output*, which has a lower correlation with the logarithm. There also exists a correlation between *Urban population* and *Kilocalories*. As these particular variables might not seem to have any apparent relationship, both will be selected and the one with the highest VIF will be deleted.

	LOG	Total population	Population growth	Urban population	Per capita plastic waste	MSW generation/capita	MSW % plastic	Ren. energy cons.	Ren. electricity output	Kilocalories/person/day
LOG	1,0000	0,3566	-0,0673	0,1672	0,1292	-0,0562	0,2578	-0,0336	-0,0905	0,2306
Total population	0,3566	1,0000	-0,0375	-0,0949	-0,0734	-0,1329	-0,0471	0,0045	-0,1021	0,0320
Population growth	-0,0673	-0,0375	1,0000	-0,0266	-0,0931	-0,0972	0,0139	0,2122	-0,0862	-0,2619
Urban population	0,1672	-0,0949	-0,0266	1,0000	0,2982	-0,1117	0,0646	-0,4398	-0,1353	0,5611
Per capita plastic waste	0,1292	-0,0734	-0,0931	0,2982	1,0000	0,3585	0,2057	-0,3022	-0,0679	0,2062
MSW generation/capita	-0,0562	-0,1329	-0,0972	-0,1117	0,3585	1,0000	-0,0077	-0,3608	-0,1879	0,0932
MSW % plastic	0,2578	-0,0471	0,0139	0,0646	0,2057	-0,0077	1,0000	-0,0472	-0,0349	0,0882
Ren. energy cons.	-0,0336	0,0045	0,2122	-0,4398	-0,3022	-0,3608	-0,0472	1,0000	0,6094	-0,5032
Ren. electricity output	-0,0905	-0,1021	-0,0862	-0,1353	-0,0679	-0,1879	-0,0349	0,6094	1,0000	-0,2999
Kilocalories/person/day	0,2306	0,0320	-0,2619	0,5611	0,2062	0,0932	0,0882	-0,5032	-0,2999	1,0000

Table 2: Correlation test for Population variables
Computed by JMP software

Regarding economy and growth variables and in terms of GDP, just the *GDP per capita growth* is chosen as it has the greatest relationship with the logarithm – 0,2666. *Food exports*, *Business*, *Tariffs*, *Manufacturing* and *Fisheries* also present interesting

correlations with the dependent variable. They will be latterly deleted according to their VIFs and p-values.

	LOG	GDP growth	GDP per capita growth	GDP (PPP) per capita	Industry	Business	Food exports	Tariff rates	Manufacturing	Fisheries	Health expenditure	Health expenditure per capita
LOG	1,0000	0,2241	0,2666	0,2147	0,2506	0,3450	-0,3856	-0,3188	0,3870	0,4441	-0,0163	0,3282
GDP growth	0,2241	1,0000	0,8945	-0,0043	0,1648	-0,0619	-0,1358	-0,0006	0,2031	0,2311	-0,2215	-0,1925
GDP per capita growth	0,2666	0,8945	1,0000	-0,1138	-0,0086	0,0999	-0,1390	-0,1044	0,2161	0,2950	-0,0307	-0,1065
GDP (PPP) per capita	0,2147	-0,0043	-0,1138	1,0000	0,3879	0,5304	-0,3882	-0,4096	0,1805	0,0025	0,0809	0,6219
Industry	0,2506	0,1648	-0,0086	0,3879	1,0000	-0,1151	-0,4808	-0,0639	0,4243	0,1553	-0,5052	-0,0900
Business	0,3450	-0,0619	0,0999	0,5304	-0,1151	1,0000	-0,2112	-0,6527	0,2309	0,1565	0,3850	0,6301
Food exports	-0,3856	-0,1358	-0,1390	-0,3882	-0,4808	-0,2112	1,0000	0,2290	-0,3411	-0,1786	0,0305	-0,2412
Tariff rates	-0,3188	-0,0006	-0,1044	-0,4096	-0,0639	-0,6527	0,2290	1,0000	-0,2606	-0,1553	-0,3241	-0,4255
Manufacturing	0,3870	0,2031	0,2161	0,1805	0,4243	0,2309	-0,3411	-0,2606	1,0000	0,2866	-0,1641	0,0197
Fisheries	0,4441	0,2311	0,2950	0,0025	0,1553	0,1565	-0,1786	-0,1553	0,2866	1,0000	-0,0521	0,1084
Health expenditure	-0,0163	-0,2215	-0,0307	0,0809	-0,5052	0,3850	0,0305	-0,3241	-0,1641	-0,0521	1,0000	0,5322
Health expenditure per capita	0,3282	-0,1925	-0,1065	0,6219	-0,0900	0,6301	-0,2412	-0,4255	0,0197	0,1084	0,5322	1,0000

Table 3: Correlation test for Economy and growth
Computed by JMP software

Regarding education variables, *Education % of GDP* will be deleted as it is quite related to *Research*, whose relationship with the dependent variable is stronger.

	LOG	Education (% of GDP)	Education (% of gov. Exp.)	Children out of school	Research
LOG	1,0000	-0,1409	-0,0889	-0,0629	0,1968
Education (% of GDP)	-0,1409	1,0000	0,3097	-0,0118	0,4962
Education (% of gov. Exp.)	-0,0889	0,3097	1,0000	-0,0370	-0,2687
Children out of school	-0,0629	-0,0118	-0,0370	1,0000	0,0777
Research	0,1968	0,4962	-0,2687	0,0777	1,0000

Table 4: Correlation test for Education variables
Computed by JMP software

Then, variables about the environment do not either arrive at the 0,3 positive correlation level, but *Basel convention*, *Aquaculture*, *Coastal size* and the *Single-use plastics bans* variables have been selected.

	LOG	Basel convention	Coastal size	Protected Marine Areas	Aquaculture	Single-use plastics bans
LOG	1,0000	0,2338	0,2113	0,0602	0,2510	0,2717
Basel convention	0,2338	1,0000	0,0539	0,0318	0,0427	0,0196
Coastal size	0,2113	0,0539	1,0000	-0,0132	0,0898	0,2084
Protected Marine Areas	0,0602	0,0318	-0,0132	1,0000	-0,0080	-0,0329
Aquaculture	0,2510	0,0427	0,0898	-0,0080	1,0000	0,2251
Single-use plastics bans	0,2717	0,0196	0,2084	-0,0329	0,2251	1,0000

Table 5: Correlation test for Environmental variables
Computed by JMP software

Regarding infrastructure variables, *Container port traffic* presents a 0.4593 correlation level for which it must be included. As *Renewable internal freshwater resources*, with a 0.4196, is highly related to *Container port traffic*, the other two remaining variables will be chosen instead – *Annual freshwater withdrawals (total)* and *Renewable internal freshwater resources per capita*.

	LOG	Container port traffic	An. freshwater withdrawals, total	Ren. int. freshwater resources, total	Ren. int. freshwater resources per capita
LOG	1,0000	0,4593	-0,0089	0,4196	-0,1652
Container port traffic	0,4593	1,0000	0,0040	0,3860	-0,0050
An. freshwater withdrawals, total	-0,0089	0,0040	1,0000	-0,0765	-0,0047
Ren. int. freshwater resources, total	0,4196	0,3860	-0,0765	1,0000	0,0330
Ren. int. freshwater resources per capita	-0,1652	-0,0050	-0,0047	0,0330	1,0000

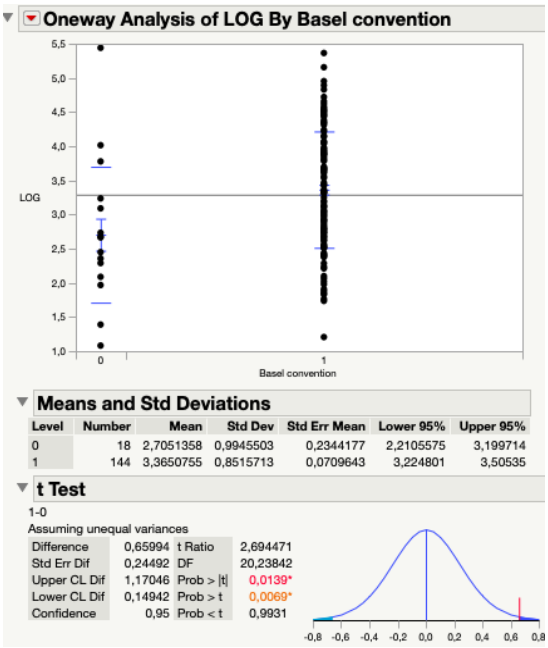
Table 6: Correlation test for Infrastructure variables
Computed by JMP software

Finally, regarding tourism variables, as *Tourism expenditures* and *receipts* had been previously eliminated, only the *Number of arrivals* will be picked up.

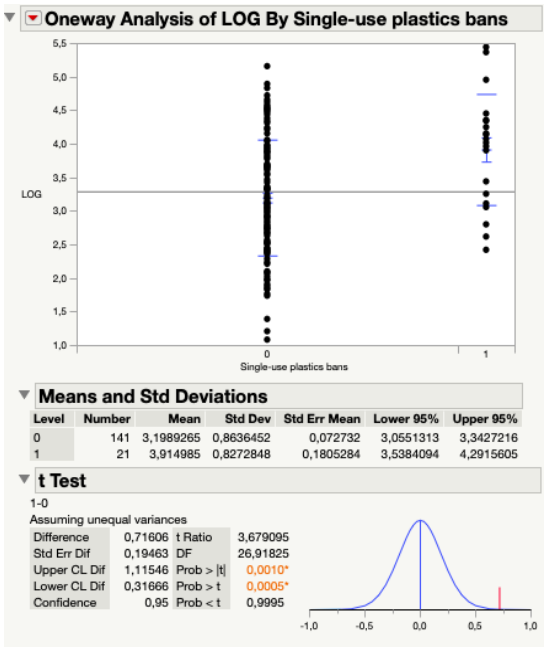
6.3 T-tests for dummies

As mentioned, this bivariant analysis is highly recommended to be done in dummies before the regression as it will be possible to see if they are predictor variables. If they are not significant, they do not have to be included in the final regression model:

Basel convention



Single-use plastic bans



Graph 3: T-test for countries within the Basel Convention
Graph 4: T-test for countries Single-use plastic bans
Computed with the JMP Software

Prob > |*t*| is the *p-value* for the two-tailed test. In the T-Test, the null hypothesis is that means are equal - the mean difference is zero:

Prob > |*t*| = 0.0139 is the p-value for H_A: $\mu_1 - \mu_0 \neq 0$

Prob > *t* = 0.0069 is the p-value for H_A: $\mu_1 - \mu_0 > 0$

Prob < *t* = 0.9931 is the p-value for H_A: $\mu_1 - \mu_0 < 0$

By default, the *Upper CL Dif* and *Lower CL Dif* is the 95% confidence interval for $\mu_1 - \mu_0$. Since the Pr*ob* > |*t*| is smaller than 0.05 in both cases, it can be concluded that the null hypothesis of the two means being equal can be rejected, which means that the dependent variable is affected by the dummy variable. Regarding the Basel Convention, it can be seen that member states have a great mean of plastics ending up in the sea

compared to countries not included in the international agreement. Regarding single-use plastic bans, those countries with such levies also have a great mean of plastics ending up in the sea compared to countries without such ban. This would mean that even putting their efforts on reducing marine debris, policies are not quite effective when doing so. In any case, both variables are significant for the model.

6.4 Regression analysis

With variables chosen through the prior correlation analysis, a regression analysis have been done. Having multiple regressors is crucial when avoiding omitted variable bias as well as reducing the noise. Starting with all of them, the ones with higher VIFs have been eliminated. The final parameter estimates are intended to have VIFs below to 5[12].

Parameter Estimates

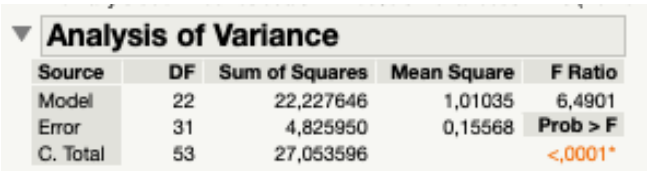
Term	Estimate	Std Error	t Ratio	Prob>|t|	VIF
Intercept	0,1762495	1,12935	0,16	0,8770	.
Surface area	1,1203e-7	4,708e-8	2,38	0,0237*	4,2019773
Water area	-9,153e-7	6,306e-7	-1,45	0,1567	2,2135665
Food production index	0,0094076	0,007169	1,31	0,1991	3,1744405
Population growth	-0,339819	0,088673	-3,83	0,0006*	2,6325473
Urban population	0,0082219	0,004302	1,91	0,0653	2,5134095
Per capita plastic waste	-0,000665	0,000718	-0,93	0,3611	2,4128293
MSW generation/capita	0,3505027	0,079457	4,41	0,0001*	1,9376747
MSW % plastic	0,0138398	0,008177	1,69	0,1006	1,4291173
GDP per capita growth	0,066074	0,02579	2,56	0,0155*	2,2032881
Food exports	-0,006062	0,004768	-1,27	0,2131	2,1558614
Tariff rates	0,0401521	0,022313	1,80	0,0817	2,2329985
Manufacturing	-0,021937	0,01509	-1,45	0,1561	1,948226
Education (% of gov. Exp.)	0,0239271	0,020228	1,18	0,2459	2,3765623
Children out of school	0,0198767	0,013726	1,45	0,1576	2,5743437
Research	-0,073081	0,085377	-0,86	0,3986	2,7791314
Basel convention	1,3297202	0,745092	1,78	0,0841	3,5001017
Aquaculture	2,1638e-7	6,847e-8	3,16	0,0035*	1,7515114
Single-use plastics bans	-0,342558	0,205768	-1,66	0,1060	2,6845278
Container port traffic	4,1769e-8	1,682e-8	2,48	0,0187*	4,6815348
An. freshwater withdrawals, total	0,0002446	0,00012	2,03	0,0505	1,5255488
Ren. int. freshwater resources per capita	-1,31e-6	9,608e-7	-1,36	0,1826	1,7904171
Arrivals	6,4242e-9	4,924e-9	1,30	0,2016	2,0326396

Table 7: Regression analysis parameter estimates
Computed by JMP software

Firstly, by looking at the F-Ratio[13] and its p-value in the table of analysis of variance, it can be safely concluded that there are one or more predictors in the model that are significant.

[12] VIFs below to 5 are associated to variables without multicollinearity, while in VIFs between of 5 or 10 indicates that the collinearity might be problematic for which p-values would not be reliable.

[13] Calculated by dividing the Mean Square Model and the Mean Square Error. To state that the model explains at least some of the variation response, it must be greater than 1. However, as F-Ratio can be influenced by the number of parameters and the number of observations, it is crucial to also analyse the p-values ("Interpreting Results in Explanatory Modelling", n.d.)



Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	22	22,227646	1,01035	6,4901
Error	31	4,825950	0,15568	Prob > F
C. Total	53	27,053596		<,0001*

Table 8: Analysis of variance
Computed with JMP software

Nevertheless, the p-values[14] are the ones that indicate which of the included factors are statistically significant for the dependent variable, so all regressors not significant for the dependent variable mean that data cannot support with a 95% confidence that such variables have a significant impact on the plastic littered in the ocean. What JMP does is partial tests for each variable, and each test is adjusted for the other predictors in the model meaning that they take into account correlation among variables. With these results, then, the econometric model that explains the behaviour of the share of plastic waste that was littered in 2010 is:

$$Log(Plastic\ littered) = \beta_0 + \beta_1\,(Surface\ area) + \beta_2\,(Water\ area) + \beta_3\,(Food\ production\ index) + \beta_4\,(Population\ growth) + \beta_5\,(Urban\ population) + \beta_6\,(Per\ capita\ plastic\ waste) + \beta_7\,(MSW\ generation\ per\ capita) + \beta_8\,(MSW\ \%\ plastic) + \beta_9\,(GDP\ per\ capita\ growth) + \beta_{10}\,(Food\ exports) + \beta_{11}\,(Tariff\ rates) + \beta_{12}\,(Manufacturing) + \beta_{13}\,(Government\ expenditure\ on\ education) + \beta_{14}\,(Children\ out\text{-}of\text{-}school) + \beta_{15}\,(Research) + \beta_{16}\,(Basel\ Convention) + \beta_{17}\,(Aquaculture) + \beta_{18}\,(Single\text{-}use\ plastic\ bans) + \beta_{19}\,(Container\ port\ traffic) + \beta_{20}\,(Annual\ freshwater\ withdrawals,\ total) + \beta_{21}\,(Renewable\ internal\ freshwater\ resources\ per\ capita) + \beta_{22}\,(Tourism\ arrivals) + \varepsilon$$

Then, the first research question about which variables had the highest relationship with marine debris in 2010 can already be answered. To correctly interpret the coefficients, it is crucial to bear in mind that the dependent variable is a logarithm. Then, for instance, with the *Surface area*:

$$(\partial / \partial\ Surface\ area)\ ln(Tons\ of\ plastic\ littered) = \beta_0 + \beta_1\,(Surface\ area) + \beta_2\,(Water\ area) + \beta_3\,(Food\ production\ index) + \beta_4\,(Population\ growth) + \beta_5\,(Urban\ population) + \beta_6\,(Per\ capita\ plastic\ waste) + \beta_7\,(MSW\ generation\ per\ capita) + \beta_8\,(MSW\ \%\ plastic) + \beta_9\,(GDP\ per\ capita\ growth) + \beta_{10}\,(Food\ exports) + \beta_{11}\,(Tariff\ rates) + \beta_{12}\,(Manufacturing) + \beta_{13}\,(Government\ expenditure\ on\ education) + \beta_{14}\,(Children\ out\text{-}of\text{-}school) + \beta_{15}\,(Research) + \beta_{16}\,(Basel\ Convention) + \beta_{17}\,(Aquaculture) + \beta_{18}\,(Single\text{-}use\ plastic\ bans) + \beta_{19}\,(Container\ port\ traffic) + \beta_{20}\,(Annual$$

[14] The variable is significant when the p-value is smaller than the alpha level of 0.05.

freshwater withdrawals, total) + β_{21} *(Renewable internal freshwater resources per capita)* +
β_{22} *(Tourism arrivals)* + ε

(d Plastic littered / Tons of plastic littered) = d Surface area x β_1
100 x (d Plastic littered / Tons of plastic littered) =100 x d Surface area x β_1
%∆ Tons of plastic littered = 100 x d Surface area x β_1

The intercept indicates that if all regressors were 0, the plastic littered on a log scale would be of 0.1762495 per country, which is equal to ῾Ωﮪ ۵ ۴ ۰ ۲ ۷ سي ۳1.193 tons of littered plastic. Globally, significant regressors are interpreted as semi-elasticities :

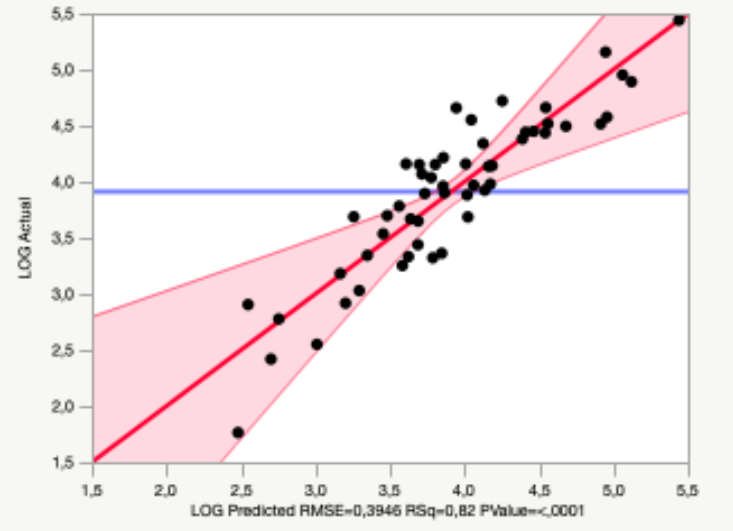
- If the *surface area* were increased by a ῏Ω ά, the plastic littered in the ocean would also be increased by 0.000011203%.
- If *population growth* were increased by 1%, the plastic littered in the ocean would be reduced by 33.98%.
- If the *municipal solid waste generation per capita* were increased by one *Kg* per capita per day, the plastic littered in the ocean would also be increased by 35.05%.
- If the *GDP per capita growth* were annually increased by 1%, the plastic littered in the ocean would also be increased by 6.6074%
- If the *aquaculture production* were increased by a metric ton, the plastic littered in the ocean would also be increased by 0.000021638%.
- If the *container port traffic* were increased by a 20-foot equivalent unit (TEU), the plastic littered in the ocean would also be increased by 0.0000041769%.

From the above interpretation, some other research questions and hypothesis can be answered:

- Exports and industry do not explain marine debris, so the hypothesis of them being relevant can be rejected.
- Waste management frameworks were not effective enough, which meant that they had a positive relationship with marine debris. Therefore, such hypothesis is accepted.
- Education had not so much to do in terms of plastic in the ocean because there was no consciousness among citizens, so the hypothesis is accepted.
- Tourism and recreational activities were not related to marine debris at all, so the hypothesis is rejected.

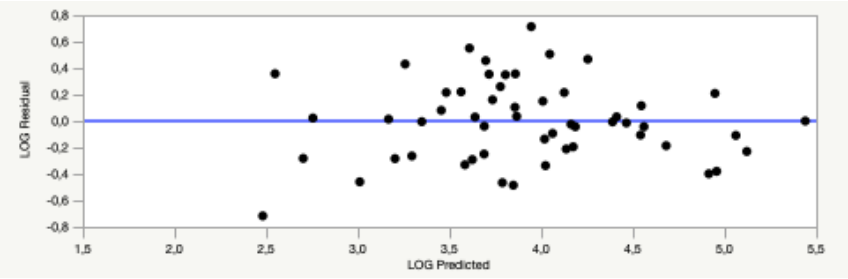
- Finally, the hypothesis of single-use plastic bans being significant is also rejected.

The related predicted plot for the model is:



Graph 5: Predicted plot from regression analysis estimates
Computed with JMP software

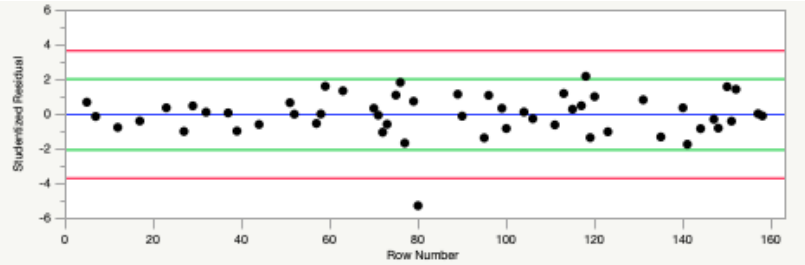
It is a non-deterministic linear relationship between the dependent variable and the other explanatory variables as there are other factors not explained in the model and included in the error. This phenomenon is captured by the R-Square, which determines, in this case, that 82% of the dependent variable – plastic littered – can be explained by regressors. On the other hand, the residuals plot is the following:



Graph 6: Residual by predicted plot
Computed with JMP software

Almost all residuals are randomly scattered around the centre line of zero, with no obvious non-random pattern, for which it can be concluded that they have a constant

variance. However, there are some few points more dispersed which could artificially inflate R-Square. To observe so, a plot for studentized residuals[15] can be done:



Graph 7: Studentized residuals plot
Computed with JMP software

Thus, as there is one residual falling outside the red limits, it can be concluded that there is only one potential outlier, which cannot be identified by the program. Were it be identified and removed, the R-Square value would be higher.

6.5 Statistical results and international policies

The final step is comparing the statistical results obtained with the international policies studied to answer the last research questions and hypothesis.

- It has been proven that the only variables taken into account in previous 2010 policies and that were not relevant anymore by that year are *Research* and *Plastic exports*.
- On the other hand, some pollutants included in previous 2010 international policies that kept having a positive relationship with marine debris, for which such hypothesis can be accepted. These pollutants are *Surface area*, linked to land-based sources, and *Container port traffic*. This demonstrates that such international legislation was not well-designed.
- Finally, in 2010, the variables *Population growth, MSW generation per capita, GDP per capita growth* and *Aquaculture* were not borne in mind by international organisations.

[15] The Studentized residuals' plot is more effective in detecting outliers and assessing the equal variance assumption. It conducts a *t*-test for each residual.

From 2010 onwards, the situation changed.

- While *Population growth, GDP per capita* growth and *Aquaculture* remained unassessed, the *Municipal Solid Waste generation per capita* became fundamental, especially for ISWA, when investing in effective waste management in low-income countries.
- *Surface area* became better assessed by the Law of Sea or the Convention on Biological diversity, which state that land-based sources, rivers, estuaries, pipelines, outfall structures, vessels, coastal activities, dumping and ports were the major pollutants in terms of plastic.
- Also, policies such as MARPOL put their efforts on *Container port traffic* by prohibiting plastic discharges and establishing monetary penalties for vessels to pollute the marine environment.

Finally, it is also crucial to mention that as seen in the correlation analysis as well as with VIFs, many possible relevant variables such as exports or land are not taken into account to explain the dependent variable due to their relationship with other variables, so such hypothesis is also accepted.

7. DISCUSSION

Once having the results, a deep analysis of each regressor can be done. Land-based sources, explained by the *Surface area*, failed to be assessed by governments probably because of the multiple water pathways such as drains, canals, rivers or wind. They were possibly the most difficult sources to control as they required the huge capacity of waste management systems to absorb, eliminate and recycle plastic items. *Population growth* seemed to affect marine debris in a negative way, which could be explained due to the pressure of governments to set proper recycling and waste frameworks with enough capacity to manage the increasing population. The positive relationship of marine debris with the *Municipal solid waste generation per capita* reinforces the idea of the waste industry failing in assessing and processing plastic litter because, as explained before, governments have not set proper recycling and waste frameworks with enough capacity to manage the increasing population. *GDP per capita growth* corroborates the idea of the more economic output (which is related to consumption and production) the more marine pollution. *Aquaculture* has been covered by the Convention of Biological Diversity, and many institutions are currently working on assessing its consequences and possible solutions. Finally, *Container port activity*, related to vessel discharges, has also been consolidated as one of the major pollutants since the beginning of international policies enforcement, and besides all efforts put to mitigate such effects, many work and research about it is still needed. About the hypothesis not met, some conclusions can also be set. Education about environmental-friendly practices was only carried out in specific developed countries or most polluted regions, but maybe it will be relevant now. On the other hand, as mentioned, possible regressors have been excluded from the model due to collinearity and only the ones less related among them and that also explained the dependent variable have been included. This fact might explain why tourism, plastic exports or industry, previously included in the hypothesis, were not relevant in 2010.

Nevertheless, the situation from 2010 onwards has changed and new policies and amendments related to marine debris have been created as during these years, consequences regarding climate change have been more perceived than ever, becoming the main focus for governments, institutions and citizens who have widely recognized the problem. These further studies also enabled more research and allowed new gathering methods and tools which have proven that other variables not taken into account before 2010 – such as marine protected areas or coastal construction – are relevant now. Besides,

during these years many developing countries have joined most of the agreements commented and they have increased the number of measures to combat plastic waste for which many debris sources were better assessed. Particularly for the relevant variables of this study, *Surface area* became of major importance and were included again in the Convention on Biological Diversity (2016), the International Solid Waste Association Task Force on Marine Litter (2017) and in the UNEP amendments about plastic waste. All these texts state that attention must be particularly put into the packaging and single-use items, which are claimed to be the vast majority of items ending up in the ocean. Secondly, the *Municipal solid waste generation per capita* was included mentioned again by the International Solid Waste Association, which created many different frameworks for low-income countries. Finally, the MARPOL put its efforts on *Container port traffic* by establishing new monetary penalties for vessels to pollute the marine environment, especially in ice-covered areas. MARPOL is characterized by its Regional Reception Facility Plan for which each State must elaborate a report with technical information on shipboard garbage management methods, packaging and provisioning methods and educational materials developed for the crew. The Basel Convention text also assesses it by regulating such transport under special bilateral or regional agreements. Nevertheless, variables such as the Population growth, GDP per capita growth or Aquaculture have not been included in any of the legislation text and policies. Overall, posterior 2010 policies have been widely criticized for not being effective enough. They pose the problem, propose a solution and act as the framework of change, but they have an important lack of enforcement.

This thesis, as exposed in the objectives, it is also aimed to propose solutions based on statistical results, previous literature and analysis of legislation. The first solution proposed consists of standardising processes and efforts so as to reduce marine debris, meaning that there would be necessary to establish a unique but effective global protocol with well-defined goals and specific actions. As stated in the Convention on Biological Diversity text (2016), it would require the same level of implication of governments, citizens and companies. States should accelerate the transition towards a new economic model before being too late for the planet through different actions:

- Improving waste management systems, especially for developing countries such as Southeast Asia regions. Recycling techniques must be enhanced and made available for all states. According to ISWA, by investing in effective waste

management, greenhouse gas emissions would be also reduced and new jobs relating to the recycling industry would be created.

- In relation, States cooperation must be enhanced in order to improve information-sharing practices and technology transfers. Cooperation must be also taken into account regarding trade practices, in which plastics should only be imported in an environmentally sound manner[16]. Thus, there is a need for equalizing the imbalances among low and high-income countries in this sense, as well as aligning the trade rules with climate change needs.
- Supporting a circular economy[17] model sustained by new technologies and research investments.
- Regulating consumers' behaviour through education, in which environmental-friendly practices are crucial. Education would also push the individual's social identity[18] which would lead to a reduction in consumers' demand for plastic. If such demand is modified, industries will have to adopt other approaches not relying on fossil fuel feedstocks.
- Creating social awareness and media campaigns by carrying out different call-to-actions, especially in developing countries.
- Using economic instruments such as bans, fees and levies to producers, distributors and consumers for single-use plastic production and purchasing. Small charges act as a reminder for not consuming plastic items.
- Increasing plastic value by finding new applications such as the production of energy. Many firms have started to create their products and packaging with plastic coming from oceans. In increasing the plastic value, it must reflect its full life cycle cost.

[16] Basic condition for allowing or prohibiting an export/import of waste that consists of protecting human health and the environment by minimizing hazardous waste traded and mitigating the impacts.

[17] It consists of re-entering the plastic debris collected from oceans in the production stream through its reduction, reusability, recyclability, proper distribution and sustainable consumption. Thus, nothing would go on waste.

[18] When a person's behaviour is tied to the image he/she wants to Project (Akerlof and Kranton 2000).

- Supporting and promoting zero waste[19], greener initiatives and financial support in research, such as on plastic substitutes, renewable energies, new products made of plastic or on organism capable of breaking plastics to discompose them.
- Supporting non-profit organisations[20] which fight for ocean conservancy, awareness-raising activities and clean-up movements. All the posterior 2010 amendments and texts mention coastal clean-ups as a key success factor for ocean citizenship[21].
- Facilitate data collection and monitoring processes for their macro-economic and environmental variables. All studies state that there is still limited information available for debris prevalence by source and pathway and that information is not collected systematically in most regions. There are also many methodological limitations for quantitative approaches to evaluate.

Regarding citizens and in the context of a neoliberal political system, individual behaviour can modify plastics' and specific products' demand, which would accelerate the change in the current economic model. A great example of this is the increasing purchase of bulk goods in small environmental friendly shops, which demonstrates that collective action is highly related to education and culture. However, it is very difficult to change the current collective thought and culture based on convenience and ease, but the global change will be made of small daily changes in terms of consumption. Finally, a complete change will not be reached without the cooperation of firms, which should include new corporate social responsibility frameworks. All stakeholders must also pursue the common goal of a free-plastic economy for which they should be transparent regarding their production processes as well as they should report all measures they undertake regarding the plastic use.

[19] Strategy based on waste reduction, reuse and recycling and producer responsibility that are adopted worldwide both in developed and developing countries. It aims to redesign resources' life cycles in which litter sent to landfills must be minimal (Le Guern, C. 2009).

[20] It is crucial to highlight the 5 Gyres Initiative, Project Kaisei, the Plastic Pollution Coalition, Surf-riders, the Dyer Island Conservation Trust, the Marine Conservation Society, the World Wildlife Fund and the Ocean Clean-up project.

[21] It describes the relationship between the marine environment and coastal health and citizens' day-to-day lives. Individuals have the responsibility to carry out a sustainable lifestyle to minimize and mitigate their impact on marine pollution (Fletcher S. and Potts J. 2007).

8. LIMITATIONS

The first great constraint has been data limitation for the dependent variable, regressors and countries. In terms of the dependent variable, the *share of plastic waste that was inadequately managed* was previously taken, which can be defined as the percentage of waste that was not properly managed and included disposal in dumps or open and uncontrolled landfills and that had a high risk of polluting rivers and oceans (McCarthy, 2019). Nevertheless, as some countries had 0%, which is quite impossible due to the information obtained in previous literature, *tons of plastic waste that were littered in 2010* has been used. Regarding regressors data, as mentioned in the methodology, some variables that could have been relevant when explaining the dependent variable and would have reduced the noise of the model could not be included. Finally, countries without information in some drivers of demand had to be omitted, so some of the results might not be well estimated. Also, even though the sources from which data have been extracted are mostly official and linked to international organizations, there might exist a problem of data reliability which would modify the results. Methodologies for data gathering are not always consistent and effective, as it has been proved by analysing international policies and by reading partial studies. Data are also subjected to inconsistent and omitted units or value estimates. In developing countries, data are also subjected to seasonal variations, incomplete waste collection and disposal and lack of weight scales at landfill sites to record waste quantities (Daniel Hoornweg, P, 2012). In this study, some data sources are probably done as the results are not what it was expected. In terms of previous literature, the vast majority of reports, articles and other thesis written are from countries and local organizations of Europe, Australia or America, which do not reflect the whole reality. There exist a lack of studies and their availability from Africa, South America and some parts of Asia. In terms of the international legislation analysed, there were selected those with a more global impact, but there exist other documents and policies that could have been analysed too, such as the National Oceanic and Atmospheric Administration, the Ocean Conservancy Centre for Marine Conservation, the Oslo Convention (1972), the Water Framework Directive (2000) or the Land-Based Sources Protocol. This analysis could be complemented with important regional policies.

Limitations in statistics and methodology also exist. Firstly, endogeneity can appear in case there is a correlation among observable variables and hidden variables not included in the analysis. Secondly, even though it was intended to avoid it, heteroskedasticity

might exist as constant variances are difficult to be perceived among small and large countries. Finally, multicollinearity can also occur as, for instance, the *Basel convention* and *Single-use plastics bans* variables, which have been proved to be significant, are not. It could be explained as there are other explanatory variables related to them. In terms of methodology, it is also crucial to say that other possible statistical analysis could be also done, such as the Stepwise method or the analysis of the principal components, which are also quite common. However, it has been proven that with the Stepwise method, the regressors that explain the dependent variable would be the same as with the Regression analysis method.

Finally, there would be a limitation in terms of specific explanations and analysis for each significant variable. This thesis gives a global situation context, but to solve the problem, there is a huge need of studying specifically each relevant regressor as well as a need of better show the upsides and downsides for each of the analyzed agreements.

9. CONCLUSION

This thesis raises two major concerns about marine debris: the lack of knowledge about its sources and the possible ineffectiveness of its related international policies. As there is no other study linking marine debris with as many macroeconomic and environmental factors, this study is intended to give a snapshot of the global marine waste situation involving its evolution (taking 2010 as the analysed year), causes and the possible solutions countries should develop in the future based on the results. In the theoretical framework, international policies have been described and various articles mentioning different sources have been carefully analysed. The hypothesis presented are related to the expected results on specific variables: land-based sources, trade, industry, waste management frameworks, education or tourism. Also, it is wanted to observe which variables have been handled, which kept having a positive impact on marine debris and if posterior legislation covers them. The methodology has consisted of qualitative analysis on international agreements and policies and qualitative analysis based on a regression model with debris sources, to later relate both. For this second one, prior steps have been done such as normality test, correlation analysis and t-tests for dummies. Once having the regression model, variables with lower VIF's and higher p-values were selected to construct the final regression model. However, some limitations about data sources, data reliability, previous literature, statistical approaches used or specific studies must be taken into account for further future studies.

The findings showed that the main explanatory variables are the surface area, population growth, urban population, municipal solid waste per capita, GDP per capita growth, aquaculture tons produced, container port traffic and annual freshwater withdrawals. Only land-based sources and container port traffic were previously mentioned in policies' texts, so international organisations and governments failed in assessing them. On the other hand, while posterior policies started to also contemplate municipal solid waste created per capita as responsible of polluting, population growth, urban population, GDP per capita growth or aquaculture remained without being assessed. It has also been concluded that education, exports, industry or tourism had not a great impact on marine debris, but, in any case, results could be influenced by regressors correlation among them. This thesis, through the results and the analysis, also wanted to pose some solutions to the problem. Some of them are based on standardizing processes and efforts with a global unique protocol, the proactive participation of governments through investing in waste

management systems, the cooperation with other states, supporting circular economy projects, investing in new technologies for recycling and research, regulating consumers' behaviour, creating social awareness, regulating consumption through economic instruments and education, finding new applications for plastic, supporting greener initiatives and movements or facilitating data collection and monitoring about certain specific macro-economic and environmental variables that would help to know better the current situation. Citizens and companies should also collaborate by redefining the demand for certain products, changing behaviours and including greener and environmental-friendly actions in their daily routine. Overall, the thesis results present a great call-to-action to change the current model and behaviour patterns in terms of plastic production, consumption and disposal for individuals, governments, legislation, industries, the technological sector, education, philosophy and international sustainable development. Thus, by finding and analysing the corresponding international agreements regarding plastics in the ocean, finding its explanatory variables and by evaluating the effectiveness of such legislation, the objectives of this study have been successfully met. Future lines of investigation might include, firstly, a similar statistical analysis for 2020 to compare the results to 2010 and better estimate the evolution of legislation, further analysis on regional policies or even a study on the numerous uses of plastics.

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11. APPENDIXES

Appendix 1: Analysis of environmental, social and economic impact of plastics in the oceans

Environmental impacts	
Ingestion	Some sea animals are unable to process plastic through their digestive systems which may result in malnutrition, intestinal blockage, starvation or even death. In addition, toxins from ingested plastics also harm animals' breeding and immune systems .
Entanglement	Observed in 270 different marine species, it leads to chronic injuries or even death. It can be done by fishery materials such as nets, roles, packing bands, balloon strings or wraps. Specifically, the term *ghost fishing* is widely used to explain the great number of gears floating or stuck in the deep sea.
Provision of fisheries and aquaculture	Due to ingestion and entanglement, commercial activities related to fishing suffer a reduction in effectiveness and productivity, as well as having a direct risk to fish stocks. Overall, it ends up affecting the total food supply chain.
Microplastics	Derived from both the breakdown of larger plastic items and the industrial activity, they are specially difficult to remove so can be easily be ingested by sea animals.
Habitat damage	Plastic deteriorates sea habitats such as coral reefs, which challenges the survival of many species which rely on these habitats. Specifically, plastic reduces the oxygen sediments on the seafloor and changes their material composition.
Vessel damage and navigation hazards	Navigate on plastic could lead to costly vessel damage, either to the vessel structure or through a tangled propeller or clogged intake.
Non-native and invasive species transport	Debris acts as a mean of transport for many marine species which end up in far-away shorelines or non-characteristic sea regions.

Biodiversity loss	It is the final output. As indicated by The Convention on Biological Diversity of 2018, humanity has only two years to reverse the current decline.
Long-term ecosystem deterioration	Long-term effects of marine litter are not straightforward to determine and nowadays, it is unclear to what extent these impacts mentioned will combine and cause ecosystem deterioration. Furthermore, marine debris is just one more factor of the ocean deterioration along with tourism, climate change or overfishing.
Social impacts	
Coastal contamination	Pieces of plastic are being accumulated in shores, damaging the natural environment.
Recreational opportunities	Activities such as water sports or sailing are being eliminated as people trend to avoid areas where litter is concentrated.
Loss of aesthetic value	Reduction of people enjoyment of surrounding natural scenarios, which affects their lifestyle quality and their recreational use of the marine environment.
Loss of non-use value	Related to the altruistic profits created by knowing that a particular ecosystem is maintained.
Human ingestion	As well as marine species, humans also ingest great amounts of microplastics, other toxins or chemicals by consuming sea animals, which have ingested plastic coming from plastic patches.
Heritage loss	Many protected coastal areas, specifically islands, are being damaged by plastic items arriving to their shores. A great example of this phenomenon is the Herderson Island in the Pacific Ocean.
Public health and safety impacts	They relate to navigational risks, possible physical and mental injuries and risks associated to plastic toxins.
Economic impacts	

Fisheries and aquaculture	Plastic usually obstructs the machines used for fishing activities. Costs of interruption are estimated to be the 0,9% of the total industry revenues - €61,7 million per year. Other costs include damage of vessels equipment, debris removal and staff downtime.
Shipping costs	The cost of litter damage to commercial shipping is estimated to be $297 million per year. Other shipping costs involve harbours removal and management tasks or emergency rescue operations of damaged vessels.
Tourism	Not only does tourism concern citizens, but it is also an economic issue as plastic debris reduces its revenues and increases its costs. Removing plastic items from touristic regions implies a huge governments and businesses inversion.
Litter cleaning costs	Then, removing litter from coastal areas is needed to sustain the tourism rates. These tasks are carried out by both local authorities and altruistic local citizens, and their costs involve cost of collection, transportation, disposal, contract management, administration and volunteer time.
Control and eradication of invasive and non-native species	It is extremely difficult to trace and identify such marine species, as well as the fact that these operations involve expensive procedures which lead to high economic losses.
Coastal agriculture costs	They include damage of property and equipment, livestock damage and even wasting time removing the debris. It is estimated that the 96% of coastal farmers have experienced litter-related problems, which equals to $400 losses per year.
Power station costs	They involve blockage of cooling water intake screens, raising removal debris from screens and other preservation costs. It is estimated that companies have costs of $50.000 to remove marine litter.
Economic loss	Overall, it is estimated that the economic impact of plastic litter in the sea is of $8 billion per year, according to the UN

	Environment Program. Thus, there is 4 times more plastic pollution on the sea rather than on land.

Sources: Anderson and Brown (1984), Cheshire et al (2009), Derraik (2002), Donnan (2009), Hall (2000), "Impacts | OR&R's Marine Debris Program" (n.d.), J Beaumont, Aanesen, C Austen & Borger et al (2019), Macfadyen et al (2009), Mouat, Lopez Lozano & Bateson (2010), Nelms, S. et al (2015), Ten Brink et al (2009),Thompson et al (2009), Watts J. (2018), World Wide Fund For Nature (2019)

Appendix 2: Analysis of international policies related to plastic oceans

Before 2010:

International policies, agreements, conventions and legislation			
Name	**Current Practices**	**Goals**	**Control measures**
1982. United Nations Convention on Oceans and the Law Of Sea – Part XII (Protection and preservation of the marine environment)	- Overall, controlling and managing that all countries are accomplishing the Law - Prohibiting sailing if fail to comply with environmental policies - When there is evidence of physical violation of laws → physical inspection of the vessel + certificates of navigation - Monetary penalties for vessels to pollute the marine environment beyond their area and in the territorial sea in case of law violation - Technical assistance: communication when there is an imminent damage, exchange of information, promoting programmes of scientific research, etc. - Special attention to ice-covered areas pollution of the marine environment could cause major harm	- Preserving marine environment by preventing pollution from land-based sources (rivers, estuaries, pipelines and outfall structures), activities in the area (vessels and coastal damage – States can claim special laws for specific protected areas), toxic substances, seabed activities (artificial islands, installations and structures), dumping (just under the express prior approval of the coastal State), ports → for all pollutants, each State must elaborate regional rules, standards and recommended prevention practices - Not polluting the sea as a result of using technologies - Avoiding intentional or accidental introduction of species, alien or new, to a particular part of the marine environment - Ensuring safety in sea operations - When eliminating or preventing pollution, not to transfer, directly or indirectly, damage or hazards from one area to another (not damaging other states), or transform one type of pollution into another - Enhancing states cooperation through elaborating international rules, standards and recommended practices and procedures; notifying imminent damages; making contingency plans; boosting research programmes and data exchange; and using scientific criteria regulations to formulate rules - Granting developing states with funds, technical assistance and specialized services	- International inspections, but the same state members shall observe, measure and evaluate (by scientific methods), the risks or effects of marine pollution, as well as those activities with a higher risk - States shall keep under surveillance the effects of any activities which they permit or in which they engage in order to determine whether these activities are likely to pollute the marine environment. - They should elaborate public reports with the results obtained and provide such reports to international organizations to make them available to all other States - When States have reasons for thinking that activities under their jurisdiction may cause substantial pollution to the marine environment, they have to assess the potential effects of such activities and have to communicate reports of the results of such assessments - In case of ratifying or acceding to this Convention, the State is be free to choose, by means of a written declaration: (a) International Tribunal for the Law of the Sea (b) International Court of Justice (c) An arbitral tribunal
Conclusions: - Monetary penalties for vessels to pollute the marine environment → see the amount of pollution coming from vessels (specially in ice-covered areas) - Sources of pollution: land-based sources (rivers, estuaries, pipelines and outfall structures), vessels, coastal damage, dumping and ports → under regional policies - Not damaging other States → see exports of plastics - Special attention to developing countries - Evaluation based on high level of bureaucracy: reports and many institutions between			
1996. London Convention - Prevention of Marine Pollution by Dumping of Wastes and other matter	- Avoiding unregulated dumping through regulatory programmes → dumping includes disposal into the sea of wastes or other matter from vessels, aircraft, platforms or other structures at sea; disposal of wastes into the seabed or any abandonment or toppling at site of platforms or other man-made structures at sea, for the sole purpose of deliberate disposal. - Prohibition of dumping persistent plastics and other persistent synthetic materials (netting and ropes) which may float or may remain in suspension in the sea in such a manner as to interfere materially with fishing, navigation or other legitimate uses of the sea. - Offering guidance and practices to address deposits into the marine environment that are done for a purpose other than disposal (ex: artificial reefs). - Improving in the compliance, the reporting requirement and the scientific evaluation of the results	- Obligations: environmental protection from dumping of wastes, taking into account the costs of permitted dumping and incinerating activities in the sea, and not transferring one type of pollution into another - Guidelines to specify which types of waste can be dumped under some circumstances - Waste management options: re-use, off-site recycling, destruction/reduction of hazardous constituents, and disposal on land, air or water. - Complementing other treaties such as MARPOL or UNCLOS - Technical support and cooperation: training of scientific and technical personnel for research, monitoring and enforcement, advise on implementation, information and technical co-operation relating to waste minimization, clean production processes and treatment of waste; and transfer of environmentally sound technologies and corresponding know-how, particularly to developing countries	- Each party should provide the Organization with information on legislation and institutional mechanisms regarding implementation, compliance and enforcement in marine internal waters. - Each party should provide summary reports on the type and nature of the materials dumped in marine internal waters → keeping records of the nature and quantities of all wastes for which dumping permits have been issued and where practicable, the quantities dumped and the location, time and method of dumping - After full consideration of any information submitted by each member State, the Meeting of Contracting Parties may offer advice, assistance or co-operation to Contracting Parties and non-Contracting Parties.

	- Specific permits for dumping or incineration at sea when these activities are permitted	- Economic goals: cleaning costs, keeping tourism rates and efficiencies in trade negotiations - Social and political goals: meeting the sustainable development goals, facilitating international relationships, joining other organizations of interest - Contracting parties should cooperate with regional agreements	- Secretariat: Protocol revised once a year + revision of the budged and financial accounts every 2 years + constant assessment and help
Conclusions: - Dumping: disposal into the sea of wastes from vessels, aircraft, platforms or other structures at sea - Great efforts to improve the reporting methods - Technical support and cooperation → see the level of research of each country - Control measures based on reports with detailed information + global revision once a year + revision of the budged and financial accounts every 2 years + constant assessment			

After 2010:

International policies, agreements, conventions and legislation			
Name	**Current Practices**	**Goals**	**Control measures**
2013. MARPOL - Annex V. Prevention of Pollution by Garbage from Ships	- Prohibited plastic discharges - When making supply and provisioning arrangements: (a) using supplies that come in bulk packaging, (b) using supplies that come in reusable or recyclable packaging and containers, avoiding the use of disposable cups, utensils, dishes, towels and rags, (c) avoiding supplies that are packaged in standard plastic. - When considering selection of materials for stowage and securing of cargo: (a) using permanent reusable coverings instead of disposable or recyclable plastic sheeting, (b) using stowage systems and methods that reuse dunnage, shoring, lining and packing materials,	- Prohibits the discharge of all types of garbage into the sea unless the explicitly permitted: food wastes, identified cargo residues, animal carcasses, identified cleaning agents and additives, and cargo residues entrained in wash water which are not harmful for marine environment. - Manufacturers, cargo owners, ports and terminals, shipowners and operators and Governments should minimize the generation of garbage in all forms. - Specially governments, they are encouraged to undertake research and technology development about biodegradable materials	- Governments should consider the use of garbage management reporting systems with valuable data for measuring and monitoring the impacts of garbage regulations and management → information in garbage record books or ship's official log-book. - Operational wastes: the ship's record should contain evidence provided by the producer of the cleaning agent or additive that the product meets the criteria for not being harmful to the marine environment → Safety Data Sheet: dated and signed statement to this effect from the product supplier would be adequate for the purposes of a ship's record.
	(c) discharging to port reception facilities the dunnage, lining and packaging materials generated. - Gears, fish aggregating devices, traps and static nets are prohibited. - To facilitate recycling, garbage must be separated in the same vessel, distinguishing recyclable and non-recyclable plastics - Keeping asking governments to ensure adequate reception facilities at ports and terminals. - State control officers inspect those ships that are thought not to follow the essential procedures - All crew members and passengers must be notified about such policies → placards in every ship - Governments can amend their maritime certification examinations and requirements, as appropriate, to include a knowledge of duties imposed by national and international law regarding the control of pollution of the sea by garbage. - Government incentives: tax, loan guarantees, business preferences, funds, subsidies, etc.	and recyclability of current garbage. They should also undertake training, education and public information programmes suited for all seafaring communities - Developing other requirements for those regions with particularities (ex: endangered marine species). - Programs should influence plastic manufacturers - Governments must establish measures consistent with international law and the creation of positive incentives and initiatives to facilitate more effective compliance	- Periodical inspections and audits at port to ensure the policies compliance → governments have to establish the appropriate agencies to enforce so - Specially, fishing gears disposal must be reported as they may cause vessel accidents - IMO Member State Audit Scheme (IMSAS) - Governments should provide: technical information on shipboard garbage management methods such as minimization, recovery, recycling, reuse, incineration, compaction, separation, sorting and sanitation system, packaging and provisioning methods; educational materials developed such as printed materials; and information and reports on the nature and extent of garbage from shipping found along beaches and in coastal waters under their respective jurisdictions. In order to assess the effectiveness of Annex V, these studies should provide details on amounts, distribution, sources and impacts of garbage from shipping (Regional Reception Facility Plan) - Governments and the same Organization should continue to gather information and review these guidelines periodically
Conclusions: - Prohibited plastic discharges → see the amount of vessel plastic discharges - Manufacturers, cargo owners, ports and terminals, shipowners and operators and Governments should minimize the generation of garbage → see the amounts of plastic produced by some of the collectives mentioned - Governments: encouraged to do research about biodegradable materials and recyclability of current garbage + undertake training, education and public information programmes suited for all seafaring communities + offer incentives (taxes, funds, etc.) → see which states are involved - Developing special requirements for those regions with particularities (ex: endangered marine species).			

- Wide range of reports elaborated by ships and Governments: garbage record books and ship's official log-book (safety data sheet) - External audits done periodically and specific agencies for vessel inspections → IMO Member State Audit Scheme (IMSAS) - Regional Reception Facility Plan by each State: technical information on shipboard garbage management methods; packaging and provisioning methods; educational materials developed; and reports → details on amounts, distribution, sources and impacts			
2016. United Nations Convention on Biological Diversity – Marine Debris	- Especial attention to Tourism: approval and licensing processes for activities, controlling the construction (resorts on the beach), controlling the vulnerable areas, setting national standards (land-used), ensuring linkages between tourism and agriculture, coastal management and water resources, solve inconsistencies between policy goals and legislation, application of economic instruments (taxes, fees, bonds, levies), creating incentives for sustainable tourism, supporting private sector certification schemes, fees to regulate tourism activities which involve nature (scuba diving). - Improvements: protected area coverage and water quality in rivers since 1980 - Responding to citizens' demand: governments are starting to ban plastic bags and straws and to control the use of single use plastic bottles. - Responding to consumers' demand: companies are increasingly pledging that their packaging will be reused, recycled or composted in the near term - Responding to their communities' needs: individuals are turning into innovators, transforming plastic debris into things that they need	- 2010: parties accorded, by 2020, to reduce pollution to levels that are not detrimental to ecosystem function and biodiversity → fail - Different types of policy approaches and research needs to tackle predominantly land-based sources of marine debris: packaging reduction, use of waste as a resource, fees for single-use items, bans for certain items, engaging industries with CSR for plastics, biodegradable plastics, facilitate plastic recycling, etc. - Trade policies: in the long run, the removal of subsidies for fisheries and agriculture has the potential to benefit biodiversity; in the short term, trade liberalization will accelerate its loss if not well-planned. - Marine areas: to be effectively managed to reduce biodiversity loss; designate protected areas; involvement of local indigenous communities - Plastics: single use fees, packaging reduction; eco-labels (identify environmental performance in products, packaging and services - effective to provide information to consumers who are then equipped to make better, more proactive environmental decisions in purchasing → New Zealand has an eco-label certification standard for recycled plastic products. Dependent on the type of product to be awarded the logo, the producer has to use 30-90 % recycled post-consumer plastic resin, identify its involvement in take back programs, and not use any hazardous substances); voluntary action; biodegradable products; producer responsibility; incentives for collection and recycling, municipal ordinances and user fees, engagement with business leaders (make them see it as part of business sustainability); use plastic to generate electricity; population education and programs → influence consumer behaviour - Preventing end-of-life materials from leaving the waste stream and entering the marine environment - Education and awareness-raising campaigns, especially for countries without a proper waste management infrastructure	- Overall, identifying processes and categories of activities which are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques - Tourism: monitoring information on activities - Biodiversity: observe trends about ecosystem and distribution of species; coverage of protected areas; area of forest, water and agriculture under sustainable management, products from sustainable sources; water quality - Marine areas: number of countries involved and number of actions performed - Gaps in knowledge about amount of plastics and microplastics in the sea → need of smart technology and citizen science - Regular coastal clean-ups: part of long-term monitoring programmes important for removing harmful debris items - 70% per cent of all plastic debris has been estimated to eventually sink to the seafloor → need to better understand the abundance and distribution of marine plastic debris in the deep sea. - Assessing the occurrence and frequency of such debris in the deep sea is challenging and expensive, but can be combined with existing survey programmes to collect information on marine litter during on-going assessments of marine fauna or habitats
Conclusions - Limited information available for debris prevalence by source and pathway - Information is not collected systematically in most regions, even where there is monitoring effort → see countries without proper data collection - No robust data for the amount of debris in the ocean or how much enters the ocean each year + most of plastics end up in the seafloor - Knowledge of marine debris characteristics is constrained by methodological limitations - No information the main sources of plastic pollution entering the marine environment - Need of tourism regulation: coastal construction, agriculture, etc. → see the impact - Implication of governments (ban plastic items in supermarkets), companies (reusable and recyclable materials) and citizens - Land-based sources of marine debris: packaging and single-use items - Trade policies → see subsidies for fisheries and agriculture and trade liberalization policies - Marine areas → see protected areas per country - Developing countries need awareness-raising campaigns as their waste systems are not adequate - Crucial to identify and monitor activities with adverse impacts on marine environment → expensive, they are complemented with survey programmes - Biodiversity related to protected areas, area of forest, water and agriculture under sustainable management - Regular coastal clean-ups: important when removing harmful debris items		

2017. ISWA Task Force on Marine Litter	- Dumpsite closure campaign for raising awareness - Collaborate in clean-up movements - Partnerships with other organizations: CCAC - reduce emissions and greenhouse gases and black carbon through effective waste - Impose barriers to avoid plastic packaging - Make reports about waste management for other institutions (ex: Task Force on Resource Management – series of reports for assessing industries) - Collaborating with scientific publications	- Short term: preventing dumping, closing dumpsites, create appropriate and accessible waste collection management systems, create awareness, work with the maritime sector - More important: investing in effective waste management in low-income countries → the most cost-effective and immediately practicable solution - Medium term: enhance plastic value, create stable markets for secondary plastics (improve data gathering), efficiency in waste plants - Long-term: build a circular economy infrastructure without single-use plastics and with an improved recyclability, Innovate and invent at the materials, design and processing level - Population with no access to minimum waste management services: south Asia, east Asia and Pacific and sub-Saharan countries - Providing waste management for all will: make cities inclusive, safe, resilient and sustainable; production and consumption systems based on circularity (creation of secondary materials); decent livelihoods (particularly for the poorest – recycling services available for all); reduction of greenhouse gases by cutting methane emissions from uncontrolled dumps and landfills; generation of energy from waste products → Sustainable Development Goals - Next steps: communicate best practices more effectively; identify hot spots for intervention; actively participate in other major efforts and international fora; assess the level of investment needed and create a platform for information	- Data on waste management practices → no clear internationally agreed protocol for data collection and reporting, the quality and type of data collected on waste management activities varies significantly in terms of quality and scope. This makes it very difficult to establish a clear baseline; it makes is very challenging to monitor changes in provision of effective waste management; and almost impossible to track the effect that changes in waste management provision - Consistent data on quantities and movement of marine litter: quantities of marine litter leaking from the system; pathways and sinks for marine litter - Need of linking the monitoring data to the SDGs
Conclusions: - Collaboration in clean-up movements → see the relationship - Reduce emissions and greenhouse gases and black carbon through effective waste → see the relationship - Investing in effective waste management in low-income countries → see the most affected ones (south Asia, east Asia and Pacific and sub-Saharan countries) - Other variables: data gathering, efficiency in waste plants, dumping practices, marine litter quantities of leaking from the system, pathways and sinks for marine litter - Importance of building a circular economy infrastructure without single-use plastics and with an improved recyclability, innovate materials - Importance of Sustainable Development Goals for monitoring data - Need to identify hot spots for intervention and to create a platform for information - Need of a clear internationally agreed protocol for data collection and reporting			
2019. UNEP + UNEP plastic waste and marine litter	- Special Executive Secretary + expert group on marine litter just to implement the new resolutions → they should evaluate the existing activities and actions, identify technical and financial resources to support countries, encourage partnerships and analyse the effectiveness of all activities - Banning single use plastics (2021) - Restrictions (bans and levies) on plastic bags and Styrofoam products: better waste management system (less landfill and dumping), promotion of eco-friendly activities, social awareness and public pressure, voluntary reduction strategies and agreements - Clean seas campaign: targeting the production and consumption of non-recoverable single-use plastics - Regional Seas Conventions and Action Plans (ex: 1976, Barcelona). Most important one in terms of plastics → **Honolulu strategy*** (2011): common framework of reference for collaboration and sharing best practices and	- Stressing the importance of environmentally sound waste management and international cooperation - Boosting regional action plans for marine protection → Regional Seas Programme. It involves engaging neighbouring countries. - Supporting evidence-based management and reduction of problematic products causing marine litter and plastic pollution, incorporating the work within collaborative frameworks such as the Global Partnerships on Marine Litter and other entities - Plastic-related principles are: biodiversity conservation, natural habitats, and sustainable management of living resources; and resource efficiency, pollution prevention and management of chemicals and wastes - Improve waste management programs: IPLA - International Partnership for Expanding Waste Management Services of Local Authorities - By 2030, biodiversity conservation and integrated ecosystems management will result	- Systematic assessment of sub-programs through projects and portfolio evaluations (strategies, operations and impacts) - Medium-term strategies evaluated through a formative stage (planning evaluation), mid-term evaluation (operational feedback) and end-cycle evaluation (results and expected achievements). - Biennial Evaluation Synthesis Report - Criteria: relevance, effectiveness, efficiency, impact, sustainability of outcomes, etc. - All member states should report, disclosure, disseminate and follow-up - Evidence-based tracking of progress - Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities: - Global Partnership on Marine Litter (2012): new advisory group to be set, update of marine litter network on a database, regional assessment to inform about the development of action plans, monitoring marine litter indicators;

	lessons learned in preventing and reducing marine litter.
	- Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities:
	  - **Global Partnership on Marine Litter** (2012): support to the development of regional marine action plans; development of databases and action plans (specially for Islands, Universities); land-based source protocols in many regions; community involvement; clean-up movements
	  - **Global Partnership for Waste Management:** platform to support the exchange of information, knowledge, practices and experiences among countries, regions and cities, empowering their capacity to manage waste related matters.
		in healthier marine, freshwater and terrestrial ecosystems.
		- Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities:
		  - **Global Partnership on Marine Litter** (2012): protect human health and environment through a reduction of marine litter, waste management (ST), upstream reduction (LT), harmonization and standardization of methods, gaps and solutions for government frameworks, establishment of public/private partnerships, campaigns for awareness-raising
		  - **Global Partnership for Waste Management:** cooperation among stakeholders, identify and fill information gaps, share information and strengthen awareness, political will, and capacity to promote resource conservation and resource efficiency
			need of an integrated protocol for assessing and monitoring pollution from marine debris, providing data for decision-making, and increasing the effectiveness of future remediation and mitigation techniques through the use of an integrated PDA-GPS system
			- Global partnership on Waste Management: On the "*kNOwWaste*" it will be possible to consult experts and other users that might be facing similar issues or that have may have a solution to propose.

Conclusions: - Bans and levies on single-use plastics, clean-up campaigns, community involvement - Variables: land-based sources - Regional Seas Programme which involves neighbouring countries - Concept of sound waste management - Qualitative methods of evaluation			
2019. Basel Convention – transboundary movement of hazardous waste	- 3 types of plastic: hazardous waste, non-hazardous waste and others. Shipment must consist almost exclusively of either one non-halogenated polymer, one cured resin or condensation product, or specific fluorinated polymer wastes.	- Overall, human health and environmental protection - Strengthen policy and framework with prevention and regulatory strategies - Environmentally sound management of plastic waste: analysing barriers, best practices and solutions, launching pilot projects on the	- Reports about information on plastic waste amounts and types shipped - All transboundary movements will require: PIC procedure, consent of all parties/countries involved and also local companies dealing with plastic transit must give their consent (and must submit the

	- New plastic waste amendment: certain plastics can only be exported if the importing country grants a *Prior Informed Consent*, which has to secure that waste will be managed in an environmentally sound manner in the importing country. Careful planning will be required to ensure the operation of a unified, global system accessible by all signatory countries is successful → equalizing the imbalances among low and high income countries. - Parties are prohibited from shipping hazardous waste to and from non-parties, unless such transfers are regulated under special bilateral or regional agreements that contain standards equivalent to those established under the Basel Convention - Further actions: minimization and prevention of plastic waste, reducing the risk from hazardous constituents, review the annexes I and III technical guidelines, partnership on Plastic Waste and public awareness. - Technical guidelines for the identification and environmentally sound management of plastic wastes and for their disposal - Framework for the ESM of hazardous wastes and other wastes - Guidance to assist Parties in developing efficient strategies for achieving the prevention and minimization of the generation of hazardous and other wastes and their disposal - Practical manuals for the promotion of the ESM	prevention and minimization of plastic waste, identifying national, regional and international initiatives and actors that can provide capacity building, and technical advice and technology transfer - Collaboration with private sector: stimulating innovations for increasing the durability, reusability, reparability and recyclability of plastics, exploring how the quality of recycled plastic can be maintained through repeated circular operations, exploring how value chains can be established to improve the economic viability of the separation, collection and recycling of plastic waste, and engaging the private sector in the environmentally sound management of plastic waste - Stimulate outreach, education and awareness-raising - Taking into account developing countries' limited capabilities - Reviewing the annexes I and III and technical guidelines through working groups of member states	necessary supporting documents) to obtain the Basel Permit from NEA and Bankers' guarantee. - Feedback on new domestic control measures can be submitted in order to improve the procedures

	- Draft practical manuals on extended producer responsibility and financing systems for ESM - Guidance manual on how to improve the sea-land interface - Plastic waste partnership: involves business, government, academic and civil society resources, interests and expertise to enhance the environmentally sound management		
Conclusions: - Certain plastics can only be in an environmentally sound manner in the importing country → need of equalizing the imbalances among low and high income countries - Prohibition to ship hazardous unless such transfers are regulated under special bilateral or regional agreements - Variables: businesses, pilot projects for preventing plastic waste			
2020. World Economic Forum Annual Meeting – International Cooperation to tackle plastic pollution	- Facilitating environmental goods and services trade and building circular economy → eliminate tariffs on environmental friendly goods (ex: renewable energy), tariffs/bans/taxes on certain type of plastic products (in 2018, 61 countries adopted manufacturing and import bans on plastic bags), avoiding ambiguity on scope of obligations, less barriers for subsidiaries for the supply of environmental services, addressing issues related to data transfer, promoting environmental standards and labelling requirements for plastic products, and identifying specific challenges when implementing circular economies - Others: extended producer responsibility schemes, including deposit- refunds, product take-back and recycling targets; regulations to improve plastic supply chain transparency and subsidies and tax incentives to spur innovation, use, trade and technology transfer in plastic	- Support existing international efforts to reduce plastic pollution and transform the global plastics economy by focusing on trade liberalization policies - Complement intergovernmental cooperation underway in UN Environment processes, Basel Convention, UN SDGs, and any future global agreement on marine litter, microplastics and plastic pollution - Promote coherence with the WTO's objective of sustainable development → coherence between domestic and international policies, less trade barriers for technology transfers - Promote a more transparent, predictable and coherent trade policy framework. - Information-sharing: enhancing shared understanding of sustainable trade policies among member states as well as measures, innovations and best practices - Voluntary action: encourage voluntary trade-related targets and pledges to reduce trade,	- To date, neither the scope or impacts of measures have been systematically studied → further research is needed - From 2009 to 2018: 128 measures affecting trade in plastics for environmental reasons → measures relate to technical requirements to ensure proper waste management and recycling, import licensing schemes to control trade flows, and bans on certain polluting plastics (single use plastic items or shopping bags). - Over 80% of measures were notified by developing countries and most trade measures affecting trade in plastics were notified under the WTO Agreement on Technical Barriers to Trade.

	substitutes, 'greener' plastics, and waste management technologies. - Report, reducing and eliminating fossil-fuel subsidies, which increases virgin production of plastics. - Dialogue on climate policies: dialogue between trade and climate change policy-makers to ensure that there is alignment between trade rules and climate change goals. - Free Trade Agreements (FTA): bilateral agreements among countries related to binding policies or cooperation (ex. tariffs on environmental goods, voluntary eco-labelling programmes) → more and more common	production of unnecessary plastics and harmful subsidies. - Cooperation: both with developing countries (no exports) and with other international organisations and stakeholders	
Conclusions: - See tariffs on environmental friendly goods, bans on plastic products and waste management technologies - Goal: regulate trade liberalization - States cooperation is fundamental: information-sharing + focus on developing countries + technology transfers - Alignment between trade rules and climate change goals - Free Trade Agreements (FTA): bilateral agreements among countries related to binding policies or cooperation → see countries with bilateral agreements - To date, neither the scope or impacts of measures have been systematically studied →further research is needed - Other measures: strengthen coherence between trade policy frameworks and domestic policies, reduce trade barriers for products and services that reduce and phase out plastic pollution (alternatives to plastic products), encourage voluntary action, promote transparency, monitoring and information-sharing on trends in plastic trade and supply chains, and to improve capacity building for trade-related aspects of reducing plastic pollution in developing countries and boost cooperation among the WTO Secretariat, Member States and other international organizations active on plastic pollution.			

Appendix 3: Variables (regressors) to be included

Agriculture and rural development

Agricultural land (% of land area)	Share of arable land area under permanent crops and permanent pastures.
Agriculture, forestry and fishing value added (% of GDP)	Agriculture includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs
Surface area (km2)	Country's total area, including areas under inland bodies of water and some coastal waterways.
Land area (km2)	Country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones.
Forest area (km2)	Land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems and trees in urban parks and gardens.
Water area (km2)	Sum of the surface areas of all inland water bodies (lakes, reservoirs, and rivers) within international boundaries and coastlines. Coastal internal waters (some small bays) may be included.
Food production index (2004-2006=100)	It covers food crops that are considered edible and that contain nutrients. Production quantities of each commodity are weighted by 2004-2006 average international commodity prices and summed for each year. To obtain the index, the aggregate for a given year is divided by the average aggregate for the base period 2004-2006 ("Production Indices", n.d.).

Source: The World Bank (n.d.), FAOSTAT (n.d), World By Map (2011) and Wikipedia (2015)

Population and urban development

Total population	It counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.
Population growth (% annually)	The exponential rate of growth of the midyear population from year t-1 to t, expressed as a percentage.
Urban population (% of total population)	People living in urban areas.
Plastic waste generation per person (kg per person per day)	Daily plastic waste generation per person, measured in kg per person per day. It measures the overall per capita plastic waste generation rate before waste management, recycling or incineration. It does not therefore directly indicate the risk of pollution to waterways or marine environments.
Total municipal solid waste generation (tons/day)	Tons of waste generated in cities with populations over 100.000. Data provided by a 2010 World Bank study about urban waste generation.
Municipal solid waste generation per capita (kg/capita/day)	Tons of waste generated per person in cities with populations over 100.000. Data provided by a 2010 World Bank study about urban waste generation.
Municipal solid waste % of plastic	Share of plastic waste over the total waste generated in cities with populations over 100.000. Data provided by a 2010 World Bank study about urban waste generation.
Renewable energy consumption (% of total final energy consumption	Share of renewable energy in total final energy consumption.
Renewable electricity output (% of total electricity output)	Share of electricity generated by renewable power plants in total electricity generated by all types of plants.
Average daily dietary energy consumption per capita (kilocalories)	Kilocalories consumed per day per person as an indicator of fast food consumption.

Source: The World Bank (n.d.) and Wikipedia (2015)

Economy and growth

GDP (current US$)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.
GDP growth (annual %)	The annual percentage growth rate of GDP at market prices based on constant local currency.
GDP per capita (current US$)	GDP divided by midyear population.
GDP per capita growth (annual %)	The annual percentage growth rate of GDP per capita based on constant local currency.
GDP (PPP) per capita (current US$)	Gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.
Industry (including construction), value added (% of GDP)	It comprises value added in mining, manufacturing, construction, electricity, water, and gas. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.
Ease of doing business score (0-100)	Distance of an economy to the "frontier," which represents the best performance observed on each Doing Business topic across all economies and years included since 2005. An economy's distance to frontier is indicated on a scale from 0 to 100, where 0 represents the lowest performance and 100 the frontier. It does not hardly vary since 2005 onwards.

Exports of plastics ($ thousand)	Amount of exported plastics in 2010.
Imports of plastics ($ thousand)	Amount of imported plastics in 2010.
Food exports (% of merchandise exports)	Food comprises the commodities food and live animals, beverages and tobacco, animal and vegetable oils and fats, and oil seeds, oil nuts, and oil kernels.
Tariff rate, applied, weighted mean, all products (%)	Average of effectively applied rates weighted by the product import shares corresponding to each partner country. It is an indicator of trade liberalization.
Manufacturing, value added (% of GDP)	It refers to industries belonging to ISIC divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.
Capture fisheries production (metric tons)	It measures the volume of fish catches landed by a country for all commercial, industrial, recreational and subsistence purposes.
Current health expenditure (% of GDP)	Level of current health expenditure expressed as a percentage of GDP. Estimates of current health expenditures include healthcare goods and services consumed during each year.
Current health expenditure per capita (current US$)	Current expenditures on health per capita in current US dollars. Estimates of current health expenditures include healthcare goods and services consumed during each year.

Source: The World Bank (n.d), The World Integrated Trade Solution (n.d.) and Wikipedia (n.d)

Education

Government expenditure on education (% of GDP)	General government expenditure on education (current, capital, and transfers) expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to the government.

Government expenditure on education (% of government expenditure	General government expenditure on education (current, capital, and transfers) expressed as a percentage of total general government expenditure on all sectors (including health, education, social services, etc.). It includes expenditure funded by transfers from international sources to the government.
Children out of school (% of children)	Primary-school-age children who are not enrolled in primary or secondary school.
Wage and salaried workers, total (% of total employment)	Workers who hold the type of jobs defined as "paid employment jobs," where the incumbents hold explicit or implicit employment contracts that give them a basic remuneration that is not directly dependent upon the revenue of the unit for which they work.
Research and development expenditure (% of GDP)	Gross domestic expenditures on research and development (R&D), expressed as a percent of GDP. They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development.

Source: The World Bank (n.d.)

Environment

Basel convention in 2010 or before (0-1)	Adopted in 1989, it was aimed to reduce the amount of waste and protect the environment, as well as restricting transboundary movements of hazardous wastes. Even though there exist several international policies to which countries can actively participate, this one, in particular, is very related to the aim of this study.
Coastal size (km)	Length of the coast for each country.
Average proportion of Marine Key Biodiversity Areas (KBAs) covered by	SDG 14 states conserving and sustaining the oceans, seas and marine resources. It specifically involves minimizing the impacts of ocean acidification, including through enhanced

protected areas (%) (SDG 14)	scientific cooperation at all levels, and conserve at least 10 per cent of coastal and marine areas.
Aquaculture production (metric tons)	Farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Aquaculture production specifically refers to output from aquaculture activities, which are designated for final harvest for consumption.
Single-use plastics bans before or in 2010 (0-1)	Countries banning the use of single-use plastics (such as plastic bags) before 2010 or in 2010 are indicated with 1. Otherwise with 0.

Source: The World Bank (n.d.), The World by Map (2011) and the United Nations Environment Programme (2018)

Infrastructure

Container port traffic (TEU: 20 foot equivalent units)	The flow of containers from land to sea transport modes., and vice versa, in twenty-foot equivalent units (TEUs), a standard-size container. Data refer to coastal shipping as well as international journeys. Transhipment traffic is counted as two lifts at the intermediate port (once to off-load and again as an outbound lift) and includes empty units.
Annual freshwater withdrawals, total (% of internal resources)	Total water withdrawals which include water from desalination plants in countries where they are a significant source. Withdrawals can exceed 100% of total renewable resources where extraction from non-renewable aquifers or desalination plants is considerable or where there is significant water reuse. This rate has been observed not to vary a lot overtime. Withdrawals can be classified into agriculture, domestic or industry, but there are not enough data for all countries.
Renewable internal freshwater resources, total (billion cubic meters) 2007	Internal renewable resources (internal river flows and groundwater from rainfall) in the country. There are no data for 2010, but according to Blok (2019), there is no difference at all on the results.

Renewable internal freshwater resources per capita (cubic meters) 2007	Internal renewable resources (internal river flows and groundwater from rainfall) in the country. There are no data for 2010, but according to Blok (2019) there is no difference at all on the results.

Source: The world Bank (n.d.)

Tourism

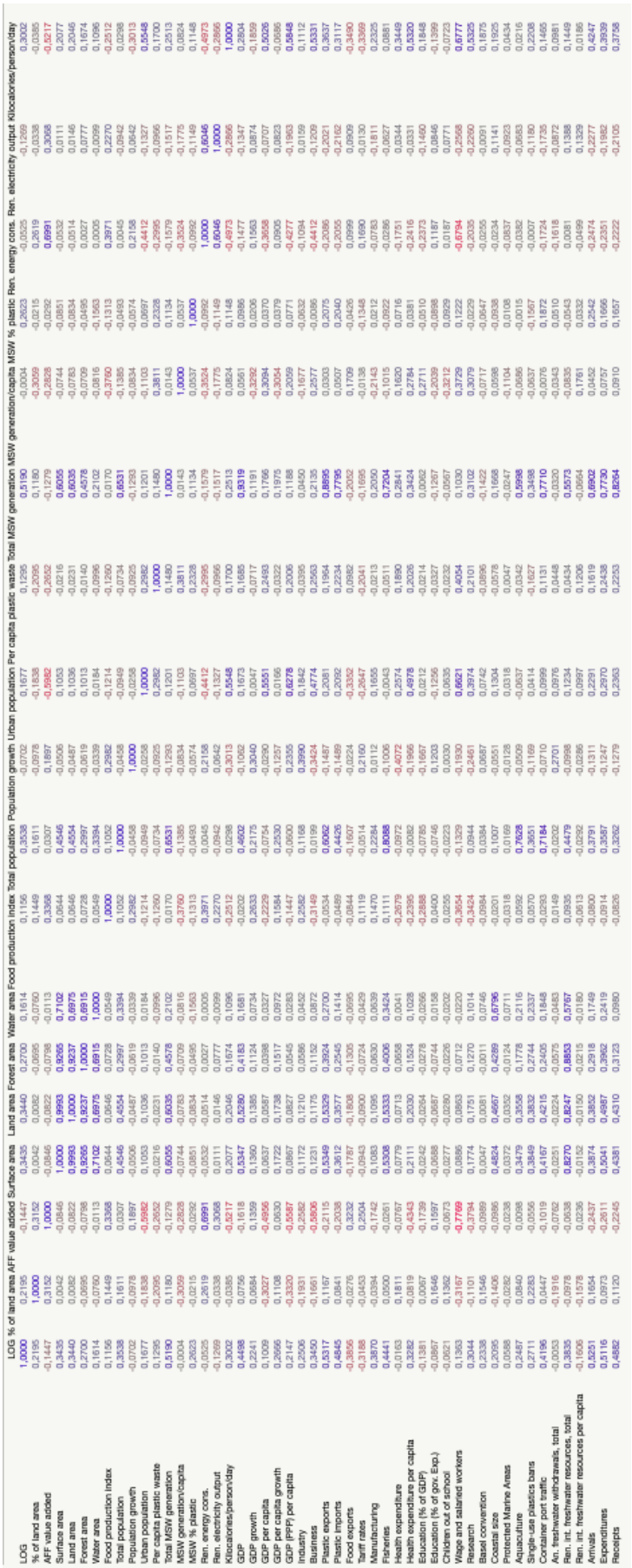
International tourism (number of arrivals) – coastal visitors	The number of tourists who travel to a country other than that in which they have their usual residence, but outside their usual environment, for a period not exceeding 12 months and whose main purpose in visiting is other than an activity remunerated from within the country visited. It is highly related to hospitality industry.
International tourism, expenditures (current US$)	Expenditures of international outbound visitors in other countries, including payments to foreign carriers for international transport.
International tourism, receipts (current US$)	International tourism receipts are expenditures by international inbound visitors, including payments to national carriers for international transport.

Source: The World Bank (2011)

Appendix 4: Coastal countries not taken into account for the regression analysis

Countries	Habitants in 2010	Surface area (km^2)
Anguilla	13.800	91
Christmas Islands	1.402	135
Cocos Islands	596	14
Cooks Islands	18.391	236,7
Falkland Islands	2.901	12.173
French Guiana	233.002	83.534
Gibraltar	33.189	6,8
Guadeloupe	403.995	1.628
Guernsey	65.345	78
Martinique	394.173	1.128
Macao	536.959	115,3
Monaco	37.094	2,2
Montserrat	4.899	102
Netherlands Antilles	197.621	999
Niue	1.618	261,5
Norfolk Islands	2.155	34,6
Réunion	830.519	2.512
Saint Helena	5.183	121,7
Saint Pierre et Miquelon	6.353	242
Sint Merteen (dutch part)	34.056	87
Taiwan	23.187.551	36.193
Tokelau	1.140	10
Turks and Caicos Islands	30.994	417
Total	**26.042.936**	140.121,8
%	(26.042.936/6.956.823.603) x 100 = **0.37435096%**	(140.121,8/148.940.000) x 100 = **0.094079365%**

Appendix 5: Correlation matrix with all variables



GDP	GDP growth	GDP per capita	GDP per capita growth	GDP (PPP) per capita	Industry	Business	Plastic exports	Plastic imports	Food exports	Tariff rates	Manufacturing	Fisheries	Health expenditure	Health expenditure per capita	Education (% of GDP)	Education (% of gov. Exp.)	Children out of school	Wage and salaried workers
0,4498	0,2241	0,1009	0,2666	0,2147	0,2506	0,3450	0,5317	0,4845	-0,3856	-0,3188	0,3870	0,4441	-0,0163	0,3282	-0,1381	-0,0867	-0,0621	0,1363
0,0756	0,0684	-0,3027	0,1108	-0,3320	-0,1931	-0,1661	0,1167	0,0841	-0,0276	-0,0453	-0,0394	0,0500	0,1811	-0,0819	0,0067	0,1646	0,1362	-0,3167
-0,1618	0,1359	-0,4956	0,0630	-0,5587	-0,2582	-0,5806	-0,2115	-0,2038	0,3232	0,2504	-0,1742	-0,0261	-0,0767	-0,4343	-0,1739	0,1597	-0,0573	-0,7769
0,5347	0,1360	0,0637	0,1722	0,0867	0,1172	0,1231	0,5349	0,3612	-0,1787	-0,0943	0,1083	0,5308	0,0779	0,2111	-0,0242	-0,0688	-0,0277	0,0886
0,5280	0,1385	0,0587	0,1738	0,0827	0,1210	0,1175	0,5329	0,3577	-0,1808	-0,0900	0,1095	0,5333	0,0713	0,2030	-0,0264	-0,0687	-0,0280	0,0863
0,4183	0,1124	0,0398	0,1517	0,0545	0,0586	0,1152	0,3924	0,2545	-0,1305	-0,0724	0,0630	0,4006	0,0658	0,1524	-0,0278	-0,0744	-0,0226	0,0712
0,1681	0,0734	0,0327	0,0972	0,0283	0,0452	0,0872	0,2700	0,1414	-0,0695	-0,0429	0,0639	0,3424	0,0041	0,1028	-0,0266	0,0158	-0,0202	-0,0220
-0,0202	0,2633	-0,2229	0,1584	-0,1447	0,2582	-0,3149	-0,0534	-0,0489	-0,0844	0,1119	0,1470	0,1111	-0,2679	-0,2395	-0,2888	0,0400	0,0255	-0,3654
0,4602	0,2175	-0,0754	0,2530	-0,0600	0,1168	0,0199	0,6062	0,4426	-0,1607	-0,0514	0,2284	0,8088	-0,0972	-0,0082	-0,0785	-0,0746	-0,0223	-0,1329
-0,1062	0,3040	-0,0290	-0,1257	0,2355	0,3990	-0,3424	-0,1487	-0,1489	-0,0224	0,2160	0,0112	-0,1006	-0,4072	-0,1966	-0,1667	0,1203	0,0030	-0,1930
0,1673	0,0047	0,5551	0,0166	0,6278	0,1842	0,4774	0,2081	0,2092	-0,3352	-0,2647	0,1655	-0,0043	0,2574	0,4978	0,0212	-0,1256	0,0635	0,6621
0,1685	-0,0717	0,2493	-0,0322	0,2006	-0,0395	0,2563	0,1964	0,2234	0,0982	-0,2041	-0,0213	-0,0511	0,1890	0,2026	-0,0214	-0,0327	-0,0232	0,4054
0,9319	0,1191	0,1766	0,1975	0,1188	0,0450	0,2135	0,8895	0,7795	-0,2052	-0,1695	0,2050	0,7204	0,2841	0,3424	0,0062	-0,1267	-0,0567	0,1030
0,0561	-0,3292	0,3094	-0,3054	0,2059	-0,1677	0,2577	0,0303	0,0507	0,1709	-0,0138	-0,2143	-0,1015	0,1620	0,2784	0,2711	-0,2039	-0,3212	0,3729
0,0986	0,0206	0,0370	0,0379	0,0771	-0,0632	-0,0086	0,2075	0,2040	-0,0426	-0,1348	0,0212	-0,0922	0,0716	0,0381	-0,0510	-0,0898	0,0929	0,1222
-0,1477	0,1563	-0,3658	0,0905	-0,4277	-0,1094	-0,4412	-0,2086	-0,2055	0,0999	0,1690	-0,0783	-0,0286	-0,1751	-0,2416	-0,2373	0,1187	0,0187	-0,6794
-0,1347	0,0874	-0,0707	0,0823	-0,1963	0,0159	-0,1209	-0,2021	-0,2162	0,0909	-0,0130	-0,1811	-0,0627	0,0344	-0,0331	-0,1460	0,0846	0,0771	-0,2568
0,2804	-0,1859	0,5026	-0,0586	0,5848	0,1112	0,5331	0,3637	0,3117	-0,3490	-0,3369	0,2325	0,0881	0,3449	0,5320	0,1848	-0,1399	-0,0723	0,6777
1,0000	0,0531	0,2468	0,1093	0,2282	0,0180	0,2840	0,8286	0,8171	-0,1836	-0,2061	0,1381	0,5414	0,3244	0,5077	0,0217	-0,1342	-0,0236	0,1756
0,0531	1,0000	-0,1592	0,8945	-0,0043	0,1648	-0,0619	0,1276	0,0996	-0,1358	-0,0006	0,2031	0,2311	-0,2215	-0,1925	-0,2163	0,1290	0,0697	-0,1645
0,2468	-0,1592	1,0000	-0,1583	0,8710	0,0347	0,6426	0,2770	0,3056	-0,2077	-0,3168	-0,0221	0,0135	0,3008	0,8977	0,1019	-0,2116	-0,0588	0,6073
0,1093	0,8945	-0,1583	1,0000	-0,1138	-0,0086	0,0999	0,2080	0,1788	-0,1390	-0,1044	0,2161	0,2950	-0,0307	-0,1065	-0,1586	0,0692	0,0674	-0,0838
0,2282	-0,0043	0,8710	-0,1138	1,0000	0,3879	0,5304	0,2641	0,2918	-0,3882	-0,4096	0,1805	0,0025	0,0809	0,6219	-0,0002	-0,1965	-0,0534	0,6660
0,0180	0,1648	0,0347	-0,0086	0,3879	1,0000	-0,1151	0,0594	0,0698	-0,4808	-0,0539	0,4243	0,1553	-0,5052	-0,0900	-0,1603	-0,0324	-0,1386	0,1250
0,2840	-0,0619	0,6426	0,0999	0,5304	-0,1151	1,0000	0,3802	0,3729	-0,2112	-0,6527	0,2309	0,1565	0,3850	0,6301	0,1832	-0,0808	-0,0974	0,6791
0,8286	0,1276	0,2770	0,2080	0,2641	0,0594	0,3802	1,0000	0,9045	-0,2625	-0,2923	0,2521	0,6789	0,2544	0,4738	0,0093	-0,1460	-0,0329	0,2157
0,8171	0,0996	0,3056	0,1788	0,2918	0,0698	0,3729	0,9045	1,0000	-0,2401	-0,2746	0,2889	0,5513	0,2716	0,5046	0,0064	-0,1524	-0,0286	0,2176
-0,1836	-0,1358	-0,2077	-0,1390	-0,3882	-0,4808	-0,2112	-0,2625	-0,2401	1,0000	0,2290	-0,3411	-0,1786	0,0305	-0,2412	0,2266	0,3174	-0,0830	-0,2905
-0,2061	-0,0006	-0,3168	-0,1044	-0,4096	-0,0539	-0,6527	-0,2923	-0,2746	0,2290	1,0000	-0,2606	-0,1553	-0,3241	-0,4255	-0,0266	0,1093	0,2108	-0,4149
0,1381	0,2031	-0,0221	0,2161	0,1805	0,4243	0,2309	0,2521	0,2889	-0,3411	-0,2606	1,0000	0,2866	-0,1641	0,0197	-0,1273	-0,0577	-0,1041	0,1639
0,5414	0,2311	0,0135	0,2950	0,0025	0,1553	0,1565	0,6789	0,5513	-0,1786	-0,1553	0,2866	1,0000	-0,0521	0,1084	-0,0770	-0,0553	-0,0292	-0,0392
0,3244	-0,2215	0,3008	-0,0307	0,0809	-0,5052	0,3850	0,2544	0,2716	0,0305	-0,3241	-0,1641	-0,0521	1,0000	0,5322	0,3440	-0,0246	-0,0641	0,3366
0,5077	-0,1925	0,8977	-0,1065	0,6219	-0,0900	0,6301	0,4738	0,5046	-0,2412	-0,4255	0,0197	0,1084	0,5322	1,0000	0,2024	-0,2117	-0,0508	0,5405
0,0217	-0,2163	0,1019	-0,1586	-0,0002	-0,1603	0,1832	0,0093	0,0064	0,2266	-0,0266	-0,1273	-0,0770	0,3440	0,2024	1,0000	0,2600	-0,0108	0,2367
-0,1342	0,1290	-0,2116	0,0692	-0,1965	-0,0324	-0,0808	-0,1460	-0,1524	0,3174	0,1093	-0,0577	-0,0553	-0,0246	-0,2117	0,2600	1,0000	-0,0384	-0,2106
-0,0236	0,0697	-0,0588	0,0674	-0,0634	-0,1386	-0,0974	-0,0329	-0,0286	-0,0830	0,2108	-0,1041	-0,0292	-0,0541	-0,0508	-0,0108	-0,0384	1,0000	-0,0293
0,1756	-0,1645	0,6073	-0,0838	0,6660	0,1250	0,6791	0,2157	0,2176	-0,2905	-0,4149	0,1639	-0,0392	0,3366	0,5405	0,2367	-0,2106	-0,0293	1,0000
0,4132	-0,0522	0,5926	0,0878	0,4414	-0,2188	0,6286	0,4433	0,5134	-0,2928	-0,3881	0,0804	0,1648	0,5161	0,7287	0,3321	-0,2637	-0,2724	0,4381
-0,1140	0,0696	-0,0667	0,0457	0,1376	0,0714	0,1849	0,0039	-0,0112	-0,1365	-0,1273	0,1862	0,0295	-0,0797	0,0284	-0,0997	0,0809	0,0269	0,0983
0,2082	-0,0080	0,2795	0,0213	0,1850	0,0332	0,2315	0,2334	0,1807	-0,0856	-0,1880	0,0154	0,2542	0,1555	0,3989	0,0250	-0,0539	-0,0207	0,1279
0,0036	0,0447	-0,0390	0,0553	0,0016	0,0954	-0,0315	-0,0006	-0,0082	-0,0640	0,1698	0,0046	-0,0066	0,0170	-0,0325	-0,0387	0,0878	-0,0073	-0,0173
0,3373	0,1734	-0,0586	0,2078	-0,0500	0,1242	0,0170	0,6084	0,4348	-0,0950	-0,0449	0,2315	0,8486	-0,0935	-0,0494	-0,0457	-0,0377	0,0170	-0,0763
0,3001	0,0531	0,0747	0,1151	0,0624	-0,0057	0,1040	0,3243	0,2085	-0,1604	-0,1470	0,1307	0,3047	0,0853	0,2398	0,0072	-0,1142	-0,0326	0,0294
0,5847	0,2162	0,1100	0,2664	0,1230	0,0937	0,2103	0,8087	0,6714	-0,1784	-0,1696	0,2810	0,8215	0,0494	0,1462	-0,0301	-0,0493	-0,0239	0,0606
-0,0377	0,0381	0,0361	-0,0888	0,1682	0,2148	0,0073	-0,0349	-0,0386	-0,1419	0,0121	0,0043	-0,0563	-0,1684	-0,0459	-0,1264	-0,1015	-0,0169	0,1680
0,4703	0,1793	0,0498	0,2489	0,0082	0,0617	0,1110	0,4544	0,3092	-0,1097	-0,1054	0,0895	0,5414	0,0918	0,1273	-0,0418	-0,0523	-0,0330	0,0214
-0,0288	-0,0511	0,1597	-0,0392	0,0391	-0,0579	0,0493	-0,0412	-0,0365	0,2401	-0,0526	-0,0958	-0,0201	0,0428	0,1165	0,0541	0,0175	-0,0290	0,0670
0,6648	0,0436	0,2713	0,1082	0,2780	0,0394	0,4227	0,8116	0,6901	-0,2684	-0,3300	0,1822	0,4461	0,2474	0,4447	0,0015	-0,1822	-0,0412	0,2662
0,8496	0,0676	0,4390	0,1298	0,4797	0,0476	0,4323	0,8772	0,8726	-0,2698	-0,3075	0,1423	0,4298	0,3385	0,6212	0,0248	-0,1642	-0,0354	0,2976
0,8987	0,0342	0,3535	0,0911	0,3899	-0,0115	0,4052	0,8118	0,7649	-0,2136	-0,2925	0,1203	0,3789	0,3503	0,5691	0,0243	-0,1620	-0,0335	0,2526

Research	Basel convention	Coastal size	Protected Marine Areas	Aquaculture	Single-use plastics bans	Container port traffic	An. freshwater withdrawals, total	Ren. int. freshwater resources, total	Ren. int. freshwater resources per capita	Arrivals	Expenditures	Receipts
0,3044	0,2338	0,2095	0,0588	0,2487	0,2711	0,4196	-0,0053	0,3835	-0,1606	0,5251	0,5116	0,4882
-0,1101	0,1546	-0,1406	-0,0282	0,0840	0,2283	0,0447	-0,1916	-0,0978	-0,1578	0,1654	0,0973	0,1120
-0,3794	-0,0989	-0,0986	-0,0238	0,0098	-0,0556	-0,1019	-0,0762	-0,0638	0,0236	-0,2437	-0,2611	-0,2245
0,1774	0,0047	0,4824	0,0372	0,3479	0,3849	0,4167	-0,0251	0,8270	-0,0152	0,3874	0,5041	0,4381
0,1751	0,0081	0,4667	0,0352	0,3558	0,3832	0,4215	-0,0224	0,8247	-0,0150	0,3852	0,4987	0,4310
0,1270	-0,0011	0,4289	-0,0124	0,1778	0,2744	0,2405	-0,0575	0,8853	-0,0215	0,2918	0,3962	0,3123
0,1014	0,0746	0,6796	0,0711	0,2116	0,2337	0,1848	-0,0483	0,5767	-0,0180	0,1749	0,2419	0,0980
-0,3424	-0,0984	-0,0201	-0,0318	0,0592	0,0570	-0,0293	0,0149	0,0935	-0,0613	-0,0800	-0,0914	-0,0826
0,0944	0,0384	0,1007	0,0169	0,7628	0,3651	0,7184	-0,0202	0,4479	-0,0292	0,3791	0,3587	0,3262
-0,2461	0,0687	-0,0551	-0,0128	-0,0509	-0,1169	-0,0710	0,2701	-0,0998	-0,0286	-0,1311	-0,1247	-0,1279
0,3974	0,0742	0,1304	0,0318	-0,0637	0,0414	0,0999	0,0976	0,1234	0,0997	0,2291	0,2970	0,2363
0,2101	-0,0896	-0,0578	0,0047	-0,0342	-0,1627	0,1131	0,0448	0,0434	0,1206	0,1619	0,2438	0,2253
0,3102	-0,1422	0,1668	-0,0247	0,5998	0,3498	0,7710	-0,0320	0,5573	-0,0664	0,6902	0,7730	0,8264
0,3079	-0,0717	0,0598	-0,1104	-0,0686	-0,0637	-0,0076	-0,0343	-0,0835	0,1761	0,0452	0,0757	0,0910
-0,0229	-0,0647	-0,0938	0,0108	-0,0015	-0,1567	0,1872	0,0510	-0,0543	0,0332	0,2542	0,1666	0,1657
-0,2035	-0,0255	-0,0234	-0,0837	-0,0382	-0,0007	-0,1724	-0,1618	0,0081	-0,0499	-0,2474	-0,2351	-0,2222
-0,2260	-0,0091	0,1141	-0,0923	-0,0683	-0,1180	-0,1735	-0,0872	0,1388	0,1329	-0,2277	-0,1982	-0,2105
0,5325	0,1875	0,1925	0,0434	0,0216	0,2208	0,1465	0,0981	0,1449	0,0186	0,4247	0,3939	0,3758
0,4132	-0,1140	0,2082	0,0036	0,3373	0,3001	0,5847	-0,0377	0,4703	-0,0288	0,6648	0,8496	0,8987
-0,0522	0,0696	-0,0080	0,0447	0,1734	0,0531	0,2162	0,0381	0,1793	-0,0511	0,0436	0,0676	0,0342
0,5926	-0,0667	0,2795	-0,0390	-0,0586	0,0747	0,1100	0,0361	0,0498	0,1597	0,2713	0,4390	0,3535
0,0878	0,0457	0,0213	0,0553	0,2078	0,1151	0,2664	-0,0888	0,2489	-0,0392	0,1082	0,1298	0,0911
0,4414	0,1376	0,1850	0,0016	-0,0500	0,0624	0,1230	0,1682	0,0082	0,0391	0,2780	0,4797	0,3899
-0,2188	0,0714	0,0332	0,0954	0,1242	-0,0057	0,0937	0,2148	0,0617	-0,0579	0,0394	0,0476	-0,0115
0,6286	0,1849	0,2315	-0,0315	0,0170	0,1040	0,2103	0,0073	0,1110	0,0493	0,4227	0,4323	0,4052
0,4433	0,0039	0,2334	-0,0006	0,6084	0,3243	0,8087	-0,0349	0,4544	-0,0412	0,8116	0,8772	0,8118
0,5134	-0,0112	0,1807	-0,0082	0,4348	0,2085	0,6714	-0,0386	0,3092	-0,0365	0,6901	0,8726	0,7649
-0,2928	-0,1365	-0,0856	-0,0640	-0,0950	-0,1604	-0,1784	-0,1419	-0,1097	0,2401	-0,2684	-0,2698	-0,2136
-0,3881	-0,1273	-0,1880	0,1698	-0,0449	-0,1470	-0,1696	0,0121	-0,1054	-0,0526	-0,3300	-0,3075	-0,2925
0,0804	0,1862	0,0154	0,0046	0,2315	0,1307	0,2810	0,0043	0,0895	-0,0958	0,1822	0,1423	0,1203
0,1648	0,0295	0,2542	-0,0066	0,8486	0,3047	0,8215	-0,0563	0,5414	-0,0201	0,4461	0,4298	0,3789
0,5161	-0,0797	0,1555	0,0170	-0,0935	0,0853	0,0494	-0,1684	0,0918	0,0428	0,2474	0,3385	0,3603
0,7287	0,0284	0,3989	-0,0325	-0,0494	0,2398	0,1462	-0,0459	0,1273	0,1165	0,4447	0,6212	0,5691
0,3321	-0,0997	0,0250	-0,0387	-0,0457	0,0072	-0,0301	-0,1264	-0,0418	0,0541	0,0015	0,0248	0,0243
-0,2637	0,0809	-0,0539	0,0878	-0,0377	-0,1142	-0,0493	-0,1015	-0,0523	0,0175	-0,1822	-0,1642	-0,1620
-0,2724	0,0269	-0,0207	-0,0073	0,0170	-0,0326	-0,0239	-0,0169	-0,0330	-0,0290	-0,0412	-0,0354	-0,0335
0,4381	0,0983	0,1279	-0,0173	-0,0763	0,0294	0,0606	0,1680	0,0214	0,0670	0,2662	0,2976	0,2526
1,0000	0,0372	0,1745	-0,0767	0,0844	0,1694	0,2464	-0,1127	0,0866	0,1781	0,3400	0,5261	0,4112
0,0372	1,0000	0,0536	0,0288	0,0368	0,0195	-0,0248	0,0457	-0,0325	0,0191	0,0457	-0,0264	-0,0977
0,1745	0,0536	1,0000	-0,0128	0,0868	0,2067	0,0946	-0,0441	0,4315	0,1722	0,1684	0,3026	0,1726
-0,0767	0,0288	-0,0128	1,0000	-0,0074	-0,0336	-0,0056	-0,0076	-0,0193	-0,0093	-0,0202	0,0215	-0,0207
0,0844	0,0368	0,0868	-0,0074	1,0000	0,2271	0,9026	-0,0163	0,3194	-0,0391	0,3599	0,2722	0,2040
0,1694	0,0195	0,2067	-0,0336	0,2271	1,0000	0,2617	0,0516	0,3108	-0,0405	0,2084	0,2567	0,2704
0,2464	-0,0248	0,0946	-0,0056	0,9026	0,2617	1,0000	0,0039	0,3687	-0,0698	0,5561	0,5330	0,4938
-0,1127	0,0457	-0,0441	-0,0076	-0,0163	0,0516	0,0039	1,0000	-0,0773	-0,0698	0,0662	-0,0305	-0,0082
0,0866	-0,0325	0,4315	-0,0193	0,3194	0,3108	0,3687	-0,0773	1,0000	0,0394	0,2906	0,4004	0,3278
0,1781	0,0191	0,1722	-0,0093	-0,0391	-0,0405	-0,0698	-0,0698	0,0394	1,0000	-0,0507	-0,0688	-0,0817
0,3400	0,0457	0,1684	-0,0202	0,3599	0,2084	0,5561	0,0662	0,2906	-0,0507	1,0000	0,7291	0,8188
0,5261	-0,0264	0,3026	0,0215	0,2722	0,2567	0,5330	-0,0305	0,4004	-0,0688	0,7291	1,0000	0,8561
0,4112	-0,0977	0,1726	-0,0207	0,2040	0,2704	0,4938	-0,0082	0,3278	-0,0817	0,8188	0,8561	1,0000