Correlation Analysis and Countermeasure Research of Mismanaged Plastic Waste

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ABSTRACT
Poor management of plastic waste will endanger the marine environment, species diversity and human food chain with unknown consequences. Therefore, it is particularly necessary to identify the places where Mismanaged Plastic Waste (MPW) is growing rapidly, then take timely measures. This paper makes the correlation analysis and establishment of regression model of MPW which could measure and predict the variation of MPW through STATA software. The results show that high-income countries and countries with large flow of international tourists need to strengthen the sense of responsibility for plastic recycling and comprehensively use economic means to control tourism behavior.

Keywords: *plastic waste, mismanaged plastic waste, plastic recycling*

1. INTRODUCTION

1.1 The current situation of plastic waste

There are many types of polymers used in common plastics. These materials have different properties and are therefore suitable for different purposes. The structure of the polymer also affects the recyclability of the plastic. Of all plastic packaging waste generated worldwide, 14% is recycled, 14% incinerated, 40% is landflled, and 32% escapes collection [1]. In addition to littering in our cities and villages and accumulation in landfills, about 8 million tons of plastic leak into our oceans every year [2]. It harms hundreds of species. Plastic fragments are also entering the human food chain with unknown consequences.

Mismanaged waste is fabric which is at high chance of getting into the ocean by means of wind or tidal transport, or carried to coastlines from inland waterways. Mismanaged waste is the sum of fabric which is either littered or inadequately disposed [3]. Mismanaged Plastic Waste (MPW) will accumulate in the environment, unless problem is solved effectively, the downstream costs of disposal, recycling and environmental damage may surge in the future [4]. What determines the amount of mismanaged waste we produce, and what are we supposed to do to deal with mismanaged waste are the two central reserach questions. These questions need to be clarified urgently.

1.2 Objectives of this essay

According to the MPW-related determinants, it is significantly necessary to study the corresponding strategies to solve the plastic waste problem in a targeted manner. This study focuses on collecting the MPW and variables related to MPW in 2019 from two data sources (Our World in Data and World Bank open data) at the national level [5, 6]. The combined data and correlation analysis are carried out through STATA software, which is generally used for statistics and data science, and the indicators related to the dependent variable are found based on the results to establish a regression model of MPW.

2. LITERATURE REVIEW

2.1 The hazards of mismanaged plastic waste

The immoderate consumption of plastic and mismanage plastic waste lead to various environmental, economic, and health-related complications [7]. It also leads to the extinction of marine fauna, complicates maritime transportation, and ultimately leads to the food chain of humans and animals and accumulates in marine biological tissues [8, 9, 10]. It is reported that 4.8 million to 12.7 million tons of plastic waste enter the ocean every year. It is broadly stated that, 80% of marine particles originates from the land [11]. This is the reason why it is so important to enhance mismanaged plastic waste management.

2.2 Measures taken for Plastic recycling

There are many types of polymers used in common plastics. These materials have different properties and are therefore suitable for different purposes. The structure of the polymer also affects the recyclability of the plastic. Some polymers fail and decompose under mechanical or thermal stress which affects their recyclability too [5].

Based on 2025, in order to increase the recycling efficiency and reduce pollution, the world has established numerous recycling targets and strategies separately. At the national level, the political methods adopted by countries can be summarized into two types: levy taxes and completely ban [12]. As for the level of social initiatives, The Coca-Cola Company put forward the "World Without Waste" global sustainable packaging strategy, and promised to help achieve 100% recycling and reuse of sales product packaging by 2030. Pepsi.Co announced a new global goal: to reduce the use of 35% of virgin plastic in its beverage product packaging by 2025. Danone Group (Danone) announced that its high-end bottled water brand Evian will use 100% recycled PET bottles by 2025. Currently, the brand's mineral water bottles contain an average of 25% recyclable ingredients. From 2003 to 2018, the weight of its pulsating packaging bottle was reduced from 43 grams to 28.5 grams, and the plastic reduction reached 29% [13].

2.3 Different strategies affect the efficiency of plastic recycling

Reasonable use of different economic behaviors can encourage stakeholders to reduce waste and effectively strengthen the recycling of these plastics. Countries around the world are also adopting different plastic strategies that suit their own national conditions. Compulsory legislation or tax increases in some regions are common countermeasures. For instance, in 1993, Denmark began to levy taxes on plastic bag manufacturers, while also allowing retailers to charge for plastic bags. In 2016, the German government reached an agreement with relevant companies to impose a tax on disposable plastic bags. That is, stores no longer provide plastic bags free of charge, and customers need to pay a

certain fee to use plastic bags. Starting from 2021, the EU will completely ban member states from using 10 kinds of disposable plastic products such as drinking straws. These products will be replaced by reusable hard plastics. Some regions are also taking soft strategies to increase recycling of plastic products, in 2021, part of the communities in Shanghai, China have increased plastic bottles recycling by exchanging empty plastic bottles for food and vegetables.

2.4 Behavioral economics and "Nudge"

In the field of behavioral science, the concept of Nudge was proposed by Thaler and Sunstein [14], they regarded Nudge as "alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates". Nudges can also gain the generally popularity, due to freedom of choice and low-cost interventions by design. Life will encounter many nudge design, the purpose of each design will affect people's choice in a particular way. In addition, nudge often hints people in a gentle way to change their behaviors to protect the environment.

3. DATA

3.1 Descriptive Statistics

To enhancing the recycle of plastics waste and strengthen the management of plastics, it is needed to analyze what indexes that MPW (mismanaged plastics waste) are correlated to firstly. This study uses a combined international open data set of 161 countries in 2019 which collected from Our World in Data and World Bank open data at the national level. The data from these two sources are integrated according to the country code to make it possible to examine the determinants of mismanaged plastics waste. Table 1 presents basic indicators of the sample variables that are used in the analysis. Judging from the characteristics of indicators, there is basically no abnormal data which shows that the combined data can be used normally in the subsequent analysis.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Mismanaged plastic waste	161	9.922	3	2.833	16.38
GDP	161	24.746	2.362	19.087	30.775
International tourists inbound	161	8.237	1.919	2.565	12.202
Population	161	2.412	1.581	0	7.243
Population density	161	4.366	1.301	1.386	8.981

Purchasing power	161	9.611	1.016	7.186	11.432

Note: Table reports the number of observations and the characteristics of each indicators including Mean, Standard Deviation, Minimum and Maximum. Each observation refers to one economic indicators in one year. Sample sizes reported include observations from the full study period (January 2019- December 2019).

In the next pairwise correlation test, the results in Table 2 show that the MPW has a positively correlated and significant influence with the GDP, international tourists inbound and population, and has a negatively correlated and significant relationship with purchasing power. The higher the number of international tourists, the corresponding increase in plastic waste emissions at attractions, beaches, etc. If a country's plastic waste management capacity remains unchanged, MPW will increase. The population density does not have a significant relationship in this step so it will be added to the model at the last step in the stepwise regression process. After detecting whether there is multicollinearity through the VIF (Variance Inflation Factor) test, it is found that although GDP and population have a certain degree of collinearity, the overall VIF average result is 6.990≤10 which is showed in Table 3, so there is no collinearity in terms of overall data and there's no need to adjust it.

Table 2: Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Mismanaged Plastic Waste	1.000					
(2) GDP	0.502*	1.000				
	(0.000)					
(3) International Tourists Inbound	0.346*	0.751*	1.000			
	(0.000)	(0.000)				
(4) Population	0.799*	0.808*	0.553*	1.000		
	(0.000)	(0.000)	(0.000)			
(5) Population Density	0.012	0.039	0.057	0.068	1.000	
	(0.878)	(0.624)	(0.476)	(0.393)		
(6) Purchasing Power	-0.403*	0.481*	0.451*	-0.055	0.001	1.000
	(0.000)	(0.000)	(0.000)	(0.488)	(0.986)	

The explained variable Mismanaged Plastic Waste have a positive correlation and a significant impact with GDP, International Tourists Inbound, and Population, a negative correlation with Purchasing Power, and no significant relationship with the control of Population Density, which will be add to the model at the last step in the stepwise regression process. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Robust standard errors in parentheses.

Table 3: Variance Inflation Factor test

Variable	VIF	1/VIF
GDP	15.52	0.0644
Population	11.05	0.0905
Purchasing power	5	0.200
International tourists inbound	2.360	0.424

Population density	1.010	0.988
Mean VIF	6.990	

By calculating the VIF (variance inflation factor) to detect whether there is multicollinearity. The reciprocal of the tolerance, the larger the VIF, the more serious the collinearity. When 0<VIF<10, there is no multicollinearity; when 10≤VIF<100, there is strong multicollinearity; when VIF≥100, there is severe multicollinearity.

3.2 Determinants of the mismanaged plastic waste

The author continuously add controlled variables to investigate the impact from GDP on the predicted variable MPW through the stepwise regression. The OLS results can be obtained from Table 4.

Table 4: OLS stepwise regression

	(1) Mismanaged Plastic Waste	(2) Mismanaged Plastic Waste	(3) Mismanaged Plastic Waste	(4) Mismanaged Plastic Waste	(5) Mismanaged Plastic Waste
GDP	0.637***	1.149***	0.820***	0.723***	0.711***
	(0.09)	(0.05)	(0.17)	(0.18)	(0.18)
Purchasing power		-2.472***	-2.066***	-2.099***	-2.086***
		(0.12)	(0.24)	(0.24)	(0.24)
Population			0.452**	0.456**	0.474**
			(0.23)	(0.22)	(0.23)
International tourists inbound				0.166*	0.169*
				(0.09)	(0.09)
Population density					-0.073
					(0.08)
_cons	-5.848***	5.258***	8.399***	9.729***	10.166***
	(2.17)	(1.27)	(2.02)	(2.11)	(2.17)
N	161	161	161	161	161
r2	0.252	0.791	0.796	0.801	0.802
r2_a	0.247	0.788	0.792	0.796	0.796
F	53.490	298.948	204.407	156.931	125.514

robust standard errors in parentheses for the OLS regression. R squared keep stable at around 0.8 at final, that is, at least 80% of the sample data can be explained by model 5, * Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level;* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

It can be seen from the results Table 4 that GDP has a stable positive correlation significant impact on MPW in the process of continuously adding controlled variables, and finally stabilized at about 0.7, that is to say, every unit of GDP increases, the corresponding MPW can increase by 0.7 units. It can also be seen from the results of equation fitting and goodness of fit. Finally, the R squared is stable at 0.8, that is, at least 80% of the sample data can be interpreted by the final model 5 which is marked.

Based on that, the author assume the following regression can estimate the total number of MPW under the influence of other factors:

$$MPWtotal_i = \beta_0 + \beta_1 GDP_i + \beta_2 PurchasingPower_i + \beta_3 Population_i$$

$$+ \beta_4 Inbound_i + \beta_5 PopulationDensity_i \qquad (1)$$

MPWtotal is a measure of the total amount of mismanaged plastics waste during certain year i, GDP 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 in a year. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates. International inbound tourists (overnight visitors) are 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. Population density is midyear population divided by land area in square kilometers.

4. DISCUSSION

As mentioned in the previous section, the plastic waste that the country fails to manage properly had a very significant positive relationship with the country's GDP and purchasing power. Since the end of 2017 China introduced a complete ban on the imports of non-industrial plastic waste, the world's plastic trading pattern has undergone tremendous changes, especially before then China had imported 72.4 percent of global traded plastic waste each single years. To some extent, this means that high-income countries and previous top exporters, after losing their largest plastic scrap export markets, should pay more attention to plastic waste management and optimization once again.

The conclusion drawn from the data analysis is that the mismanaged plastic waste is also related to international tourists. In the process of developing and operating tourism resources, it will cause certain pollution to the environment. The sustainability of tourism development largely depends on the ability of destination authorities to coordinate the activities of tourists, local communities, entrepreneurs and other tourism actors [15].

For instance, Break Free From Plastic engaged 14,734 volunteers in 55 countries to conduct 575 brand audits. These volunteers collected 346,494 pieces of plastic waste. Among the 63% of plastic waste with clear consumer brand logos, Coca-Cola, Nestlé, and PepsiCo have got Top Three Global Polluters[16]. The waste of these plastics does not come from one single source, including the aforementioned non-degradable packaging waste discarded by tourists during the tour, the daily casual waste of the locals, and the on-site promotion activities of beverage companies, etc.

The wasteful behaviors of local people need to be controlled through legal prohibitions, regulations and taxation. Visitors are not subject to these mandatory constraints, so the implementation of deposits and nudges to lead reducing plastic waste is quite needed. In addition, the companies also ought to take environmental protection measures for recycling to demonstrate their social responsibility.

5. CONCLUSION

This article merges the public data of the Our World in Data and World Bank into the same data set to make the correlation analysis and establishment of regression model of MPW which could measure and predict the variation of MPW. The results show that high-income countries which have lacked plastic export destinations after the 2018 China plastic trend ban should pay more attention to the handling of MPW again. Additionally, it is found that MPW is also related to international tourists flow, so it is necessary to use economic means comprehensively to control tourism behavior while strengthening the company's awareness of responsibility for plastic recycling.

This study relies on public data submitted to different websites. The collection scope of the two sets of data samples is not completely the same, so the matching degree of the data is not perfect. Besides, MPW is consist of inadequately disposed and littered waste which are different [3], so the corresponding decision-making is arguably different. Since in this study, MPW is regarded as the general research object, if MPW needed to predicted more precisely and suggestions to be more targeted, it should be divided into two categories to analyse.

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