Study on the impact of plastic pollution based on multiple regression model

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Abstract. Plastic has become an indispensable and important part of human beings. In the past decades years, using plastic we have found that their biggest advantage is the disadvantage of causing fatal effects on the environment. The worsening of plastic pollution also makes us learn the severity of the problem gradually. We have established an evaluation model and adopted a local analysis method to global analysis method to analyze the impact of plastic pollution.

Keywords: First Variable, Second Variable, Multiple Regression, Environmental Harmlessness Index

1. Introduction
Since the 1950s, plastic products have been widely used in various human industries because of their characteristics of low cost, corrosion resistance and high plasticity. The use of plastics not only affects the development of the national economy, but also is closely related to everyone’s life, and because of the advantages of plastics, the use of plastic products is growing exponentially.

While humans enjoy the endless convenience of plastic, they ignore the sword of Damocles hanging over their heads. Seriously, none of the commonly used plastics are biodegradable.[1] Humans regard the advantages of plastic as angels, but they do not expect that they are the real demons destroy the environment. For humans, the advantages of plastic products’ corrosion resistance have become difficult to handle and cannot be recycled for the environment. The advantage of low cost of plastic products has actually caused the explosive growth of plastic production, and because humans do not know enough about plastic products, they have caused a large amount of these plastic waste to be discharged into the ocean and soil, causing irreversible harm to the environment. The plastic has good plasticity and other advantages. For the environment, plastic waste can exist in any corner, making it more difficult to handle these waste.

At present, we know the harm of plastic waste to marine ecosystems, and we have obtained corresponding research results; but the harm of plastic to human health is still unknown, and plastic pollution has become an important part of environmental pollution. Home, the war against plastic pollution has begun.
2. Restatement of problems
To solve the increasingly serious plastic environmental crisis, reduce or completely eliminate the hazards caused by disposable plastic products. As a team hired by the International Council of Plastic Waste Management (ICM), we need to do as follows:

By considering different variables, we establish a corresponding model to estimate the maximum amount of disposable plastic products that can be reduced without further environmental damage.

Based on the sources and uses of disposable plastics, the availability of plastic substitutes and the impact on human beings, the reduction degree of plastic waste can be discussed to meet the environmental safety.

Set a minimum amount of disposable waste and discuss the impact of reaching this level.

For the global problem of plastic pollution, the impact of different countries is uneven. How to solve the global distribution of plastic pollution and which countries need to take the main responsibility is important.

To simplify the problem, we have the following basic assumptions which are properly justified:

• Variables are only related to factors after fuzzy processing, and the degree of interaction between the variables obtained is negligible, the variables are not related to each other
• The severity of the waste problem includes only environmental impacts
• The set first variable is completely consistent with the corresponding substituted variable, and the replaced factors are not considered at other levels.
• Plastic waste is assumed to be disposable plastic waste, and other plastic waste is ignored.
• The environmental pollution caused by disposable plastic waste is only water pollution and air pollution, regardless of soil pollution.
• In the coming decades, there will be no new products that can completely replace plastics and have little pollution.
• Greenland, the Union of Central African States and Brunei, the East Emperor’s Tomb are not considered.

3. The Multiple Regression for Fuzzy synthesis Models

3.1 Fuzzy Variable Analysis

![Fig. 1. Correspondence between fuzzy variables and original variables](image-url)

According to the previous analysis, we found that the source of this waste, the extension of the current waste and the availability of resources are extremely difficult to quantify [2]. So we fuzzy these variables. For the source of plastic waste, in general, the larger the output of plastic products is, the
wider the source of plastic waste will be [3]; For the severity of pollution problem, we choose ecological stability for fuzzy treatment, we have selected the degree of forest area damage as the main reference point for the ecological level and then as the first variable. For the availability of plastic waste products, the comprehensive strength of different countries has an important relationship with them [4]. We only consider GDP as the first variable in the country’s economic level, not military, political and other factors.

3.2 Multiple regression relationship between the first and second variables
1) The GPF system for the First variable and the Second variable

According to the previous, we consider the Plastic manufacturing volume, GDP and the Forest area to be the three first variables that affect plastic waste. To this end, we set up a PGF system (named according to their initials), and analyze each of the first variables accordingly, and then integrate them.

![Diagram](image)

Fig. 2. Linking primary and secondary variables

2) Data Sources

As a country with a large population and economy, and a country with a large territory, we choose China as the object of our research. For regression analysis, we selected about ten corresponding variable indicators, which can completely guarantee the authenticity of the data.

For China’s GDP and population-related data, we have selected the China National Data Network for reasonable selection and use[5]. The same goes for forest area-related data and plastic data.

3) Introduction to Multiple Regression Analysis

Multiple regression analysis refers to treating one variable as the dependent variable and the other one or more variables as independent variables in the relevant variables. Establishing a linear or non-linear mathematical quantity relationship between multiple variables and using Statistical analysis method for analyzing sample data. Let the dependent variable be Y, and the k independent variables that affect the dependent variable are X1,X2...Xn respectively. It is assumed that the effect of each independent variable on the dependent variable Y is linear. The mean value changes uniformly with the change of the independent variable.

\[
Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + ... + \beta_nX_n \quad (1)
\]

The above is called the overall regression model, and \(\beta_1, \beta_2, ..., \beta_n\) is called the regression parameter.

4) Multiple Regression Analysis of the First and Second variables of the system

Now we perform multiple regression analysis on the corresponding primary variables one by one by using SPSS and Lingo.

For the Production of plastic supplies, with the Multiple Regression Analysis, we found that the resulting formula is:
\[ E_1 = -0.286 - 0.667e_1 + 1.276e_2 \quad (2) \]

For the Forestry land area, with the Multiple Regression Analysis, we found that the resulting formula is:

\[ E_2 = 1.556 - 0.604e_3 - 1.253e_4 \quad (3) \]

For the GDP, with the Multiple Regression Analysis, we found that the resulting formula is:

\[ E_3 = -2.322 - 2.312e_5 + 0.073e_6 + 0.619e_7 \quad (4) \]

5) The Metric of GPF system

Using SPSS software to perform a linear fit to obtain the corresponding quantitative relationship between the secondary variable and the primary variable. The relationship between the primary variable and the environmental allowable baseline waste production has been studied. Due to the increasingly serious climate problems in recent years, the combination of various countries' policy, we consider whether or not to implement a plastic limit order as an important indicator of evaluation. We use LINGO to perform linear programming to reasonably limit seven of the two secondary variables, and solve the optimal solution to obtain the results that can be generated under certain conditions. Baseline benchmark waste indicators to quantitatively evaluate the country's environmental level and the amount of waste that needs to be reduced or the maximum amount of waste allowed to continue to increase to meet China's standard level.

\[ P = -0.987 - 0.129E_1 + 0.047E_2 + 0.476E_3 \quad (5) \]

Through Lingo's solution, we can get the maximum value of -102791.5.

4. Multi-component evaluation based on Analytic Hierarchy Process

4.1 Establishment of evaluation indicators

Against the previous regression model, we can get the maximum value that can be achieved by satisfying these variables through the first and second variables. But based on these variables, we cannot get the minimum. Based on the previous GPF system, we choose to use the Analytic Hierarchy Process (AHP) to evaluate comprehensive indicators. We supplement our original variables on the basis of the first variable and the second variable. And set an Environmental safety level. Evaluate this indicator we classify the factors into four main fields: Social Stability, Economic Development, Ecological Stability and National policy. Through their respective initials, we call it the ESEN indicator.

![Fig. 3. The ESEN indicator](image)

4.2 Economic Stability

We use four security indicators in Ecological Stability. Through these four indicators, we set the score to 1 (lowest value) -7 (highest value).

Gross National Income (GNI) per Capita: We believe that total income has a certain relationship with environmental safety value. For low-income countries, high-income countries have high levels of consumption and high demand for products. Corresponding waste generated during the consumption
process and in the manufacturing process of factories. More than underdeveloped low-income countries, we use indicators from China’s National Bureau of Statistics for index analysis.

Growth of Gross Domestic Product (GDP): Countries with high gross domestic product will generally turn to environmental governance, especially those with polluting first, then governance, while countries with lower GDP may inevitably sacrifice the environment in order to develop their economies. Get the corresponding data through the World Bank.

Investments Abroad: On the one hand, foreign investment is to attract developed countries to set up factories in third world countries and discharge waste in these countries to pollute them. On the other hand, the transboundary migration of pollutants such as the import and export of garbage is also closely related to it. We search for the corresponding data in UN Data and mainly import and export styrene and polystyrene products.

Uneven Development: A country with a high degree of development also has a high awareness of environmental protection, and also has a strong ability to manage its own environmental problems, while a country with a low level of development can only deal with "visible" environmental problems. Degree of development is also an important factor affecting environmental safety.

Using the multiple regression model we used earlier, we represent the relationship between them as:

\[
ECO = \alpha_1 ECO_{GNI} + \alpha_2 ECO_{GDP} + \alpha_3 ECO_{IA} + \alpha_4 ECO_{UD} \tag{6}
\]

4.3 Social Stability
We use four security indicators in Social Stability. We believe that social stability is, on the one hand, internal governance and on the other hand, external interference. For this, we choose these four aspects and set the score to 1 (lowest value) - 7 (maximum value).

- War or Stability: War has a great impact on the stability of a country’s society. Some are wars directly in its own territory. Some countries are economic and technological cold wars caused by territorial disputes. Such wars will affect social stability.
- Human Rights: Human rights issues show the influence of the basic rights of people in different regions. When human rights issues reach a limit, low human rights issues generally represent high government welfare, and high human rights issues represent prominent social conflicts.
- Terrorism and Refugees: Terrorism threatens the security of many countries, and the refugee wave in recent years has made many terrorists sneak into developed countries as refugees. So we get refugee movement data from UN Data and evaluate it with data from Russian satellite news agency.
- Social Competitiveness: Social competitiveness is also an important source of social instability. Based on this, we collected the distribution of the gap between the rich and the poor in the country to evaluate social competitiveness.

\[
NSS = \beta_1 NSS_{WAR} + \beta_2 NSS_{NHR} + \beta_3 NSS_{TAR} + \beta_1 NSS_{SC} \tag{7}
\]

4.4 Ecological Stability
We use three security indicators in Ecological Stability. We believe that they respectively reflect the ecological self-purification ability and environmental destructiveness.

- Foresty Area: The forest area level has a more important relationship with the environmental restoration capacity of a country or region, so we choose the forest area for evaluation.
- Carbon Emission Per Capita: Compared to the country’s total carbon emissions, for some developing countries with larger populations, the evaluation of per capita carbon emissions is more reasonable.
- Pollution Discharge: The discharge of pollutants directly affects ecological stability, we use China’s environmental years of pollutant emissions data analysis.

\[
ES = \gamma_1 ES_{FA} + \gamma_2 ES_{CEP} + \gamma_3 ES_{PD} \tag{8}
\]

4.5 National Policy
We use three security indicators in National Policy, set the score to 1 (lowest value) - 7 (highest value).

- National Surveillance: The state’s ability to supervise the local area will reduce the waste emitted
by local factories or reduce the probability that they will exceed the standard.

- **Degree of legal rigor:** Although many countries have corresponding emission standards and laws, the law enforcement is different in different countries. And different execution power also has an important relationship with its execution level.

- **Government Influence:** Government influence is also an indispensable factor, for a country or region, the government’s influence is closely related to the degree of support the residents of the region have for the government’s corresponding policies.

\[
NaP = \omega_1NaP_{NaS} + \omega_2NaP_{DLR} + \omega_3NaP_{Gr} \tag{9}
\]

Using the multiple regression model we used earlier, we represent the relationship between them as:

\[
P = \mu_1ECO + \mu_2NSS + \mu_3ES + \mu_4NaP \tag{10}
\]

Among them, the weight of \(\mu_1, \mu_2, \mu_3, \mu_4, \mu_5\) we choose to analyze by AHP.

### 4.6 Evaluation of minimum target value based on Differential Equation

#### 1) Selection of plastic waste Variables

The production of plastic waste often causes other pollution, which makes the cross reaction between pollutants [6]. Through the corresponding channels, the world’s plastic product output, waste water, and exhaust gas were found. [7]

![Fig. 4. Fitting relationship between global plastic waste and corresponding variables](image)

We correlate global plastic waste production with these three variables. Then we performed a fit analysis on plastic waste and these three variables. The conclusion is similar to a linear function:

\[
Y = kx + b \tag{11}
\]

Y stands for total global output of plastic waste, x represents the corresponding variable.

Then we process Y to get the corresponding weight. Here we choose to use Differential Processing.

\[
dY/dx = \xi \tag{12}
\]

After getting the weight, we integrate the weight with the previous one to get the following equation.

\[
Y = \xi_1x_1 + \xi_2x_2 + \xi_3x_3 \tag{13}
\]

### 5. The Value Evaluation Model

#### 5.1 Model introduction

Under the pollution of disposable plastic waste, such a fierce situation of plastic pollution has caused a great impact on every country. Therefore, in order to solve the problem of plastic pollution, each country has to pay different responsibilities. We use The Value Evaluation Model and consider the different countries as different companies based on the weights obtained from the previous analytic hierarchy process. First, we analyze the relationship between developing countries, developed countries and underdeveloped regions, and then evaluate all countries.

\[
Q_i = E_i a_{i-1} - (r_i - E_i \pi_i - Z_i) \tag{14}
\]

#### 5.2 Tectonic balance index

Based on the dynamic implementation of the equity allocation method, we use the environmental harmless value equation set up above to process the balance index in our model.
Through The Value Evaluation Model, we have developed countries as developed countries, developing countries, underdeveloped countries and regions, and compared them to three different companies for evaluation. The chart obtained through the evaluation is as follows:

Fig. 5. Impact factor of indicators of developed, developing and underdeveloped countries

From the figure above, we can know that the impact factor of developed countries is large, so the impact of disposable plastic waste pollution on developed countries is small, and the stability of developed countries is high, but for developed countries, not only per capita income High makes people more disposable plastic waste, which increases the usability of disposable plastics, and in 2009-2015, many countries issued plastic limit orders, but not all countries Plastic-restricting orders and plastic-restricting orders have different impacts on different developed countries, so they show large fluctuations in their impact factors, but they have generally stabilized; for some developing countries, their development levels and economic strength (Based on the variables set by the previous regression analysis) the level is not weaker than developed countries, or the gap is not large, just because there is a large population or uneven development and there is a large gap with developed countries, so for developing countries, disposable plastics The impact of garbage pollution on developing countries is slightly greater than that of developed countries. Although the stability is lower than that of developed countries, it still has a high stability; For economically underdeveloped areas like underdeveloped countries, they have various problems such as economic development, political stability, disease, war, religious conflicts, and terrorism. If one-off plastic waste causes great damage to the world, it will worsen these underdeveloped regions. The impact factor of these countries is extremely low, making these countries more vulnerable. Therefore, the ICM should focus on these areas and provide more reasonable care for these countries.

6. Result analysis

6.1 Environmentally sound results based on The GPF system
After blurring the corresponding three variables and performing regression analysis separately, we set the P value as an environmental impact indicator, and fitted the equations of the previous three fuzzy processing second variables with lingo fitting, we find that the maximum value of the environmental harmlessness index P we set is less than zero, indicating that under the conditions that GDP, forest area, and plastic production are the first variables, the degree of damage to the environment by this model is very low and close to no impact. To meet our previous needs.
Therefore, the model we developed can be used to obtain the maximum disposable plastic waste level without destroying the environment or with very low environmental damage.

6.2 The environmental safety level for reducing plastic waste to a certain level
Based on the foregoing, we supplemented and explained the variables of the model, and began to consider the impact of national policies. On the basis of the previous multiple regression model, we reanalyzed the new variables and obtained a new multiple regression model. At the same time, we
explained the weight of the first variable after supplementation through the analytic hierarchy process.

**Table 1** The Weights from AHP

| The Variation          | The weight |
|------------------------|------------|
| Social Stability       | 0.1667     |
| Economic Development   | 0.1667     |
| Ecological Stability   | 0.25       |
| National Policy        | 0.4167     |

Through the weight analysis of the analytic hierarchy process, we get that the weight for the impact of national policy is 0.4167, the weight for ecological development is 0.25, and the social stability and economic development is 0.1667. Therefore, in view of the results of our analytic hierarchy process, we believe that the most relevant to the impact of achieving environmental safety levels is national policies. In the back is ecological stability, and in the end is social stability and economic development. Therefore, we believe that national policies have the greatest influence on disposable plastic pollution.

Based on the Hannah Ritchie and Max Roser’s research [8], We found that 70% of the industrial applications of plastic products are Packing and Building and Construction. And these can be controlled through government policies or people’s subjective consciousness. We believe that under the influence of environmental safety, the use of packages can be reduced to a level close to zero. In addition, under the strong guidance of government policies, we believe that the control of plastic waste is focused on reducing package Production, and reducing the amount of plastic used in building construction.

In view of the second largest ecological stability of weights, we believe that for own countries, when the demand for economic development is high and the ecological stability of their own countries is poor, the problems caused will also become serious, and for the latter Social stability and economic development, we believe that their influence on the level of environmental security is low. The main reason is that the control of national policies on social stability and economic development also has a certain relationship, so that the proportion of weight increases. Only economic development and social stability, the impact on disposable plastic pollution is still extremely limited.

To sum up, we believe that the biggest weight to be reached by the level of environmental safety is national policy. Among them, we can reduce the production and use of Package to near zero by national policies. Or the national scientific research strength has developed a wide range of disposable plastic bags that can replace plastics to promote their use. Secondly, we can reduce the consumption of plastics by Buildings and Constructions, and use a more environmentally friendly building material and a smaller per capita living area to limit the scope. In the second largest weight of ecological stability, we believe that ecological stability It affects almost all aspects, but the degree of impact does not occupy a very high proportion like national policies; we believe that the impact of ecological stability is a potential impact on the operation of the country, and this impact needs time to prove, like Seventy years ago we enjoyed the same convenience that plastic products bring us.

And economic development and social stability are at the bottom of the weight. We think that they have a certain impact on the level of environmental security. However, based on the uneven global economic development, large gaps in social stability, and many war-torn areas, the gap is large Values tend to reduce their weight. Therefore, we believe that we should mainly reduce the use of packages by national policies, strive to reduce the use of packages to a level close to zero, and issue corresponding stricter laws, regulations and standards, and use plastics in other areas. The amount is reduced as much as possible, thereby reducing the amount of plastic waste generated. At present, when the population is rapidly increasing and there is still a huge demand for plastic products, the sooner plastic control is carried out, the sooner the environmental safety value can be reached.

**6.3 Minimum Achieved Goals and Impact**

We associate the amount of plastic waste generated with wastewater, waste gas, and plastic products, and set linear equations. Based on the linear equations, we differentiate them to obtain the relationship between the plastic waste production and these three variables. The output model is:
According to the data from 2009-2015, we linked the amount of plastic waste generated with wastewater, waste gas, and plastic products, and set a linear equation. Based on the linear equation, we differentiated it to obtain the plastic waste generated and these three variables, and finally calculated the model (13), so as to set the minimum achievable value of 1859623 million. And we predict that if restrictions on plastics are introduced from 2015 (the latest year for which data can be collected), this value will be reached around 2050. The following is a forecast of the amount of disposable plastic waste generated over the next few decades:

![Fig. 6. Prediction of the amount of disposable plastic waste](image)

According to previous analysis, when the minimum level is reached, we expect the impact on human life, environmental impacts and impact on industries as follows:

Human Life: From the previous analysis, we have come to the conclusion that the use of disposable plastic bags will be greatly reduced and replaced by cloth bags or other similar materials developed by degradable plastics. During the initial implementation of the corresponding policy, the shortcomings and inconveniences of the substitutes themselves, so it is unrealistic to really reduce their use in the early stage, so in the process of reaching the lowest value, the initial reduction rate is very slow, but later, when being replaced, when the advantages of goods increase and the increasingly serious environmental problems lead to people’s attention to environmental issues and more stringent policy regulations, the rate of decrease will continue to increase; but because the population growth is an indisputable fact in the next few years [9], And the advantages of plastic products are not very likely to be completely replaced, so we believe that the generation of plastic waste products will stabilize in a range.

Environmental Impacts: We think that when this minimum goal is reached, the impact of plastic waste on the environment has reached a very severe level, forcing people to reduce the production of plastic products and take real coercive measures; therefore, we have Impact has a more pessimistic attitude, thinking that the environment at that time has reached a very deteriorating level, and that the environmental impact caused by plastic waste has begun to truly affect humankind, not just on TV, as we are only talked about as news. Of course, the impact on the environment is not entirely negative. If it reaches that level, the government will choose to give priority to the treatment of plastic pollution, and the speed of environmental recovery may be accelerated.

Impact on industries: We cannot deny that factories that are highly dependent on plastic products will suffer a devastating blow in this process, especially those related to disposable plastic products; however, some other industries, such as oil pipelines, have poor replaceability and can only be used. The impact of plastics as a raw material industry is negligible. After all, the minimum value of plastic waste we set is still close to 200 million tons, and we previously predicted that the output of plastic products in other areas will not increase.

7. Strengths and Weaknesses

7.1 Strengths
- We use the latest database construction model to ensure the availability and accuracy of the model.
In the multiple regression model, we analyze and modify the variables many times, and use two methods to set the weight, so as to ensure the rationality and accuracy of the model.

We use the model to predict the amount of plastic waste generated in the next few years, and based on the data we use, the latest limit is 2015. The accuracy of the predicted results and the actual real data from 2015-2019 is high, indicating that the model is available.

7.2 Weaknesses

In the process of selecting variables, we may ignore some other variables, and for national policies, we have no way to get the method of using data to express the analysis, so in some countries, it will cause greater errors.

For some areas with special geographical location and harsh national policies, evaluation error is large.

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