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Research on Plastic Waste Evaluation Based on Multiple Regression

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Abstract: *Since the 1950s，plastics have been widely used and the manufacture of plastics has grown rapidly because of its wide usage and cheapness. However, too many plastic products bring a lot of pressure on the environment. Not only on the land, but also in the ocean, plastic waste can be seen pervasively. Without implementing effective measures, the environment system will be damaged and our life will be affected. We address the problem of providing a maximum level of single-use or disposable plastic product waste that can be mitigated. Also we evaluated the impact for achieving the level. We divide the plan into three phases. Firstly, we find influence factors and establish models to estimate the maximum levels of single-use or disposable plastic product waste that can be mitigated safely. Next, based on our models, we calculate the minimal level of the single-use or disposable plastic product waste and discuss the impacts for achieving the level. In the next phase, we give ideas on the equity issues in this global problem as well as our solutions.*

Keywords: *Multiple Regression, AD-AS model, Plastic waste*

1. Introduction

Since the 1950s, the manufacturing of plastics has grown rapidly. The wide use of plastic productions leads to a lot of environment problems. According to the statistics in 2015, around 9%of plastic waste had been recycled. [1] If current production and waste management trends continue, there will be approximately 4-12 million tons of plastic waste entering the oceans each year. It is predicted that if our current trends continue, the oceans will be filled with more plastic than fish by 2050 [2]. Because of the waste, our body health will be affected.

So, we are obliged to address this environmental crisis. We should slow down the flow of plastic production and improve how we manage plastic waste. We should also evaluate the impacts for achieving our aim level. As for the equity problem, we need to give our solutions and the different circumstances while achieving the level are needed to be discussed.

2. Model building

In order to estimate the maximum levels of single-use or disposable plastic product waste that can safely be mitigated without further environmental damage, we use the single regression model, multiple regression model and linear programming. Through the use of MATLAB to establish the model and get the results. We choose Beijing as an example. First, we query the plastic yield of Beijing from 2002 to 2012 (The table can be seen in table 1)

Table 1: 2002-2012 Beijing's plastic production

Plastic Yield (Ten thousand tons)	
2002:	13.61
2003:	13.7
2004:	14.48
2005:	25.59
2006:	28.1
2007:	32.66
2008:	28.32
2009:	42.94
2010:	43.27
2011:	35.32
2012:	38.99

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Then use MATLAB to get:

$$Y=3.0425X+10.5616$$

Then we consider national population density (x1), GDP (x2) and national forest coverage (x3) as the factors that affect the output of plastic waste, and find out their relevant data over the years (The table can be seen in table 2).

Table 2: Factors affecting the output of plastic waste

Population density (per square kilometer)	
2011:	1428
2012:	1464
2013:	1498
2014:	1525
2015:	1541
2016:	1145
2017:	1144
2018:	1136

GDP(billion)	
2010:	14114
2011:	16252
2012:	17879
2013:	19801
2014:	21331
2015:	23015
2016:	25669
2017:	28015
2018:	30320

Forest Coverage	
2007:	43.0
2008:	43.5
2009:	44.4
2010:	45.0
2011:	45.6
2012:	46.2
2013:	46.8
2014:	47.4
2015:	48.4
2016:	48.4
2017:	48.42
2018:	48.44

Using multiple regression model and MATLAB, the following conclusions are obtained:

$$Y=-33.5393+0.0015X1+0.0013X2+1.1198X3$$

Finally, according to Y= 3.0425X + 10.5616, we calculate the data of the next ten years and calculated the average value of the ten years as 67.45, which we regard as the maximum output. The minimum achievable value calculated by MATLAB is 59.292-33.5393 = 25.7527, so the maximum output that can be reduced is 41.6973.

In order to get the minimal achievable level of global waste of single-use or disposable plastic products. We divide the world's countries into developed, developing and backward countries and calculate a weight number accordingly 0.3, 0.5 and 0.2. We choose America (Y1), China (Y2) and India (Y3) representing the three levels to carry out analyze. First, we look up the annual per capita waste of plastics in each of the three countries, using one-variable regression model, multiple regression model and liner programming model and with MATLAB modeling to obtain:

$$Y1=73.1027+1.9193X1$$

$$Y2=41.4167-0.95X2$$

$$Y3=3.29+0.315X3$$

We then find national population density (x4), national forest coverage (x5) and GDP (x6) of the United States, China and India as factors influencing the amount of plastic waste per capita. By using the method and MATLAB modeling in the first question, the following results can be obtained:

$$Y4=-130.1133+6.5602X4+0.1192X5+0.0002X6$$

$$Y5=210.7056-1.1915X4+0.0133X5-0.0002X6$$

$$Y6=-22.6989+0.0677X4-0.0596X5-0.0003X6$$

Finally, we used the proportion of each of the three countries multiplied by the function relation of their respective plastic waste amount obtained in the previous step to obtain the final relation we need:

$$Ymin=67.779+1.3858X4+0.0306X5-0.0001X6$$

We use MATLAB to calculate its minimum value, that is, the global per capita plastic waste minimum value:

$$Ymin=67.779+18.328=86.107$$

In order to optimize the model. We additionally consider that the output of plastic products in each country will greatly affect the output of plastic waste in the country, so we put it into the formula (the program can be seen in Appendix 2.5), and use MATLAB to calculate:

$$Y=44.1219+0.001X1+0.001X2+0.0001X3+0.00489X4$$

Then we add the recycle amount as the factor that affects the output of plastic waste (9%) and we can

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get:

$$Y=40.4788+0.001X1+0.001X2+0.0001X3+0.00449X4$$

So the result is:

$$Ymin=0.1872+40.4788=40.666$$

3. Model solving

As for the impacts for achieving such level, we can evaluate from various aspects.

Firstly, when we achieve the level, according to our model, the amount of plastic production should be decreased. As a result, we may try to use more alternatives. For example, we will use reusable bags instead of single-use plastic bags.

Secondly, the plastic industry will be affected because of the reduction of manufacture. According to the picture, the packaging will be affected most. However, some environmental friendly plastic will be manufactured more. For instance, the PP material is taking place of PE material for the package. What's more, the plastic recycle industry will develop rapidly.

We use AD-AS model to evaluate the impact. When the supply decreases while demand remains, the prise will increase. As a result, the consumers will buy fewer products or try to find the alternatives.

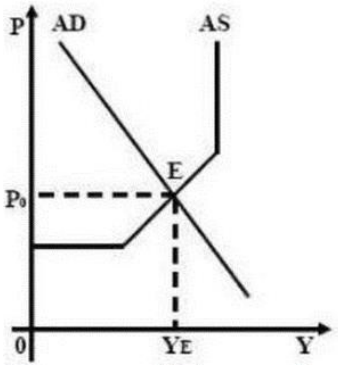

Figure 1: Aggregate demand-aggregate supply model

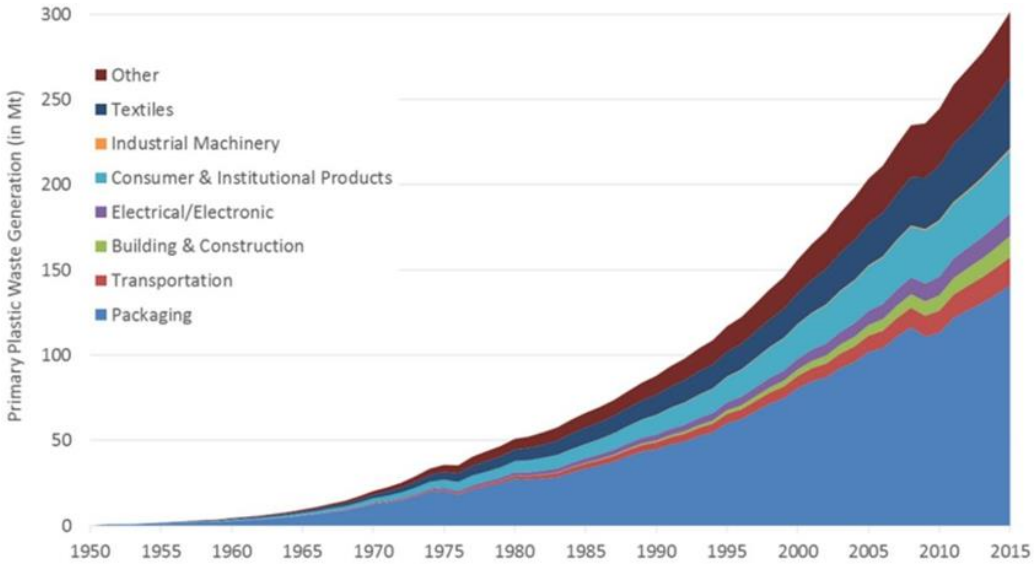

Figure 2: Global primary plastics production (in million metric tons) according to polymer type from 1950 to 2015(source from Science Advances)

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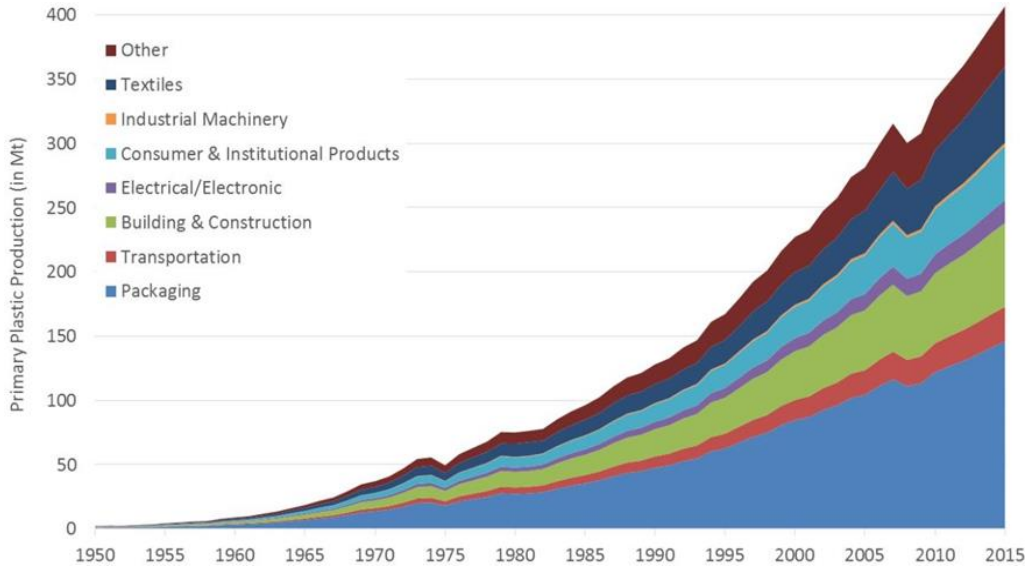

Figure 3: Global primary plastics production (in million metric tons) according to industrial use sector from 1950 to 2015(source from Science Advances)

As for the environmental impact, since the amount of output becomes less and less, there will be less plastic waste being abandoned in the marine or being incinerated. The environment can be improved. People use reusable bag instead of single-use plastic bag, which is positive to the environment.

4. Conclusion

When it comes to the equity problems, we find it is not absolutely fair. In the model we have established before, we can see that the factors that affect the total output of plastic waste include the average distribution of national population, national GDP and national forest coverage, the output of plastic products which lead to the result that plastic waste generation is not the same in different countries. Take America, China and India for example. In addition, due to the limited means to deal with plastic waste, 79% of the plastic waste generated each year go back into the environment, nearly33% are threw into the ocean. Some countries generate much plastic waste while some countries don't, but they all need to face the pollution problem. What's more, some developed countries sell these waste to developing country. It can bring some economic benefits but it also has many side effects. [3]

Here are our suggestions: Firstly, a fund can be set to help deal with the plastic waste for instance, provide technical support of recycling for some developed country. What's more, countries which generate more plastic waste should pay more tax, according to the amount of plastic waste generation per person. The tax can be a source of the fond. In addition, cooperation between countries should be encouraged. Advanced country can provide recycling technical support for developed country.

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