ASECU South-Eastern Europe Journal of Economics, vol. 19, 1(2021), 21-31 SEEJE

IMPACT OF THE LEVEL OF ECONOMIC DEVELOPMENT ON THE GENERATION OF PLASTIC WASTE WITHIN THE EUROPEAN UNION

VIOLINA KIRILOVA*
D. A. Tsenov Academy of Economics, Bulgaria

Abstract
In 2015, in New York City, the UN voted and adopted the so-called "Sustainable Development Agenda - 2030", which includes 17 main goals, related to the transformation of the world and the achievement of "a better and more sustainable future for all." These aims are focused on "global challenges", faced by developed and developing countries alike. One of the main issues affected by the programme is environmental degradation. Today the challenge that all humanity stands before is how to reduce the negative impact that human beings have on the nature around us through our day-to-day activities. The main pollutant to be investigated is plastic – one of the principal compilers of the "World Waste Crisis". The aim of this paper is to assess the impact of the level of economic development on the generation of plastic waste within the European Union, measured by regression. Therefore, this paper investigates the statistical data of plastic waste generation in EU countries for the 2004-2016 period and the trends in gross national income per capita for all countries investigated. The results of this paper suggest that the impact of the level of economic development has direct influence on the purchasing power of society, and, hence, positive dependence between consumption growth, waste generation, and one of the world's most widely used materials - plastics.

JEL Classification: F63, Q01, Q53
Keywords: Generation of Plastic Waste, Economic Development, Regression, European Union, World Waste Crisis

The paper has been awarded by the Board of ASECU with the Tsekouras Prize for Young Economists, in 2020. A first form of the paper has been also presented in the 16th International Conference of ASECU, Novosibirsk, Russia, November 2020.

Corresponding Author:* **Violina KIRILOVA, D. A. Tsenov Academy of Economics, Svishtov, Bulgaria. E-mail: violinakirilova@gmail.com
Scientific advisor: *Galin Stefanov,* Head Assistant*, D. A. Tsenov Academy of Economics, Svishtov, Bulgaria.* E-mail: g.stefanov@uni-svishtov.bg

Introduction

We live in a fast-paced high-tech world. Thousands, millions of creative ideas, are generated across the globe in a single day. The development that humanity strives for every minute indisputably gives us many benefits, which have facilitated and continue to help our daily life. However, creating a 'richer' world of possibilities and innovations has its positive meaning, negative effects are not absent. There are many socio-economic issues, such as poverty, child labour, corruption, unemployment, illiteracy, energy crisis, inflation, overpopulation, and unequal income distribution. However, today we are facing another enormous problem - the World Waste Crisis and the pollution resulting from it. Undoubtedly, this can be considered one of the biggest problems for our ecosystem. It entails immense hazards for the Earth and its resources and leads to extremely unfavourable conditions not merely for living but survival itself.

In 2015, in New York City, in order to take a step towards solving the problems affecting humanity, the United Nations voted and adopted the so-called "Sustainable Development Agenda-2030". This strategy includes 17 main goals, related to the transformation of the world and the achievement of "a better and more sustainable future for all". (United Nations, n.d.). These goals are focused on "global challenges", faced by developed and developing countries alike. One of the main issues of concern for the programme is environmental degradation. Today, the challenge all humanity encounters is how to reduce the negative impact that we, as human beings, have on nature around us through our day-to-day activities and how to develop a more sustainable economy sparing nature.

Literature review

The main pollutant to be examined in this paper is the PLASTIC – one of the greatest inventions in human history and, at the same time, one of the most hazardous materials for the environment and the health of every individual on Earth.

The history of this "incredible good" is long, but the important year in the timeline is 1907, when "the first synthetic thermoset polymer (a phenol-formaldehyde [PF]), known as Bakelite, was created in 1907 by Baekeland through the polycondensation of phenol with formaldehyde". "The commercial development of this PF material is considered to be the beginning of the truly synthetic plastic era and of the plastic industry." (Feldman, 2008). According to the Science History Institute, this breakthrough "was revolutionary. For the first time, human manufacturing was not constrained by the limits of nature. Nature only supplied so much wood, metal, stone, bone, tusk, and horn." (Science History Institute, n.d.)

As the world's population continues to grow its needs are increasing as well. Finding ways to meet these needs is crucial for increasing the chances of survival and continued development. That is why humans should create new ideas that can be turned into

real materials, parts of the new economy type in the world. Since its inception, plastic has been gaining popularity and was quickly marketed as an innovative, much more practical, inexpensive, and affordable material from all strata of society. Its features make plastic easy to process and shape, and this, in turn, makes it a useful substitute for many of the more expensive and hard-to-get materials used in the past.

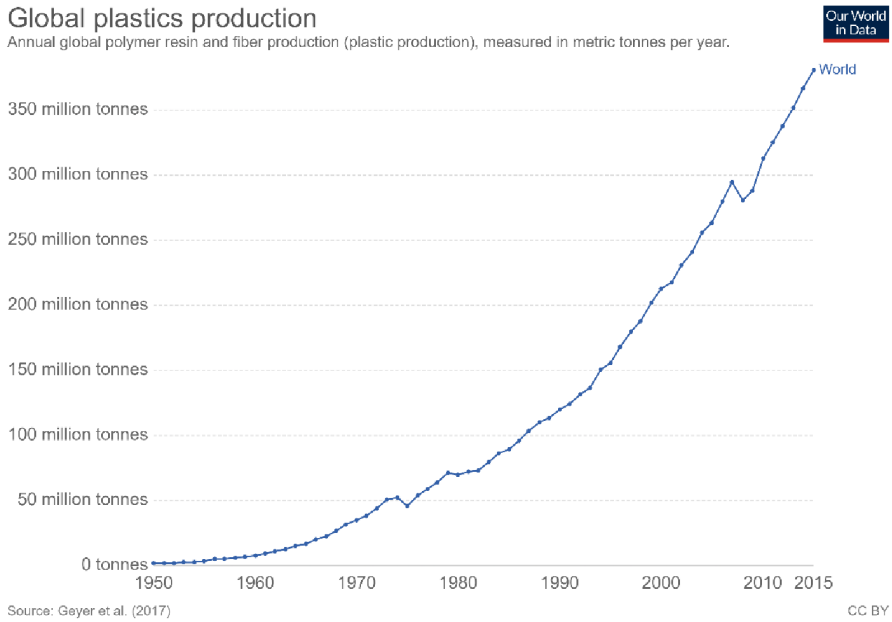
In the beginning, "this development helped not only people but also the environment. Advertisements praised celluloid as the saviour of the elephant and the tortoise. Plastics could protect the natural world from the destructive forces of human need." (Science History Institute, n.d.)

On the other hand, we have been using plastic for years and years now and its footprints ubiquitous. Because of the wide use of plastic, we are witnessing a terrible negative impact on nature. Due to the impossibility of its complete biodegradability today, we are facing an enormous problem. The impact can be seen on land and in water. "Due to high disposability and low recovery of materials discharged, plastic materials have become debris accumulating in the environment." (Rocha-Santos & C Duarte, 2015) All this affects life throughout the ecosystem. Animals die because of choking or poisoning after plastic waste ingestion. Polluted soil and water affect all users of these land resources. Consequently, destruction of life around us is observed, affecting not only of humanity but also of other inhabitants of this planet.

According to early research by Rochman, Cook and Koelmans (2016), since "Capitan Charles Moore introduced the world to the 'Great Pacific Garbage Patch' in the mid–1990s", "there has been increasing interest from scientists, the public, and policymakers regarding plastic debris in the environment." (Rochman, Cook, & Koelmans, 2016). It is clear that plastic is truly one of the main culprits behind the deaths of so many living creatures, as well as global warming, ocean pollution and climate change. Recently, there has been increasing awareness of the 'plastic issue' and active involvement of people in the effort to do something about it. Many other studies by various scientists have shown that plastic waste does have an irreversible negative impact on the environment.

As stated in the scientific publication "Plastic Pollution" (Ritchie & Roser, 2018) world plastic production has grown from some 2.00 million tonnes per year in 1950 to 381 million tonnes in 2015. (*Chart 1.)* This means that over these 65 years, "annual production of plastics increased nearly 200-fold. For context, this is roughly equivalent to the mass of two-thirds of the world population" (Ritchie & Roser, 2018).

Chart 1. Global Plastic Production



Source: "Our World in Data"

As it has become clear, plastic has many physical advantages over other materials. Due to its low cost, it is widely spread and used. What exactly affects the usage of plastic and what are the ways to reduce its use? According to Speth's article (1988), "today's pollution is integrally related to economic production, modern technology, lifestyles, the sizes of human and animal populations, and a host of other factors." (Speth, 1988) From this standpoint, it becomes clear that the economy is one of the main factors involved in plastic use and plastic waste generation.

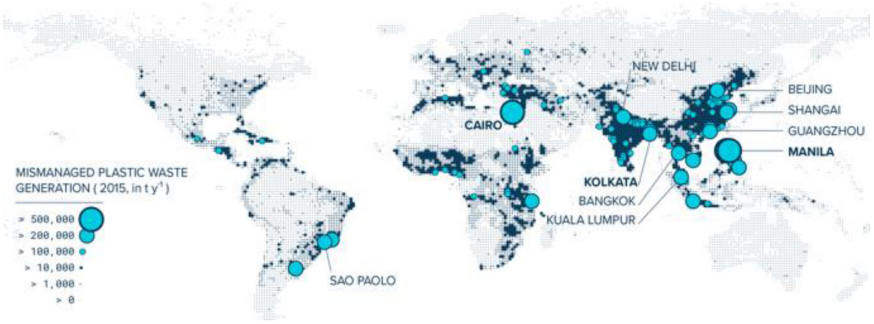
The aim of this paper is to assess the impact of the level of economic development on plastic waste generation. The chosen objects of this study are the countries of the European Union. Therefore, this paper investigates statistical data concerning the generation of plastic waste per capita in EU countries for the 2004-2016 period and the trends in the gross national income per capita for all countries investigated.

This study is designed to assess the hypothesis that the higher the income of the population, the more plastic waste is generated, due to increased purchasing power that makes plastic items, which eventually become waste after consumption, affordable.

Before understanding the connection between gross national income and plastic pollution per capita in the EU, let us first consider where the EU ranks in the world plastic pollution list.

The article by Lebreton and Andrady (2019) presents plastic as a main pollutant for 2015 *(Fig. 1.)* It shows that the Asian continent was "the leading generating region of plastic waste with 82 Mt, followed by Europe (31 Mt) and Northern America (29 Mt). Latin America (including the Caribbean) and Africa each produced 19 Mt of plastic waste, while Oceania generated about 0.9 Mt." (Lebreton & Andrady, 2019)

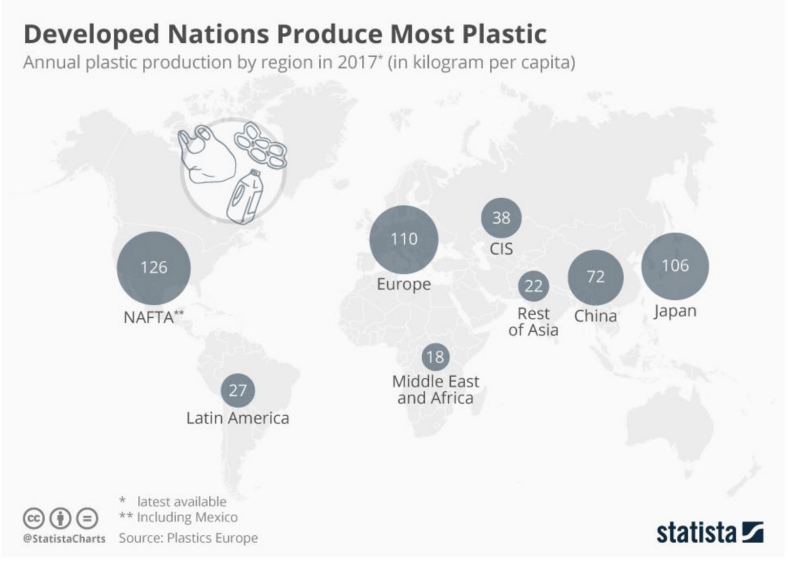
Fig. 1. Global mismanaged plastic waste generation in 2015



Source: "Palgrave communications; Humanities Social Sciences"

According to another publication related with the topic, Europe appears at the forefront of plastic pollution. (Buchholz, 2019)

Fig. 2. Developed Nations Produce Most Plastic, Annual plastic production by region in 2017 (in kilogram per capita)



Source: "Statista"

The figure shows that regions like NAFTA, Europe, Japan, and China generated most of the plastic waste in 2017.

The data presented, reveal a strange phenomenon regarding the level of pollution from countries around the world. According to scientific explanations, "high-income countries typically have well-managed waste streams and therefore a low level of plastic pollution to external environments." Why, then, do the countries from the EU, which are committed to more innovative and environmentally friendly products and create and develop sustainable development policies, are the main generators of plastic waste, as several studies show? Does the level of economic development have a real impact on plastic waste generation?

Methodology and results

To determine whether there is a connection between economic development and plastic waste generation within the European Union, the strength of the relationship between generated waste per capita and gross national income per capita is going to be evaluated. Calculations concern the 2004–2016 period.

The methodology is based on linear regression ("Panel Least Squares"), using panel data that combine two components – country fixed effects and period fixed effects. This is a type of statistical measurement "that attempts to determine the strength of the relationship between one dependent variable, in this case, this is the *"waste per capita"* and a series of other changing variables - known as independent variables", (Investopedia, 2019) (in this case the "*gross national income per capita in USD*" for all counties of the European Union).

Linear Regression Analysis is the simplest form of a regression analysis that uses one dependent variable and one independent variable. In this simple model, a straight line approximates the relationship between the dependent and the independent variable. (Devault, 2019). The core idea is "to obtain a line that best fits the data". (Swaminathan, 2018)

The following equation should be used for the calculation. To find out the dependent variable, namely plastic waste per person, one needs to multiply "beta" by gross income per capita for a respective country and add the constant, country fixed effect (which is the same for all years but different for each county) and period fixed effects (which is the same for all countries but different for each year).

$$WASTE_{CAP} = \beta * GNI_{CAP} + C + [CX = F, PER = F]$$

Where:

$WASTE_{CAP}$ – Plastic waste per capita;

GNI_{CAP} – Gross national income per capita;

β - The slope of the regression line (how much Y changes for each unit change in X);

$CX = F$ – Country effects fixed;

PER = F – Period effects fixed;

C – Constant;

The constructed panel data set for all 28 EU member states cover the 2004-2016 period with a two-year interval. Analysis is conducted with bi-annual data for each country, retrieved from Eurostat (Eurostat, 2019) and World Bank Group (US). (World Bank Group, n.d.)

The table below shows the results after the calculations according to the formula given. (Table 1.)

Table 1. Panel Linear Regression Analysis

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GNI_CAP	0.001758	0.000605	2.907010	0.0042
C	-25.88012	19.14305	-1.351933	0.1783
Effects Specification				
Cross-section fixed (dummy variables)				
Period fixed (dummy variables)				
R-squared	0.587895	Mean dependent var		29.66837
Adjusted R-squared	0.500866	S.D. dependent var		22.79400
S.E. of regression	16.10382	Akaike info criterion		8.556423
Sum squared resid	41752.62	Schwarz criterion		9.141800
Log likelihood	-803.5294	Hannan-Quinn criter.		8.793412
F-statistic	6.755206	Durbin-Watson stat		1.773725
Prob(F-statistic)	0.000000			

The results obtained show a statistically significant positive relationship between the two variables, i.e., GNI per capita and Generate Plastic Waste per person. At first glance, the relationship may seem very weak judging by the 0.001758 value. In this case, the value of beta shows how much the plastic waste per person is going to change if the unit of income changes in absolute terms. This means that, if income per person increases by $1, the plastic waste generated per person is also going to increase, but by 1.7grams. If we assume that the total income for the study period increased by $1000, this means that the amount of plastic waste generated per person increased by as much as 1.7 kilos, which is a high amount considering that this is only a fraction of the kinds of waste a human generates. If we take a county like Estonia as an example and trace how much income per capita changed during the 2004–2016 period, the result indicates an increase of $16,490. This, in turn, means that the plastic waste generated per person increased by 28 kilos – an enormous waste quantity for only one person. From this calculation, it can be concluded that the 'β' parameter is statistically significant and the hypothesis is proven.

As seen in the table, (Table 1) the value of "R-squared" (the coefficient of determination, which shows the model's capacity to describe real data) is approximate 59%. Therefore, the interpretation of the significance of the case study model created can be described as "strong". The Adjusted R-squared value is 0.50, with approximately 8% difference from the R-squared. If we had more independent variables, this would have stronger significance for the case. Still, this value indicates a positive correlation.

Since the panel regression model is characterised by providing more detailed analysis, we can find different features related to plastic pollution in the EU countries observed. In the method used, country effects describe country-specific characteristics not covered or described by the model factors. Data from the table attached express deviations from average pollution values for the entire EU (Table 2).

Table 2. Country fixed effects

	EU_COUN...	Effect
1	Austria	5.066285
2	Belgum	40.12644
3	Bulgaria	14.40465
4	Croatia	6.973825
5	Cyprus	27.82610
6	Czechia	6.628902
7	Denmark	-35.52086
8	Estonia	27.25305
9	Finland	-25.09981
10	France	-15.50499
11	Germany	-20.85822
12	Greece	11.77326
13	Hungary	7.034015
14	Ireland	2.773225
15	Italy	4.628284
16	Latvia	1.857047
17	Lithuania	4.041823
18	Luxembourg	-39.40190
19	Malta	-13.68828
20	Netherlands	-24.61015
21	Poland	10.36280
22	Portugal	11.74573
23	Romania	15.70027
24	Slovakia	3.010258
25	Slovenia	1.502253
26	Spain	-1.407604
27	Sweden	-25.90544
28	United King...	-0.710962

It is seen that countries like Denmark, Finland, France, Germany, Luxembourg, Malta, the Netherlands, Spain, Sweden, and the United Kingdom present negative values, which means that pollution in these countries is less than the Union's average rate due to unexplained, but county-specific reasons. For example, Denmark presents 35kg less of plastic waste per person than the EU average.

The rest of the countries –Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, and Slovenia present positive values, which means that plastic pollution in these counties is higher than the Union's average rate, again due to unexplained, but county-specific reasons. For example, Belgium presents 40 kg more of plastic waste per person than the EU average.

Looking at the time effects table, we can see how plastic pollution has changed over the study period. It represents the total deviation for all countries over time relative to the average amount of waste per person. Time-fixed effects are general, not country-by-country, but they change over time. The results obtained allow us to observe a clear and stable reduction of waste per capita during the observed period. (Table 3)

Table 3. Time fixed effects

	DATEID	Effect
1	2004-01-01	11.66129
2	2006-01-01	11.13679
3	2008-01-01	0.711574
4	2010-01-01	0.219681
5	2012-01-01	-7.801961
6	2014-01-01	-5.711779
7	2016-01-01	-10.21559

For example, in 2004, there was around 11 kg more plastic waste per person than the average for all study periods. In 2016, there was 10 kg less than the average per all study period, which outlines a pronounced reduction in plastic pollution. This indicates that there generated waste is being reduced, which, in turn, helps reduce pollution.

Conclusion

Plastic is one of the most used materials in our daily lives. Plastic waste is indisputably one of the greatest pollutants on our planet. According to the figures, the European Union is one of the most plastic polluted areas in the world. To find out whether there is a relationship between population income and the level of plastic pollution, a linear regression ("Panel Least Squares"), using panel data that combine two components, namely country-fixed effects and period-fixed effects. Although data show that income has a positive impact on plastic waste generation, because of wide variations in income

over time, the figures obtained over the years of the study period show that there is a steady decline in the waste amount generated. This, in turn, may be due to changes in the way people think and live, as well as to the policies adopted by EU countries.

Grossman's statement claiming there is growing concern that the continued expansion of global economy will cause irreparable damage to earth's environment and exacerbate the quality of life for future generations is more than valid today. (Grossman, 1993) The truth is that we are so privileged to be living in times when we have access to so much information and resources to deal with such a serious problem. We are witnessing various innovative products that can substitute plastic, thus reducing our negative impact on the environment. To achieve this vital goal for us, we need to spread the idea and convince as many people as possible to comply with it. Only by realising the problem we can create a more sustainable economy, establish new rules, and adopt a new way of living in harmony with nature around us! We are the last generation who can make the difference before it is too late!

References

Buchholz, K. (2019, 04 02). *Developed nations produced the most plastics*, Retrieved 08 2019, from Statista: https://www.statista.com/chart/17564/annual-per-capita-production-of-plastic-by-region/

Devault, G. (2019, 02 17). *What Simple Linear Regression is and how it works,* Retrieved 08 2019, from The balance small business: https://www.thebalancesmb.com/what-is-simple-linear-regression-2296697

Eurostat. (2019, 06 13). *Generation of waste by waste category, hazardousness and NACE Rev. 2, activit, Plastic waste, y*Retrieved 08 2019, from Eurostat: https://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Feldman, D. (2008).*Polymer History, Designed Monomers and Polymers,* doi:10.1163/156855508X292383

Grossman, G. M. (1993). *Pollution and waste: what do we know?*, Retrieved 08 2019, from The Economics Of Sustainable Development: https://epdf.pub/the-economics-of-sustainable-development.html

Investopedia. (2019, 08 05). *Regression description*, Retrieved 08 2019, from Investopedia: https://www.investopedia.com/terms/r/regression.asp

Lebreton, L., & Andrady, A. (2019, 01 29). *Future scenarios of global plastic waste generation and disposal*, Retrieved 08 2019, from Palgrade communications, Humanities Social Sciences: https://www.nature.com/articles/s41599-018-0212-7#Fig2

Ritchie, H., & Roser, M. (2018).*Plastic Pollution*, Retrieved 08 2019, from Our World in Data: https://ourworldindata.org/plastic-pollution

Rocha-Santos, T., & C Duarte, A. (2015). *A critical overview of the analytical approaches to the occurance, the fate and the behaviour of microplastics on the environment*, Retrieved 08 2019, from Science Direct: https://www.sciencedirect.com/science/article/abs/pii/S0165993614002556?via%3Dihub

Rochman, C. M., Cook, A.-M., & Koelmans, A. A. (2016).*Plastic debris and policy: usiing current scientific understanding to invoke possitive change*, doi:10.1002/etc.3408

Science History Institute. (n.d.). *The History and Future of Plastic*, Retrieved 08 2019, from Science History Institute: https://www.sciencehistory.org/the-history-and-future-of-plastics

Speth, J. G. (1988). *Environmental pollution: Along-term perspective*, Retrieved 08 2019, from http://pdf.wri.org/environmentalpollution_bw.pdf

Swaminathan, S. (2018, 02 26). *Linear regression, Detailed view*, Retrieved 08 2019, from Towards Data Science: https://towardsdatascience.com/linear-regression-detailed-view-ea73175f6e86

United Nations. (n.d.) *Sustainable development goals*, Retrieved 05 22, 2019, from https://www.un.org/sustainabledevelopment/

World Bank Group. (n.d.) *GNI per capita, PPP (current international $)*, Retrieved 08 2019, from World Bank Group: https://data.worldbank.org/indicator/ny.gnp.pcap.pp.cd