Back to Blue

An initiative of
Economist Impact and The Nippon Foundation

PEAK PLASTICS: BENDING THE CONSUMPTION CURVE

ECONOMIST IMPACT

THE NIPPON FOUNDATION

Glossary

- **Ban**: a ban on the sale and consumption of problematic, non-essential single-use plastic products (SUPPs). For each country, we calculate the decline in plastic consumption that would result from a ban on SUPPs. This ban rate will vary for each country, based on existing policy dynamics. We assume that these bans progressively increase over time, expanding the products under the purview.
- **Consumption**: the purchase of virgin resins by industries, which are then processed into virgin plastic products to be used by individuals. For the purpose of this study, the purchase of PET by a bottle manufacturer is accounted for in the consumption data (and not the purchase of a soft-drink plastic bottle by a household). The consumption number here is the total consumption at country level irrespective of production, import and export. For example, some of the countries may have zero production but instead its consumption is purely via imports. This is also referred to as 'use' in the paper.
- **GDP**: the gross domestic product is the market value of all finished goods and services produced in a country in a given period of time.
- **Landfills**: modern landfills are well-engineered and managed facilities for disposing of solid waste. They are located, designed, operated and monitored to ensure compliance with federal regulations and are also designed to protect the environment from contaminants, which may be present in the waste stream.
- **Peak plastics**: Economist Impact defines this as the hypothetical point in time when the consumption of plastic reaches its maximum rate, beyond which it will gradually decline due to various mitigation measures.
- **PET**: polyethylene terephthalate, a type of plastic polymer.
- **Plastic leakage**: this refers to plastics that enter terrestrial and aquatic environments.
- **Primary or virgin plastic**: plastics manufactured from fossil-based feedstock (eg, crude oil) that has never been used or processed before.

- **Problematic and unnecessary plastic items**: The New Plastics Economy Global Commitment[1] proposes the following criteria for identifying problematic or unnecessary plastic packaging or plastic packaging components:
  - It is not reusable, recyclable or compostable.
  - It contains, or its manufacturing requires, hazardous chemicals that pose a significant risk to human health or the environment.
  - It can be avoided (or replaced by a reuse model) while maintaining utility.
  - It hinders or disrupts the recyclability or compostability of other items.
  - It has a high likelihood of becoming litter or ending up in the natural environment.
- **Producers**: firms that make polymers—the building blocks of all plastics—almost exclusively from fossil fuels. Economist Impact identifies these firms as producers of new "virgin" polymers from oil, gas and coal feedstock. In 2019 more than half of all the single-use plastic waste created was made by 20 polymer producers, while the top 100 producers were the origin of 90%.[2]
- **Recycling**: means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes reprocessing organic material but does not include energy recovery and reprocessing into materials that are to be used as fuels or for backfilling operations.
- **Single-use plastic products**: items designed and produced to be used once before being thrown away or recycled, such as plastic bags, straws, coffee stirrers, soda and water bottles, and most food packaging.
- **Virgin plastics**: new plastic polymers that have been produced using fossil fuels such as crude oil, coal or natural gas.
- **Waste**: means any substance or object that the holder discards or is required to discard.

**The definitions of problematic plastic items, short-lived plastic products and SUPPs are adapted from working documents of the UN Plastics Treaty. The definition of consumption has been formulated in accordance with the data we have used for the model.*

Technical methodology

The *Peak plastics* study examines the potential impact of three key policies that could bend the consumption curve. These levers cover the entire lifecycle of plastic, from production to disposal, including: a ban on problematic single-use plastic products (SUPPs), mandatory extended producer responsibility (EPR) schemes for industrial consumers (ie, retailers and brands) and a producer tax on virgin plastic.[3] We study the effectiveness of their mandatory implementation on plastic consumption among 19 selected countries from the G20.

Context and rationale behind this study

In March 2022 the UN Environment Assembly in Nairobi adopted resolution 5/14 "*End plastic pollution: towards an internationally legally binding instrument*." This resolution endorses the creation of an international legally binding agreement by 2024 and focuses on the complete lifecycle of plastic, including design, production and disposal. The first round of negotiations on the global plastics treaty began in November 2022. That meeting was the first of five planned sessions of the Intergovernmental Negotiating Committee.

In tandem with the ongoing treaty negotiations, the *Peak plastics* work stream under the Back to Blue initiative has been developing an evidence-based approach to form an understanding of the extent to which selected policy measures can bend the plastic consumption curve and help to reduce plastic pollution.

We adopt a scenario analysis approach testing the effectiveness of three possible policy options to prevent future plastic pollution. The selection of the three scenarios under consideration reflects the lifecycle approach to tackling the plastic crisis. The key underlying assumption in all these scenarios is that compliance with these policies is mandatory for all industry participants. The countries in scope are the 19 countries of the G20.[4] This selection was made owing to the fact that these 19 countries account for almost 78% of global GDP.[5]

Objective

The *Peak plastics* model aims to assess if dedicated policy efforts can achieve a point of 'peak consumption', meaning the point after which plastic consumption begins to decline. Through modelling efforts, we try to establish if policy interventions can arrest the exponential increase in plastic consumption to bring about such a peak. If so, we question at what consumption level and at what time will this be achieved. At this stage, we test the possibility of achieving a 'consumption peak' before the year 2050 through three targeted interventions, namely, a ban on SUPPs, mandatory EPR schemes and a producer tax on the use of virgin resin.

Model assumptions

- **Consumption:** the purchase of virgin resins by plastic producers who process these resins into various plastic products, which are used by individuals. The consumption number here is the total consumption at country level irrespective of production, import and export. For example, some of the countries may have zero production but instead its consumption is purely via imports.

- **Fossil-fuel based plastic:** the model takes into account virgin plastic, which are polymers that have been produced using fossil fuels such as crude oil, coal and natural gas. It does not include plastics made from bio-based materials such as cellulose or bamboo.

- **Direct relationship between consumption and waste generation:** we assume that reduced plastic consumption will lead to a decrease in the volume of plastic waste generated, thereby lowering pollution levels.

- **Mandatory enforcement of scenarios:** a fundamental underlying assumption in the model is that the policy interventions discussed below are mandatorily enforced by national governments.

Variables and data

Dependent variable

- ***Total plastic consumption:*** the sum of consumption volume (in kilotonnes) of seven plastic categories (HDPE, LDPE, PET, PS, PVC, PP and others). The data were sourced from specialist data providers–Prescient, Strategic Intelligence and Grand View Research.

- We obtained historical data for plastics consumption on an annual basis for 2000-21. Our model considers data for seven main categories of polymers, which account for nearly 80% of global plastic consumption.[6]

Independent variables

- ***Retail sales:*** total annual sales of retail enterprises, excluding cash and carry (includes VAT). This is a demand side variable that represents the total volume of retail sales to account for domestic demand that covers the consumption of most consumer products that use plastic as an input commodity. These data were obtained from The Economist Intelligence Unit.

- ***Industry value added as a percentage of GDP:*** mining, quarrying, manufacturing, construction and utilities value-added as percentage of real GDP at factor cost. This has been used as a proxy for manufacturing. These data were obtained from The Economist Intelligence Unit.

- ***Environmental taxes as a percentage of GDP:*** a supply side variable that accounts for the taxes imposed on plastic products to limit plastic consumption. These data were obtained from the OECD.

- ***Crude oil price index:*** a supply side variable that represents the upstream cost. In this model we only consider transitional polymers derived from crude oil-based feedstock. These data were obtained from the International Monetary Fund (IMF).

- ***Dummy variables:*** we include dummy variables to account for country-specific effects.

Table 1: Variables and data sources

Type	Variable Name	Units	Source	Frequency	Availability
Dependent	Total plastic consumption	kilotonnes	P&S Intelligence	Annual	2000-21
Independent	Industry value added as % of GDP	%	The Economist Intelligence Unit	Annual	2000-21
	Environmental taxes as % of GDP	%	OECD	Annual	2000-21
	Crude oil price index	Index	IMF	Annual	2000-21
	Retail sales	US$	The Economist Intelligence Unit	Annual	2000-21
	Dummy variables				
	Country dummies	We use 18 dummy variables for 19 countries			
	Commodities dummy	If year = 2014, commodities dummy = 1 If year ≠ 2014, commodities dummy = 0			
	Pandemic dummy	If year = 2020, pandemic dummy = 1 If year ≠ 2020, pandemic dummy = 0			

Model specifications

- We have consumption data for 19 countries for 2000-21 with the characteristics of a balanced panel dataset. Consumption for each country is observed across 21 years, hence we use a panel data, least-squares dummy variable regression model and include 18 dummy variables to account for the country-specific individual effects. We take the US as the reference category for the dummy variables.

- The estimated model coefficients are used to generate forecasts for future plastic consumption. The forecast model generates a set of estimates that form our baseline forecast for 2022-50.

- There was a significant drop in crude oil prices in 2014. To prevent the steep trend witnessed during this year being replicated in future forecasts, we use a dummy variable for that year.

- Demand for plastic was abnormally low in some countries as a result of the extensive lockdowns and sudden drop in consumer demand following the start of the covid-19 pandemic. To prevent this trend being replicated in future forecasts, we use a dummy variable for 2020.

- The model uses the natural log transformation (log to the base e) of the regressand and one regressor (retail sales). All other regressors (industry as a % of GDP, oil price index and environmental tax as a % of GDP) are used at their level.

- The baseline forecast here represents the expected trend in plastic consumption up to 2050 in the absence of any policy interventions to prevent plastic pollution. For each scenario, we use different levers to alter the baseline estimates to quantify their impact on plastic consumption.

Regression results and interpretation

- The model yields a healthy adjusted R Squared of 95.58%. The p-values of all regression coefficients (except the constant) are significant at the 10% significance level, hence we reject the null hypothesis of zero slope coefficient.

The full regression equation is as follows:

Log (Total Plastic consumption) = β1*log (retail sales)) + β2(Industry value add as % of GDP) + β3(environmental tax as % of GDP) +β4(crude oil price index) + β5(D_commodity) + β6(D_pandemic) + β7(D_Argentina) + β8(D_Australia) + β9(D_Brazil) + β10(D_Canada)+ β11(D_China) + β12(D_Germany) + β13(D_France) + β14(D_UK) + β15(D_India) + β16(D_Indonesia) + β17(D_Italy) + β18(D_Japan) + β19(D_South Korea) + β20(D_Mexico) + β21(D_Russia) + β22(D_Saudi Arabia) + β23(D_Turkey) + β24(D_South Africa) + μi

Figure 1: Regression results

	Estimate	Std . Error	t value	Pr (> ǀtǀ)	
(Intercept)	0.28	0.40	0.70	0.49	
L_ret	0.67	0.03	24.94	< 2e - 16	***
en_tx	-0.05	0.03	-1.85	0.07 .	
oil_idx	-0.00	0.00	-2.79	5.50E-03	**
ind_gdp	0.00	0.00	1.71	0.09	
cm_d	0.00	0.04	0.06	0.96	
pd_d	0.05	0.04	1.20	0.23	
AR_d	-0.07	0.12	-0.62	0.53	
AU_d	-0.31	0.10	-3.08	2.24E-03	**
BR_d	-0.10	0.08	-1.26	0.21	
CA_d	-0.04	0.09	-0.43	0.67	
CH_d	1.03	0.06	16.74	< 2e - 16	***
GE_d	-0.24	0.08	-3.04	2.53E-03	**
FR_d	-0.04	0.09	-0.43	0.67	
UK_d	-0.81	0.09	-9.33	< 2e - 16	***
IN_d	-0.38	0.09	-4.08	5. 54e - 05	***
IND_d	0.08	0.07	1.16	0.25	
IT_d	-0.05	0.10	-0.49	0.63	
JP_d	-0.73	0.07	-11.0932e	-1.60E+01	***
SK_d	0.18	0.10	1.92	0.06	
ME_d	-0.17	0.09	-1.98	0.05	
RU_d	-0.63	0.09	-7.40	9.61e - 13	***
SA_d	0.01	0.12	0.10	0.92	
TK_d	0.25	0.11	2.23	0.03	
SAF_d	-0.60	0.12	-5.10	5. 50e - 07	***

Significance codes

0	***
0.001	**
0.01	*
0.05	.
0.1	

Residual standard error: 0.1849 on 357 degrees of freedom. (17 observations deleted due to missingness).
Multiple R-squared: 0.9586,
Adjusted R-squared: 0.9558
F-statistic: 344.3 on 24 and 357 DF,
p-value: < 2.2e-16

Source: Economist Impact calculations, 2023

- The signs of the model parameters are consistent with theory:

  - ***Retail sales:*** an increase in total annual sales of retail enterprises implies healthy demand for packaging for most consumer goods, which would lead to an increase in the demand for plastics. The positive coefficient here implies that a 1% increase in retail sales will translate into a 0.66% increase in plastic consumption.

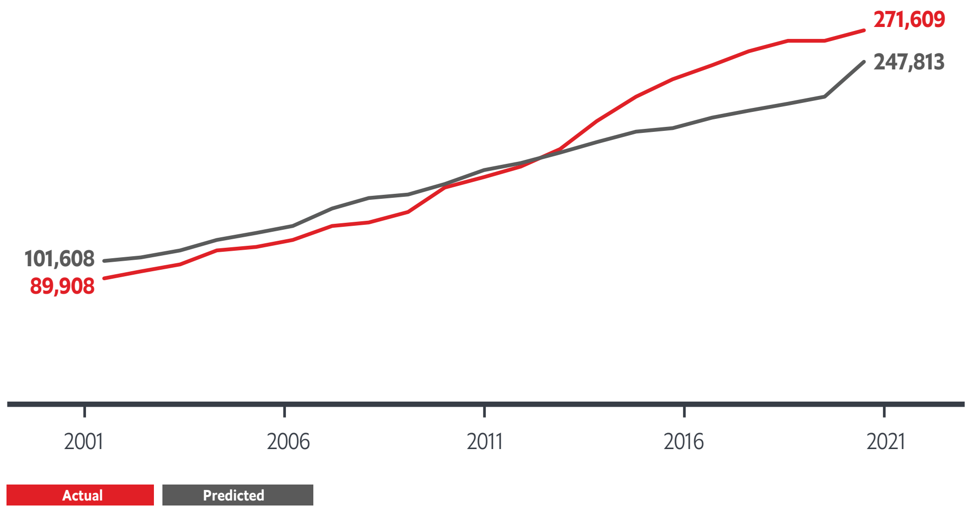
  - ***Industry value-added as a percentage of GDP:*** an increase in the contribution of industry value-added to GDP implies an absolute increase in industrial activity. A rise in industrial demand would lead to an increase in plastic consumption. The positive coefficient here is in conformity with this logic. A 1% increase in the contribution of industrial activity to GDP will increase plastic consumption by 0.15 kilotonnes.

  - ***Environmental taxes as a percentage of GDP:*** an increase in tax on consumption leads to higher prices for plastic products, thereby leading to lower demand and hence consumption. A 1% unit increase in the environmental tax as a percentage of GDP leads to a 4.7% decline in plastic consumption.

  - ***Crude oil price index:*** consumption is inversely related with input costs. A rise in the price of the key input commodity here, crude oil, directly leads to an increase in the price and hence a decrease in consumption of plastic. A 1 unit increase in the crude oil index means an increase in crude oil prices, which leads to a 0.08% decline in plastic consumption.

- We use the model parameters to generate in-sample estimates for the dependent variable. The estimated series has a good fit with the actual series and the trend matches well. See chart below:

Figure 2: Model performance: actual values vs model predicted values



Model scenarios

The selection of model scenarios is based on a literature review, consultations with experts and negotiators close to the treaty. Below we outline three selected scenarios that are under consideration.

1. **A phased ban on problematic SUPPs**

   In this scenario, ban rates are the lever to find out the rate at which we need to ban SUPPs in order to bend the curve on plastic consumption. SUPPs account for over 40% of all plastic produced.[7] We estimate SUPPs as a % of total volume in each of the seven categories by applying their recycling rates. To test the impact of a ban, we apply the ban rates to this SUPP volume derived above and deduct the same from the total plastic consumption of that country. We assume that bans progressively increase over time, increasing the number of products under its purview.

   For countries that already have a SUPP ban in place, we use the existing rates and apply incremental increases of 10%[8] each year, starting in 2025. For countries that have not yet implemented nationwide bans, we assume that the UN treaty forces them to implement a ban from 2025. We assume these ban rates widen in scope each year and hence apply a 0.1% increment for each year after 2025.

2. **A mandatory EPR policy imposed on industrial consumers**

   We evaluate the effectiveness of imposing a mandatory EPR policy on the consumption of plastic packaging by industrial consumers. Plastic is a valuable resource with myriad applications. We need to implement policies that encourage its optimal use instead of the indiscriminate overuse that currently prevails. Industrial consumers such as fast-moving consumer goods (FMCG) companies are large users of plastic packaging, many of which can be single use. We evaluate a case where governments implement a mandatory EPR policy on industrial consumers (ie, retailers and brands), wherein they are obligated to collect the plastic packaging (such as beverage bottles and shampoo bottles) and sort, clean and return it to polymer producers for recycling. The industrial consumer bears the cost of this EPR, which raises the price of plastic packaging for them. We assume that they would pass on this increase in input costs by raising the prices of final goods. We assume the transmission channel here to be through the price effect. Since polymer production generally becomes cheaper with scale, an external shock needs to be applied to make them costly in production. Based on historical data, we calculate the price elasticity of demand[9] to calculate the change in quantity demanded as the result of a price increase.

   Under a mandatory EPR scheme, we use the price elasticity of demand to calculate the impact of an increase in the price of plastic products as a result of a mandatory EPR policy imposed by a consumer. The underlying assumption here is that industrial consumers of plastic packaging, such as FMCG companies, are responsible for the collection, sorting and transportation of waste (such as plastic bottles) to the polymer manufacturer for recycling. To meet the cost of the EPR rules, they pass on the cost to the end consumer, resulting in higher prices of consumer goods that use plastic packaging.

   We use the existing price level data for each country-resin type combination until 2030 and use linear extrapolation to arrive at 2050 estimates for price growth. We use the price increment factor per country-resin combination to convert that into an impact in volume, applying this directly on the baseline numbers.

3. **Taxes on virgin resin production**

   We evaluate the effectiveness of imposing an environmental tax to increase the production cost to a level that reflects the true cost of producing a disposable plastic product. Plastic products are widely used because they are available at affordable prices. However, the current price only incorporates the price of production and not the cost of the negative externalities of producing that product. Hence, if a tax were imposed to bring up the cost of production to a level that reflects the true total cost, it might lead to a decline in consumption. A tax on virgin resin could promote action among producers by disincentivising the production of virgin plastic and promoting the use of more recycled resins in product design. We use carbon taxes as a proxy to quantify the outcomes of this scenario.

Table 2: Summary of model results

	Plastic consumption (million tonnes)				
	Baseline	**S1**	**S2**	**S3**	**Integrated approach**
2019	261	261	261	261	261
2030	334	327	320	325	304
2040	372	352	357	348	313
2050	451	385	434	409	325
2050:2019	**1.73**	**1.48**	**1.66**	**1.57**	**1.25**

Appendix

Table 1: GDP Data for 19 countries of the G20
Real GDP (US$ at 2010 prices), $ bn

Country	2019
Brazil	2,357.60
Canada	1,960.30
China	11,418.90
France	2,992.20
Germany	3,969.60
India	2,928.40
Indonesia	1,204.10
Italy	2,157.80
Japan	6,232.70
Mexico	1,308.20
Russia	1,895.70
Saudi Arabia	704.52
South Africa	481.85
South Korea	1,485.20
Turkey	1,257.87
United Kingdom	2,975.10
USA	18,306.20
World	**84,375.70**

Source: The Economist Intelligence Unit

End notes

1 "The New Plastics Economy Global Commitment | UNEP." n.d. UN Environment Programme. Accessed February 16, 2023. https://www.unep.org/new-plastics-economy-global-commitment.

2 "Executive Summary | Plastic Waste Makers Index." 2021. The Minderoo Foundation. https://www.minderoo.org/plastic-waste-makers-index/pwmi-2021/findings/executive-summary/.

3 Please refer to the glossary for the exact definition of consumption used in the context of this research.

4 We refer to the 19 countries in the G20 group. We do not include the EU in these calculations.

5 These 19 countries accounted for an average of 78% of global GDP over 2010-19. Sum of Real GDP in 19 countries = $65,659.4 bn (2019), World GDP = $84,375.7 bn (2019)
Source data: The Economist Intelligence Unit.

6 Based on internal calculations, using data purchased from P&S Intelligence and Grand View Research. The seven categories are PET, HDPE, LDPE, PS, PP, PVC and others

7 "Rethinking and optimising plastic waste management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment." 2020. NCBI. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7324921/.

8 If ban rate in year t = x, ban rate in year t + 1 = 1.1x

9 By running a univariate regression for each country and each polymer type.

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