MAPPING THE PLASTICS VALUE CHAIN

A FRAMEWORK TO UNDERSTAND THE SOCIO-ECONOMIC IMPACTS OF A PRODUCTION CAP ON VIRGIN PLASTICS

APRIL 2024

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THERE IS A GROWING PROBLEM OF PLASTIC POLLUTION

Plastic has become omnipresent on retailer shelves, in our homes and businesses, and in many products and infrastructures critical to modern life. From packaged groceries to state-of-the-art medical supplies, from lightweight vehicles to building and construction applications, it is used extensively thanks to its versatility and performance.

In recent years, the issues created by plastic pollution have gained increased scrutiny and prominence. In March 2022, the United Nations Environment Assembly (UNEA) decided to forge a legally binding international agreement to end plastic pollution by 2040. The first proposed option in the current draft foresees the implementation of a global production cap on primary plastic polymers.

The global plastics industry, represented by the International Council of Chemical Associations (ICCA), has expressed its commitment to ending plastic pollution, but believes the potential socio-economic impacts and other unintended consequences that may arise from the implementation of a production cap have not been fully evaluated. To this end, it commissioned Oxford Economics to undertake a research program to explore the socio-economic and environmental implications of policy interventions that could be used to support UNEA's objective.

This report documents our findings from our first phase of work, which has included the following major research tasks:

- Undertaking an extensive data collection and intelligence gathering exercise that has informed estimates of the current structure of the plastics global value chain and its potential future trajectory.
- Drawing on economic theory and the empirical evidence gathered from our value chain mapping to explore the expected implications of a production cap on the plastics market.

We intend for this work to be a precursor to a more extensive modelling exercise in phase two, which will enable us to quantitatively evaluate the comparative impacts of multiple policy choices.

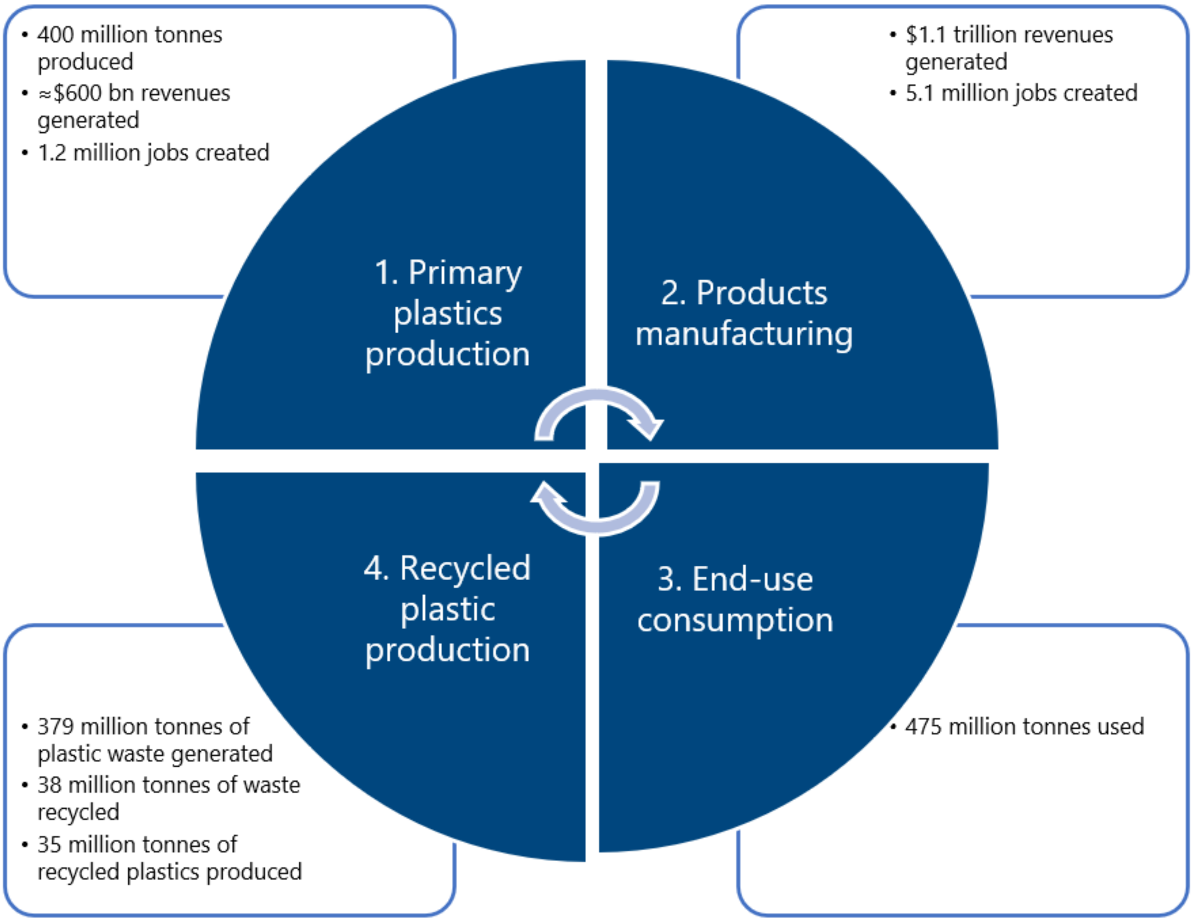
UNPACKING THE PLASTICS VALUE CHAIN: MAIN INSIGHTS

Our research to estimate the current scale and structure of the global plastics value chain has shed light on a topic where a consistent data source is absent. This section outlines the main insights that we have derived from this analysis. A more detailed presentation of the findings can be found in chapter three of this document.

1. The plastics industry is a major contributor to economic activity sustaining millions of jobs worldwide.

The global plastics value chain ranges from the extraction of raw materials for plastics production to the final disposal of plastic-containing products. The plastics value chain generates hundreds of billions of dollars in revenues and provides jobs for millions of workers globally. For simplicity, we have sought to estimate the size and structure of the sector's economic value chain through four major categories of economic activities, as illustrated in Fig. 1. This study provides a first-of-its kind attempt to map and quantify the value of the global value chain of plastics.

Fig. 1. Key actors in the plastics value chain and main statistics for 2022[1]



Source: Plastics Europe, Oxford Economics, OECD

2. In recent years, recycled plastic production has grown significantly faster than virgin polymer production.

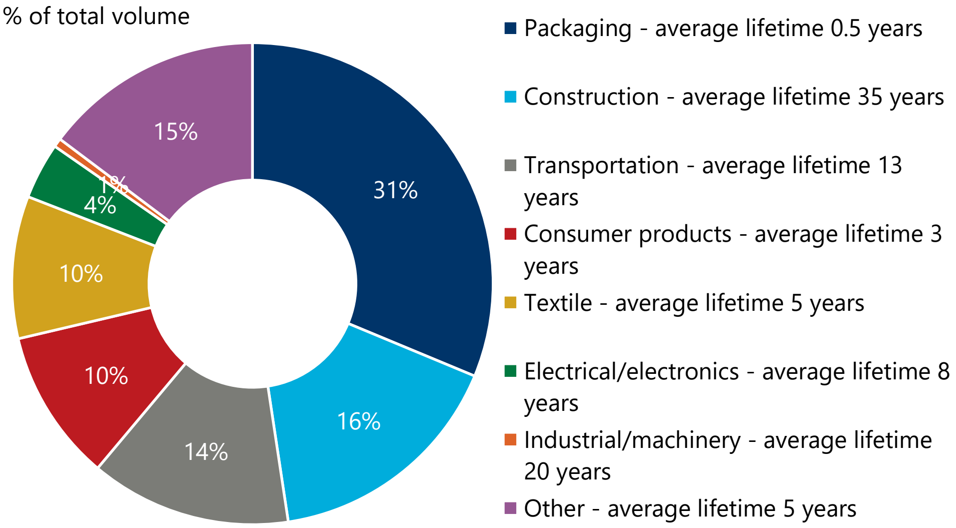
In 2022, the majority of plastics used by the manufacturing sector were fossil-based, while some 8.9% were post-consumer recycled plastics (mechanically or chemically).[2] The low share of recycled plastics masks a more encouraging trend, however—production of recycled plastics has grown by 19% over the past five years, more than twice as fast as the growth in total plastics produced (8% during 2018-22).

[1] There is a lag between plastic production and use, which explains why the numbers do not exactly line up.
[2] Plastics Europe, Plastics – the fast Facts 2023 (last accessed March 2024).

3. Most plastic products have medium to long lifespans.

The overall average lifespan of a plastic product is almost 10 years. This average value, however, masks considerable variation across certain product types. Notably, plastic packaging, the most widely used plastic application by volume has a very short lifespan, that can typically be measured in weeks or months (Fig. 2). On the other hand, applications in the construction sector, the second largest end-use type by volume, can often last for decades. The duration of this lifespan is naturally strongly predictive of the extent to which these products contribute to pollution.

Fig. 2. Plastic use by application and average lifespan



Source: OECD

4. Final consumption of plastic products is much more internationally diversified than primary plastic polymer production.

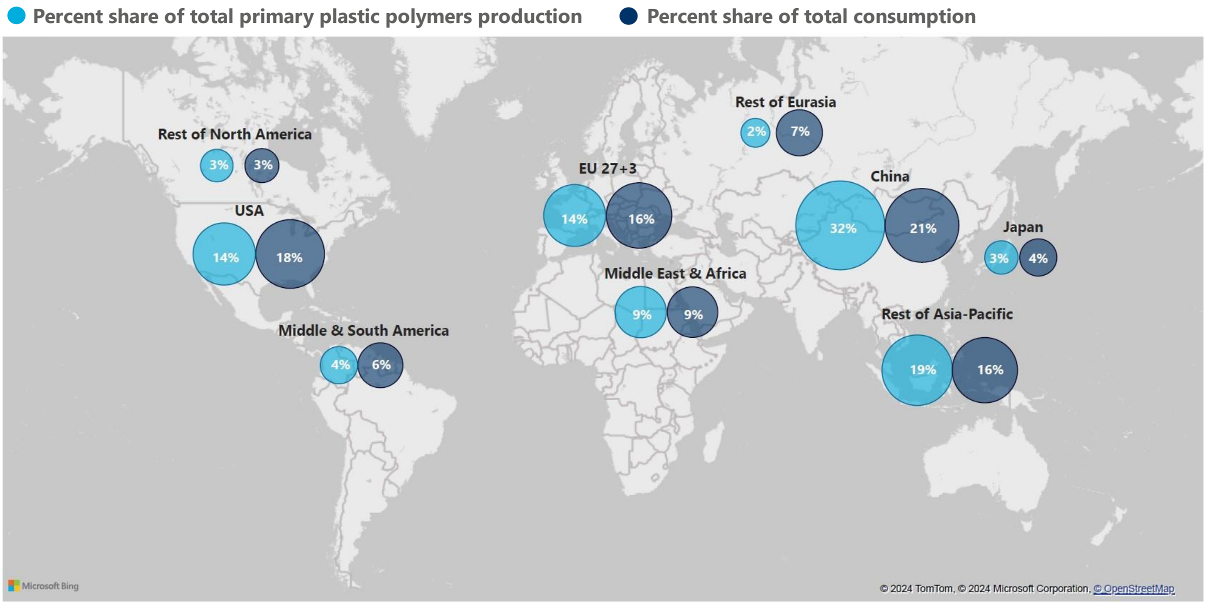
While a limited set of countries manufacture plastic polymers in primary form, finished goods containing plastics are consumed in all countries (Fig. 3). In general, we find that the international concentration of production falls as activity moves downstream in the value chain, i.e., towards end-use. Moreover, some countries that are relatively intensive consumers of plastics have very little associated primary or secondary (manufactured) production activities.

Although not individually identified in our value chain modelling due to data constraints, other research shows that this pattern is particularly prevalent in developing countries with a high source of income generated from tourism, including Small Island Developing States (SIDS). On the one hand, due to their reliance on tourism as a source of income, these countries often display the same level of plastic use and waste per capita as high-income countries, without the same infrastructure of waste treatment.[3] Coupled with typically relatively nascent recycling and waste treatment facilities, this has contributed to this group of countries suffering disproportionately from the issues created by plastic

[3] Guillotreau P. et al., Quantifying plastic use and waste footprints in SIDS: Application to Seychelles, Journal of Cleaner Production, Volume 417, 10 September 2023

pollution. On the other hand, however, even remote and uninhabited islands often experience plastic pollution washing onto their shores, due to currents coming from several directions.

Fig. 3. Share of total plastics production and consumption by region, percentages of volumes produced/consumed

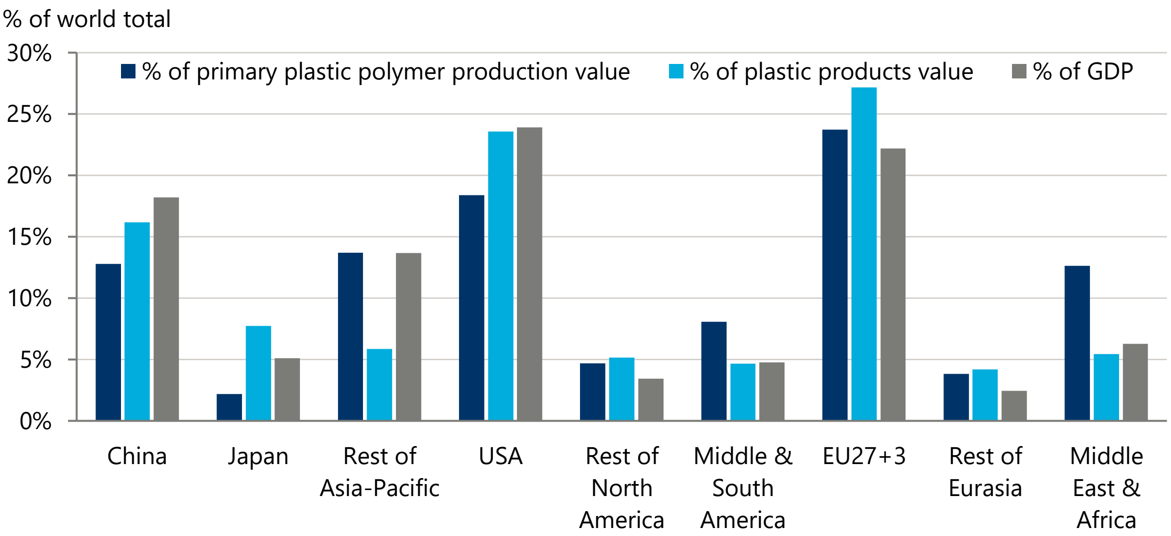


5. Absolute production levels are not predictive of economic dependence on the plastics industry.

When describing the industry, emphasis is often put on countries that are large producers of plastics in absolute terms. Our analysis, however, demonstrates that the Middle East and Africa and Latin America are the regions that are most economically exposed to the primary sector when accounting for the size of their total output (Fig. 4).

Our research also highlights that some regions are significantly more economically dependent on one sub-sector of the production chain (primary vs secondary). For example, while Japan has little exposure to primary plastic polymer production, it is relatively highly dependent on its plastic conversion industry.

Fig. 4. Percentage of world primary plastic polymers and plastic products value of production, compared with percentage of global GDP

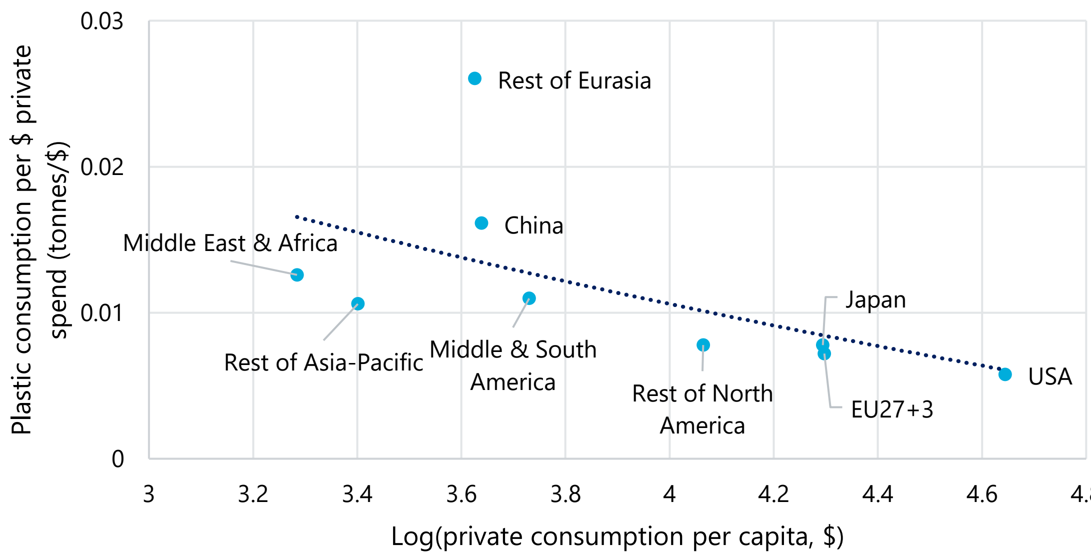


Source: Oxford Economics

6. Regions with low incomes spend a higher fraction of their spending on plastic products.

Our analysis also suggests that households in lower-income regions spend a higher fraction of their total consumption on plastics (Fig. 5). This is consistent with the fact that the final consumption of plastics by households centres on packaging for many products that represent essential staples of day-to-day life, most notably food. As displayed, the intensity of plastic consumption—as measured by the number of tonnes of plastic consumed per dollar of private spending—is higher in regions with lower levels of total private consumption per capita (a highly predictive metric of average household income).

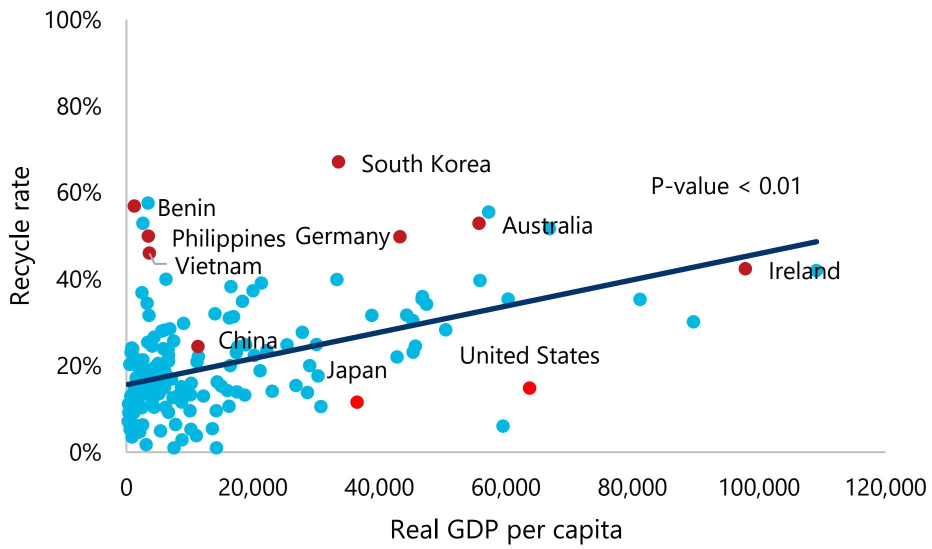
Fig. 5. Plastic consumption as a portion of total consumption



7. Recycling rates for all materials are positively associated with GDP per capita.

Recycling rates for all material types are strongly positively correlated with GDP per capita, indicating that richer countries recycle more, all else equal (Fig. 6).[4] It is estimated that 3 billion people worldwide still lack access to controlled waste disposal facilities. In these parts of the world, the informal economy is a key driver of recycling, incentivized by the value of some of the plastics recovered. It is estimated that there are currently 11.4 million waste pickers worldwide, making a significant contribution to the collecting, sorting, and recycling of plastics in many countries.

Fig. 6. Recycling rates and GDP per capita[5]



Source: Oxford Economics, EPI Yale

8. A very low fraction (2%) of plastic waste generated is currently traded internationally.

Recent import restrictions have contributed to shifting trade away from traditional destinations to new markets, while simultaneously decreasing international trade volumes, and increasing the need for domestic recycling capacities. For example, in 2017, China introduced strict import requirements which effectively banned the vast majority of waste imports and, even before this, the 1989 Basel Convention regulated the trade of hazardous waste to mitigate the unwanted transport of toxic shipments that governments did not consent to receive.

The Rest of Asia region exports the largest portion of its plastic waste, or 4% of its total waste, with China and the European Union being the largest recipients. China, on the other hand, exports only 0.1% of its plastic waste.

[4] This analysis uses data from the Environmental Performance Index (EPI), which measure recycling rates as the proportion of *all* recyclable materials (metal, plastic, paper, and glass) recycled in each country. This is therefore a broader concept than plastic recycling rates. These rates are computed in the country where the waste is collected and not where the waste is reprocessed, and these countries often do not coincide.

[5] A p-value of 0.05 or lower is generally considered statistically significant. A 0.05 p-value provides the smallest level of significance at which the hypothesis that no statistically significant relationship exists between the variables would be rejected.

THE EXPECTED IMPACTS OF A PRODUCTION CAP ON VIRGIN PLASTICS: HIGHER PRICES AND POTENTIAL UNINTENDED CONSEQUENCES

1. The implementation of a cap would push up the price of virgin plastic.

A cap on production will, by design, limit the availability of virgin plastics. Economic theory predicts that this curtailment of supply will lead to higher prices, all things being equal. It can be expected that the scale of this initial increase will depend on a number of factors including the size of the production cap, the availability, viability, and price of substitute products, and the extent of scale economies in production.

2. The extent of this price increase is likely to vary significantly for different polymers and seeking to exempt specific end uses from the cost increase would be practically infeasible.

The extent of any price increase is unlikely to be uniform across different polymers. Notably, we would expect that price increases will be proportionately larger for polymer uses where the customer (converters) has fewer available commercial substitutes. This suggests that the impact on manufacturing production costs is likely to vary significantly across different industry subsectors reflecting both these competitive dynamics and differences in the intensity of use of polymers.

While different polymers and applications will be affected to varying degrees by the introduction of a cap, it would be practically infeasible to fully exempt specific applications from any pricing effects from a cap. This is notable since the UN draft resolution is currently considering three such exemptions for medical, emergency relief, and scientific research applications.

This practical challenge stems from the fact that the production cap would be imposed at the primary polymer level and polymers are not unique to specific applications. For example, polypropylene is commonly used to produce woven bags to store food such as beans, wheat, and other items in humanitarian assistance, but is also widely used in the packaging industry to make yogurt containers and hot beverage cups.

3. As the price of primary polymers increases, demand would shift towards alternative products, generating the risk for unintended environmental consequences.

The higher price and lower availability of plastic polymers can be expected to increase demand for alternative materials, including recycled plastics. Since these alternative materials are typically more expensive than plastics, it can be expected to lead to a further increase in manufacturers' production costs. Moreover, as demand shifts towards alternatives, economic theory implies that both the production volumes and the prices of these products will increase further.

Switching towards alternative materials (excluding recycled plastics) also carries the risk of unintended environmental consequences. Broadly speaking, these risks are due to the fact that plastics are lighter than potential commercial alternatives. For example, swapping plastic for other materials may result in increases in food waste and heavier vehicles, in food packaging and automotive applications, respectively.

Similarly, available evidence shows that switching towards alternatives is likely to put upward pressure on carbon emissions; a McKinsey study, for instance, finds that plastics have a lower total greenhouse gas contribution than alternatives in most applications, with emission savings ranging from 10 to 90%.[6] Lifecycle assessments can be a critical tool for policymakers looking to evaluate the merits of alternative materials and design evidence-based environmental policies.

4. Higher prices would ripple through the plastics value chain, pushing up costs.

Economic theory suggests that the impact of such a price increase would not necessarily be shouldered entirely by the immediate customer (in this case manufacturers of plastic products). It is likely that any increase in production costs for these manufacturers will, to some extent and on an individual company determined basis, be passed through to downstream players in the industry, such as derivate manufacturers and distributors (wholesalers and retailers).

The extent to which the higher prices remain with the producers or are shared or absorbed across the value chain depends on a range of factors. Generally, the less price-sensitive side of the market bears the burden of the impact. If buyers are highly sensitive to price changes, producers may absorb some costs to maintain demand. Consumers tend to be more price-sensitive when substitutes are readily available and inexpensive to switch to.

5. Ultimately, higher costs would feed into consumer prices, pushing up the cost of living, with a disproportionate impact on low-income households.

Higher prices and production costs will also push up the cost of living**,** negatively impacting consumers. In general, we can expect these price effects to disproportionately affect low-income households and countries. Since poorer regions of the world spend significantly more on plastics as a share of their overall consumption, it can be expected that households in these regions would suffer disproportionately from this inflationary shock. This trend will be exacerbated by current variation in recycling rates internationally, which are typically much higher in high-income countries (Fig. 6), despite the significant contribution made by waste pickers in several lower-income regions.

Moreover, it can be expected that highly import-dependent countries, including SIDS for example, would be especially vulnerable to the introduction of policies curbing plastic supply, compared to plastic-producing economies. Indeed, the latter are better able to add recycled materials into their product manufacturing mix, while non-producing countries would necessarily need to rely on imported materials.

CONCLUDING THOUGHTS: CAREFUL POLICY DESIGN IS NEEDED TO ADDRESS PLASTIC POLLUTION WHILE MINIMIZING THE RISK OF UNINTENDED CONSEQUENCES

In most cases, **the implementation of economic policies entails trade-offs** and carries potential risks for unintended consequences. In the case of a production cap, besides curbing availability, the policy can be expected to increase the price of plastic polymers, particularly those that have fewer current commercial substitutes. These higher prices can be expected to ripple through the value chain, eventually, feeding up the end-use price of the very large range of products that rely on plastics as an input.

[6] McKinsey & Co., "Climate impact of plastics", July 2022 (last accessed February 2024).

Eliminating plastic pollution will require a **multi-dimensional strategy**. Notably, the World Bank has identified that whilst increased consumption is a major driver of plastic leakage, insufficient solid waste management capacity and formalised collection systems have also been important contributors to the pollution problem, in addition to limited incentives to reuse or substitute plastic, and the high cost of recycling. Indeed, it seems clear that policies which incentivise circularity and close leakage pathways need to form part of the solution.

The type of policies that are contemplated in the draft UN instrument are ambitious in scale and global in scope. All these policies, from limiting supply to introducing EPR programmes, foresee systemic changes that would affect the entire plastics value chain. Assessing the economic, social and environmental consequences of these reforms **requires a sophisticated and extensive modelling framework**, the starting point for which is a database that describes the international structure of the global value chain, as presented in this document. In the planned second phase of our research programme, we will aim to inform the policy debate further, by producing a more detailed analysis of the implications of a production cap on virgin plastics and a selection of alternative policy instruments that could be used to address the pollution problem.

1. INTRODUCTION

In recent years, the issues created by plastic pollution have gained increased scrutiny and prominence. Indeed, in March 2022, the United Nations Environment Assembly (UNEA) decided to forge a legally binding international agreement to end plastic pollution by 2040.[7] The current draft instrument sets out 13 possible provisions, addressing all parts of the plastics life cycle, from primary polymer production to waste management. The first proposed option states that "parties shall not allow their level of production and supply of primary plastic polymers to exceed a target" yet to be identified.[8] In other words, this provision foresees the implementation of a global production cap on virgin primary plastic polymers.

As recognized in provision 12 of the draft, it is key to ensure a *just* transition away from current consumption patterns; "each party should support policies to improve income, opportunities, and livelihoods for affected workers and communities in the transition to more circular economies for plastics, considering the needs and priorities of affected workers and communities".[9] Achieving this balance will be especially important in low and lower middle-income countries, where economic growth is vital to alleviating issues of absolute poverty.

The global plastics industry, represented by the International Council of Chemical Associations (ICCA), has expressed its commitment to ending plastic pollution, including helping to further the strategies, innovations, and significant investments required to achieve the UN Sustainable Development Goals (SDGs). However, the industry believes the potential socio-economic impacts and other unintended consequences that may arise from the implementation of a production cap have not been fully evaluated and scrutinized to achieve the balance required.

A few recent studies have attempted to assess the effects of various policy interventions. For example, a Nordic Council of Ministers (2023) report finds that a set of far-reaching policies across the plastic lifecycle, adopted globally, could reduce annual mismanaged plastic volumes in 2040 by 90% relative to 2019, while reducing annual volumes of virgin plastic production by 30%.[10] This study, however, did not account for likely changes in the economic behaviour of businesses and households in response to policy changes.

An almost inevitable consequence of any economic policy intervention is the existence of trade-offs—there are associated benefits and costs, and some groups may be affected more than others. Moreover, it is typically the case that these trade-offs and the unintended consequences that stem from policy interventions are driven by how these reforms influence economic behaviour.

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[7] Heads of State, Ministers of environment and other representatives from UN Member States agreed to forge an international legally binding agreement by 2024 with a view to "ending plastic pollution through the prevention, progressive reduction and remediation of additional plastic pollution by 2040".

[8] United Nations Environment Programme, "Revised draft text of the international legally binding instrument on plastic pollution, including in the marine environment", page 12, sub-option 1, 28 December 2023.

[9] Ibid, page 38, option 1, OP2 bis.

[10] Nordic Council of Ministers, Towards Ending Plastic Pollution by 2040, 12 September 2023 (last accessed March 2024).

As such, research that provides insight into the broad scale and likely direction of these effects, and how they vary depending on the type and combination of interventions, accounting for behavioural change, would be extremely beneficial and timely. To this end, Oxford Economics was commissioned by ICCA to create a framework to understand and measure the *socio-economic* impacts of a production cap.

This report documents the findings and conclusions that we have derived from the first phase of our research. This has included:

- Deepening our understanding of the current policy context and the issues that are created by plastic pollution (Chapter 2).
- Undertaking an extensive data collection and intelligence gathering exercise that has informed estimates of the current structure of the plastics global value chain and its potential future trajectory (Chapter 3).
- Drawing on economic theory and the empirical evidence gathered from our value chain mapping to explore the expected implications of a production cap on the plastics market (Chapter 4).
- Using similar tools to evaluate the respective pros and cons of a range of alternative policy options (Chapter 5).

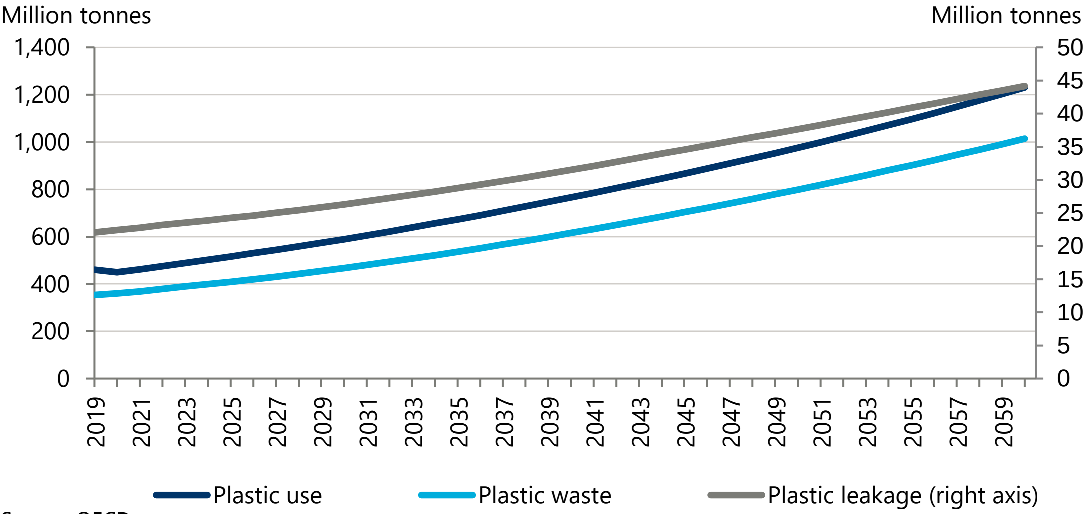
The objective of this program is to educate readers and interested parties to build awareness and a deeper understanding of the socio-economic impacts of a production cap. As part of a second phase, we plan to build on this foundation by developing a modelling framework that will be used to quantitatively assess the economic and environmental impact of a production cap and to compare this to the implications of alternative policies currently being considered to address the problem of plastic pollution.

2. POLICY CONTEXT

THE GROWING PROBLEM OF PLASTIC POLLUTION

Plastic has become omnipresent in modern life. From packaged groceries to state-of-the art medical supplies, vehicles, and water management systems, it is used extensively thanks to its versatility and performance. Its low cost and suitability for mass production have helped to widen access to many consumer products, previously reserved for privileged circles of society, and continues to do so to this day. With improving living standards across the world, the consumption of plastic products is expected to continue to rise. The OECD predicts that some 1,200 million tonnes of plastics will be consumed in 2060, up 159% from 2022 levels (Fig. 7), if current trends continue unabated.[11]

Fig. 7. Plastic use, waste, and leakage projections, 2019 to 2060



Source: OECD

The projected rise in plastics usage is mainly driven by rising incomes. Demographic change is also projected to contribute to the increase in plastics demand, although this effect is expected to be limited by the fact that the regions with the largest projected increases in population display relatively modest per capita consumption. On the other hand, the growth in plastics use is weakened by changes in the composition of the economy, particularly the move towards services away from manufacturing. The adoption of more efficient technologies in manufacturing methods also negatively contributes to plastic consumption, as the quantity of plastics used per dollar of production of plastic-using goods decreases.[12]

Over time, the growth in plastic demand will translate into growth in the volume of plastic waste from products reaching the end of their service life. Some 1,000 million tonnes of plastic waste are expected to be produced in 2060, a 167% increase from 2022 levels. As several countries across the globe lack even rudimentary methods to collect waste, used materials are often abandoned and then leak onto

[11] Throughout this study, we use metric tonnes as a unit of measure for volumes of plastics produced/ consumed.
[12] OECD, Global Plastic Outlook: Policy Scenarios to 2060, 21 June 2022 (last accessed March 2024).

land, into rivers, and oceans. The UN estimates that 3 billion people worldwide lack access to controlled waste disposal facilities, or 38% of the world's population.[13] The OECD projects that plastic leakage could reach 44 million tonnes in 2060, up from 23 million tonnes in 2022 (+91%). This is equivalent to 4-5% of total plastics used, or 4-6% of total plastic waste. This mismanaged waste can trigger severe environmental and economic damage.

While increased consumption is certainly a major driver of plastic leakage, the World Bank identifies the following additional factors as contributing to the problem, suggesting that simply curbing demand is unlikely to solve the pollution problem:[14]

- Insufficient solid waste management capacity and formalised collection systems.
- Too few options and no incentives to reuse or substitute plastic.
- Still low recycling capacity and high cost of recycling.

UN-LED POLICIES TO ADDRESS PLASTIC POLLUTION

Growing awareness of the plastic pollution problem has led policymakers to seek out policy instruments that could counter the current trends. The proposed UN instrument is an example of such efforts; the current draft proposes a range of policy interventions that can mitigate plastics-related adverse impacts. As mentioned earlier, the first proposed option currently envisages the introduction of a legally binding global production cap on primary plastic polymers, which will be the focus of this study.

Other policies also contemplated in the draft include:

- Producer fees: "A mechanism for the provision of financial resources is hereby established to support the implementation of this instrument. The mechanism shall include financial resources from the establishment of a global plastic pollution fee to be paid by international plastic polymer producers."[15]
- Extended Producer Responsibility (EPR): "Parties are encouraged to consider establishing and operating fiscal and/or non-fiscal Extended Producer Responsibility (EPR) systems as appropriate and based on national circumstances and capability, including, where relevant, to incentivize increased recyclability, support higher recycling rates, and enhance the accountability of producers and importers for safe and environmentally sound management of plastic products and increase public awareness."[16]
- Incentives to switch to alternative materials: "Parties should encourage the development and use of safe and sustainable alternative plastics and plastic products. The measures taken to implement this provision may include the use of regulatory and economic instruments."[17]

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[13] UNEP, "The Mounting Problem: World's Cities Produce up to 10 Billion Tonnes of Waste Each Year, UN Study Estimates", 7 September 2015 (last accessed March 2024).
[14] World Bank Group, "Where Is the Value in the Chain? Pathways out of Plastic Pollution", 2022 (last accessed March 2024).
[15] United Nations Environment Programme, "Revised draft text of the international legally binding instrument on plastic pollution, including in the marine environment", page 42, part III, 28 December 2023.
[16] Ibid, page 27, option 4.
[17] Ibid, page 24, option 2.

- Support to informal collection sector: "Improving working conditions for waste pickers, including by providing legal recognition and protection in informal and cooperative settings and facilitating the formalization of their associations and integrating them into local waste management systems."[18]
- Plastic labelling standards: "Encourage marking and labelling practices for plastic products to promote circularity, enable informed decision-making, and facilitate reuse, repair, refurbishment, and recycling of plastics."[19]
- Mandatory product design requirements: "Each party shall require plastics and plastic products produced within its territory and those available on its market to comply with the minimum design and performance criteria."[20]
- Consumer education campaigns: "Educational and awareness raising programs on plastic pollution, including those aimed at behavioural change and developing capacity."[21]
- Sound national waste management policies in accordance with international agreements and guidelines: "The governing body shall adopt guidelines on environmentally sound management of plastic waste, taking into account the waste hierarchy and other relevant international guidelines and guidance."[22]

Notably, the draft instrument is considering an option to exempt the following applications:[23]

- Medical and health use;
- Emergency response to public health incidents and natural disasters, etc.;
- Scientific and experimental research.

SELECTING THE POLICY MIX

Typically, the choice of policy instruments, in this context, is guided by the following criteria, as determined by the World Bank:[24]

- Environmental effectiveness (i.e., changes in plastic flows through the economy and in plastic pollution can be attributed to the policy reform);
- Economic impact on a country and financial impacts on economic actors (i.e., winners and losers are identified);
- Social impact on vulnerable households;
- Acceptability and political economy of reforms;
- Scalability, replicability, sustainable market creation, positive spillovers to the rest of the economy, such as jobs, skills, and innovation;
- Institutional and administrative feasibility; and

[18] Ibid, page 38, option 1, OP1 Alt.
[19] Ibid, page 40, option 1, OP1.c Alt 2.
[20] Ibid, page 20, sub-option 1.
[21] Ibid, page 49, part IV, OP0 Alt.
[22] Ibid, page 31, option 2.
[23] Ibid, page 8, option 3.
[24] World Bank Group, "Where Is the Value in the Chain? Pathways out of Plastic Pollution", 2022 (last accessed March 2024).

- Ancillary impacts, such as health, safety, air pollution, greenhouse gas (GHG) emissions, and others.

However, all interventions within a policymaker's toolkit come with their own set of trade-offs. Economic policies may have unintended social consequences, for instance. Similarly, and most importantly for this study, environmental policies can generate socio-economic spillover effects, which need to be carefully considered. Combining measures in different doses has the potential to dilute these trade-offs and spread the burden more evenly, a feature that UN member states are acutely aware of, as demonstrated by the wide-ranging recommendations included in the current instrument draft.[25]

In the case of "industrial policymaking", which refers to government efforts targeting specific industries, firms, or economic activities (typically with a view to shape the economy, but in the case of a production cap, with an environmental objective), the incidence of any policy heavily depends on the structure of the industry it is imposed on.

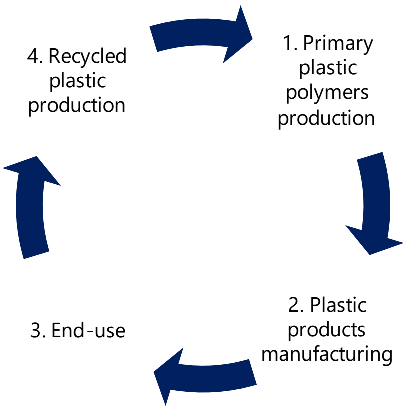
Any evaluation of the likely consequences of these policy instruments, therefore, should consider the structure of the industry value chain. Moreover, the fact that these instruments are intended to be applied on a global scale implies that such consideration needs to be extended to account for international trade flows that link producers and consumers together across different countries in our increasingly globalized economy. As part of our research, therefore, we have sought to shed light on this topic by mapping the current international value chain. The next chapter of this report documents our findings.

[25] United Nations Environment Programme, "Revised draft text of the international legally binding instrument on plastic pollution, including in the marine environment", 28 December 2023 (last accessed March 2024).

3. THE GLOBAL VALUE CHAIN

The global plastics value chain ranges from the extraction of raw materials for plastics production to the final disposal of plastic-containing products. As illustrated in Fig. 8, key actors in the plastics value chain are 1) primary plastic polymer producers; 2) plastic product producers (or plastic converters); 3) end-use industries; and 4) (mechanical and chemical) recyclers.

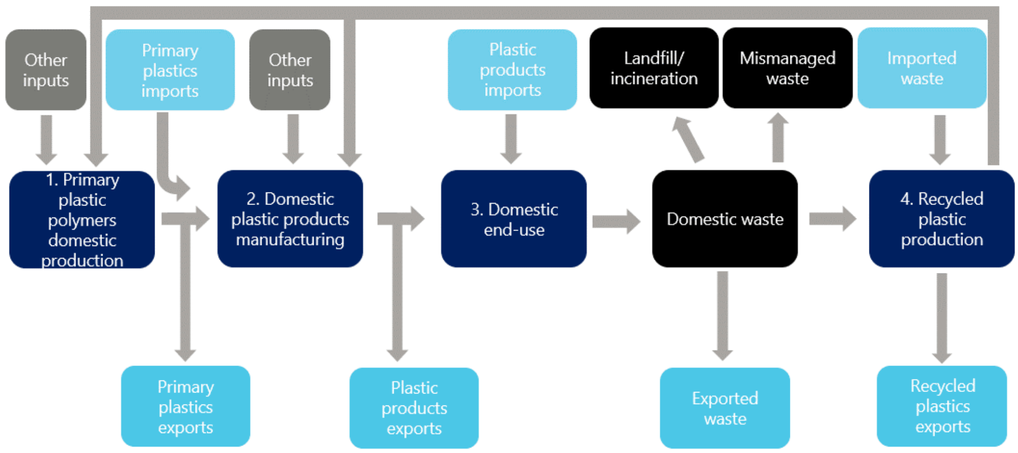
Fig. 8. Key actors in the value chain of plastics



> Data scarcity is the first bottleneck that many countries face when starting to strategize for managing plastic pollution. World Bank

Fig. 9 provides a schematic overview of the plastics value chain in an illustrative country. Each of the previously defined actors interacts with other industries (e.g., to source intermediate inputs) and countries (e.g., by exporting their goods) in order to produce its revenue and employ its workforce. The remainder of this chapter addresses each of these industry players in turn, providing a first-of-its kind attempt to map the global value chain of plastics.[26]

Fig. 9. A stylized plastics value chain for an illustrative country[27]



[26] Before this study, the closest effort to mapping the value chain of plastics was undertaken in 2018 by the United Nations (UNEP, Mapping of global plastics value chain and plastics losses to the environment, 2018). This study, however, focused predominantly on volumes of plastics produced and consumed and did not attempt to cover any socio-economic metrics, such as revenue, jobs, or trade.

[27] The term incineration includes waste that is incinerated in a state-of-the art industrial facility, with or without energy recovery.

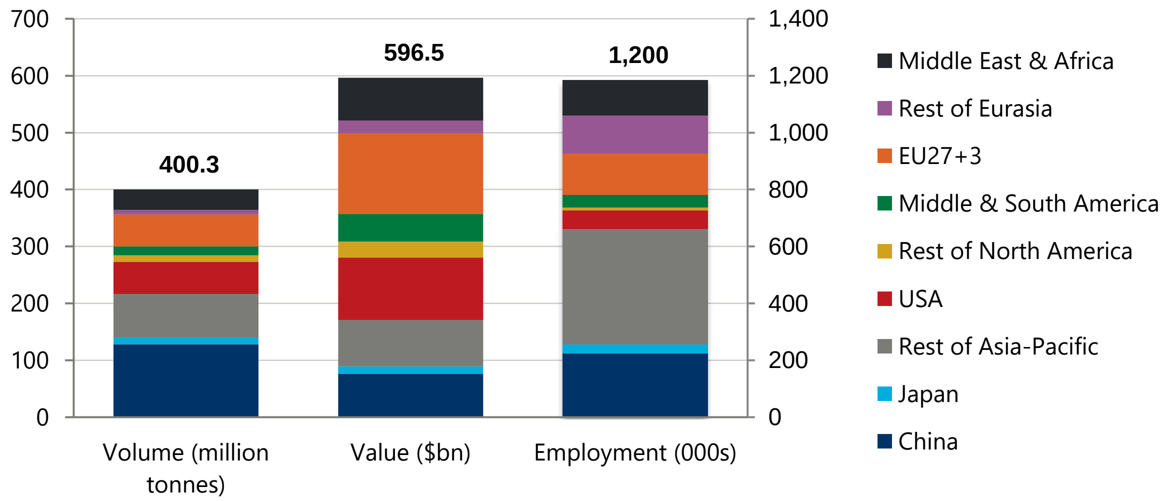
1. PRODUCTION OF PLASTIC POLYMERS IN PRIMARY FORM

Key markets for plastic polymer production

The industry producing plastic polymers in primary form comprises establishments engaged in the manufacturing of plastic polymers and materials. This is a capital-intensive industry, characterised by substantial barriers to entry, significant R&D spending, and a highly skilled and specialised workforce.[28] Plastics Europe estimates that in 2022 over 400 million tonnes of plastics were produced globally.[29] While data on volumes of plastics produced by region are readily available, consistent data on the value of the industry globally are not. By using a triangulation of sources, we estimate that the sector manufacturing plastic polymers in primary form generated revenues worth nearly $600 billion and employed 1.2 million people globally in 2022.[30]

While much of the production, by volume, takes place in Asia-Pacific, especially China, the West, and especially Europe, dominates the industry in terms of global revenues (Fig. 10). For example, while China is the largest producer in volume terms (32% of the total), the value of its production makes up a much smaller share of the world's total (13% of the total). Among smaller producers, Latin America produces 4% of plastic volumes and 8% of the value. When looking at employment, Eurasian countries are estimated to employ a larger portion of workers in the industry (11%) than would be expected based on the size of the industry in value terms (4%).

Fig. 10. Volume, value of production and employment of plastic polymers in primary form producers, by region, 2022[31]



Source: Plastics Europe, Oxford Economics

[28] KPMG, The Future of Industry: Focus on Plastics Manufacturing, 2023 (last accessed March 2024).

[29] Plastics Europe, Plastics – the fast Facts 2023 (last accessed March 2024). In our analysis, the industry producing recycled plastics is included in the sector manufacturing plastic polymers in primary form.

[30] A full set of the data sources employed can be found in Appendix 2.

[31] The Rest of Asia-Pacific region includes Asian countries (except China & Japan) and Oceania. The Rest of North America includes Canada and Mexico. Rest of Eurasia includes Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, and Uzbekistan.

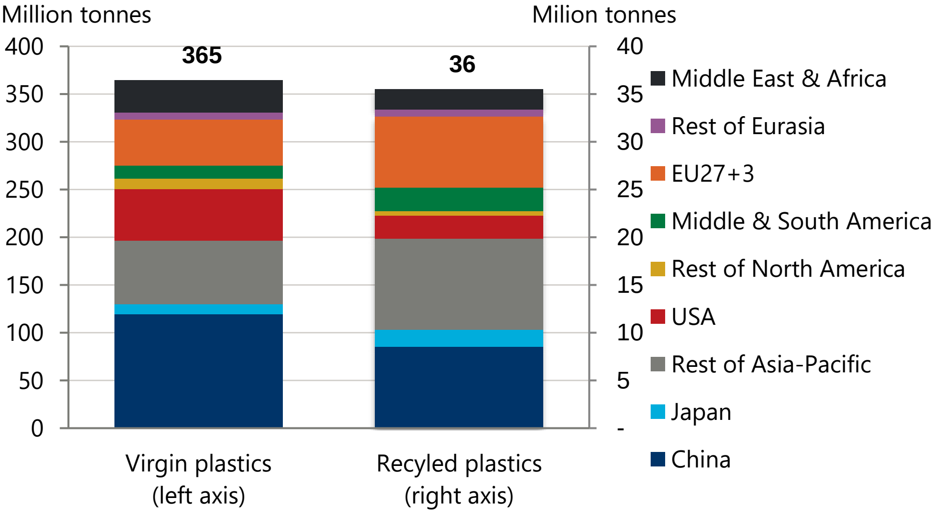
Feedstock sources

In 2022, the majority of plastics used by the manufacturing sector were fossil-based, i.e., they were produced from crude oil and/or natural gas. Some 8.9% were post-consumer recycled plastics (mechanically or chemically) and only 0.5% were derived from bio-based sources.[32]

The business case for recycling and the market for secondary plastics heavily depend on the relative cost of production of virgin and recycled plastics. Fluctuations in the price of primary polymers, which secondary plastics track closely, can greatly affect the economic viability of recycling due to the disconnect between secondary price and the costs of secondary production (e.g., waste collection, sorting, and processing).

The low share of recycled plastics masks a more encouraging trend, however—production of recycled plastics has grown by 19% over the past five years, more than twice as fast as the growth in total plastics produced (8% during 2018-22). In 2022, the largest volumes of recycled plastics were produced in Asia-Pacific countries. As illustrated in Fig. 11, while China was still a large producer (manufacturing nearly one fourth of the world's recycled plastics), other Asia-Pacific countries made up the lion's share of the recycled production (at 27% of the world total).

Fig. 11. Volumes of virgin and recycled plastics produced, by region, 2022



Source: Plastics Europe, Oxford Economics

Trade in primary plastic polymers

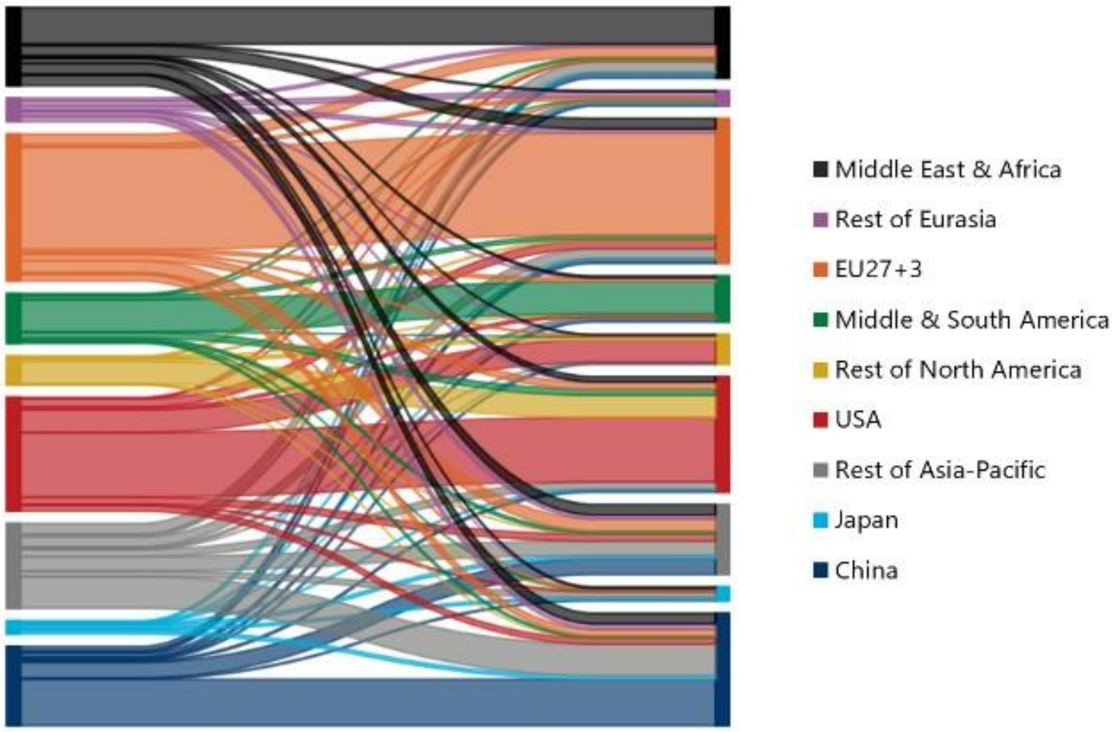
Plastic polymers in primary form are traded all across the globe. Eurasian countries, and Mexico and Canada (defined as Rest of North America in Fig. 12) are large *exporters*, with a substantial portion of their domestic production leaving the regions to reach other global markets to be manufactured into intermediate and finished goods. Notably, Mexico and Canada are also major *importers* of plastic polymers in primary form, highlighting that different regions specialise in different polymers and trade

[32] Plastics Europe, Plastics – the fast Facts 2023 (last accessed March 2024).

enables them to produce a broader range of products by leveraging each other's production capacities.

Europe and China, instead, retain a sizeable share of their domestic production for their home markets, with local product manufacturers using these plastics as intermediate inputs into the production of other goods. European countries also import a relatively small portion of polymers, suggesting that countries within the region are able to address demand for a multitude of polymers internally.

Fig. 12. Visual representation of trade flows for plastic polymers in primary form, value of sales[33]



Source: UN Comtrade (2022)

2. PLASTIC PRODUCTS MANUFACTURING

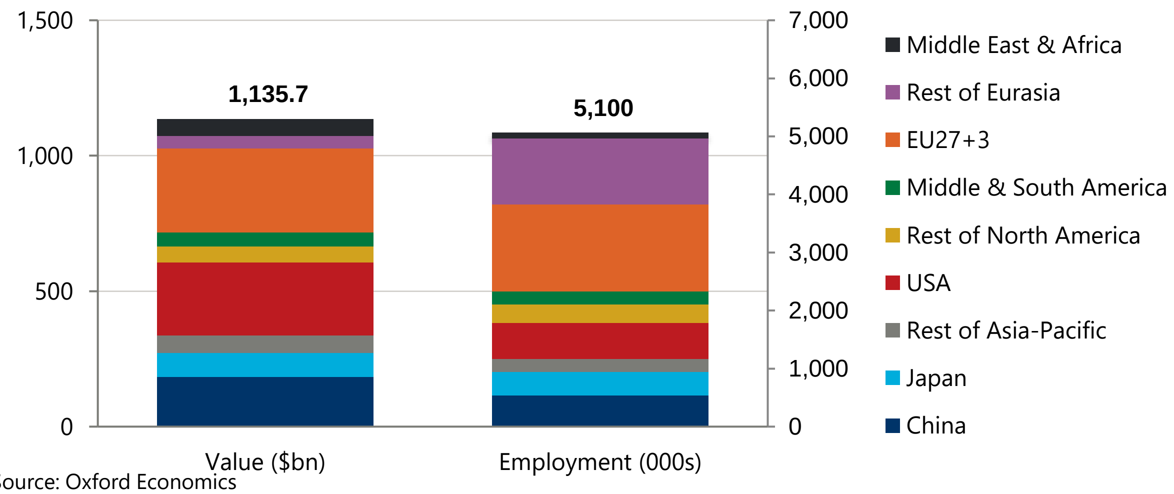
Plastic polymers in primary form are used as inputs to manufacture a host of products, some of which are finished products, others are inputs into the production of other goods (e.g., plastic components for electric vehicles, building materials, and medical equipment). The focus of this chapter is on plastic products manufacturing, or plastic converters, a rich and extremely varied industry encompassing companies as diverse as food packaging makers and residential water pipe manufacturers. This industry is highly competitive and is characterised by low margins, high labour intensity, and a

[33] This includes both virgin and recycled plastics. Unfortunately, UN Comtrade data do not distinguish between these kinds of plastics.

widespread presence of small and medium sized organisations.[34] It represents the second level in our simplified value chain illustration.

We estimate that the plastic products manufacturing industry generated revenues worth over $1.1 trillion globally in 2022, with the US and Europe each making up about a quarter of global sales (Fig. 13). Among smaller producers in absolute levels, Eurasian countries and Japan also stand out as "large" producers when considering the relative size of their economies. Comparatively, the Rest of Asia-Pacific region manufactures a much smaller share of plastic products than one would predict based on the size of its economy. The industry is estimated to employ over 5 million workers globally, with a large share of workers in Europe. Eurasian countries are estimated to employ a much larger portion of workers in the industry than would be expected based on the size of the value of their domestic industry.

Fig. 13. Value of production and employment of plastic products manufacturers, by region, 2022

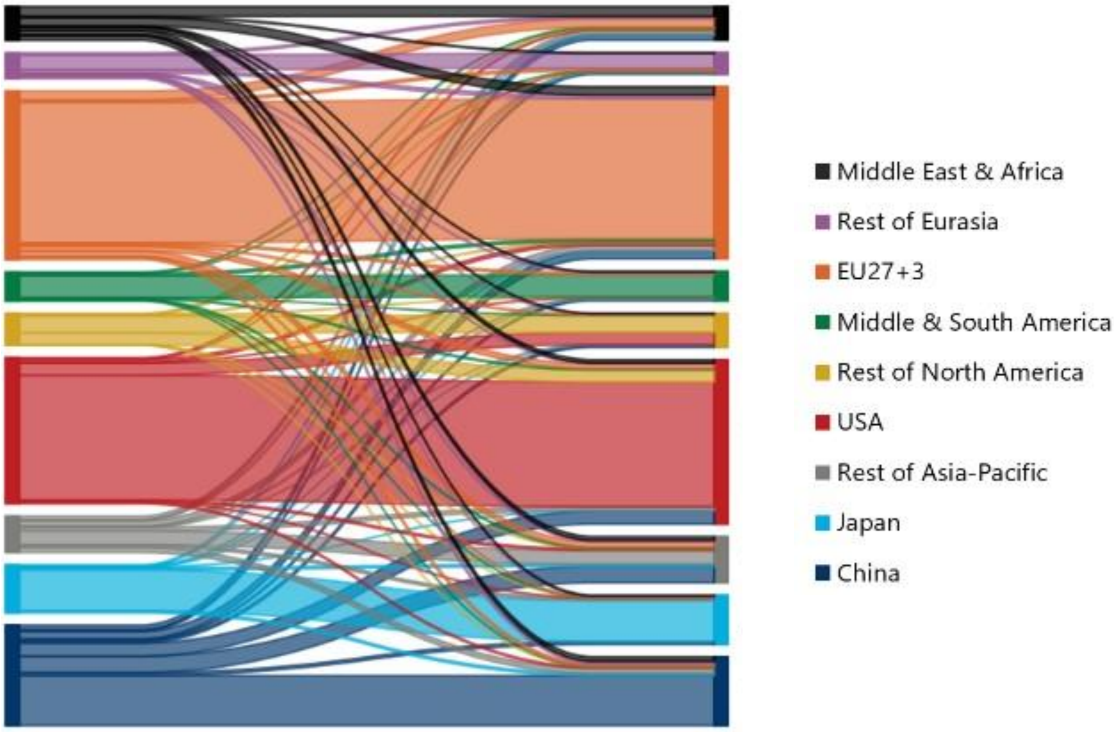


Source: Oxford Economics

Eurasian countries are also large exporters of plastic products relatively to the size of their total exports, as is China (Fig. 14). Mexico and Canada are major importers of plastic products, just like the Middle East & Africa and Eurasia regions.

[34] KPMG, The Future of Industry: Focus on Plastics Manufacturing, 2023 (last accessed March 2024).

Fig. 14. Visual representation of trade flows for plastic products, value of sales



Source: UN Comtrade (2022)

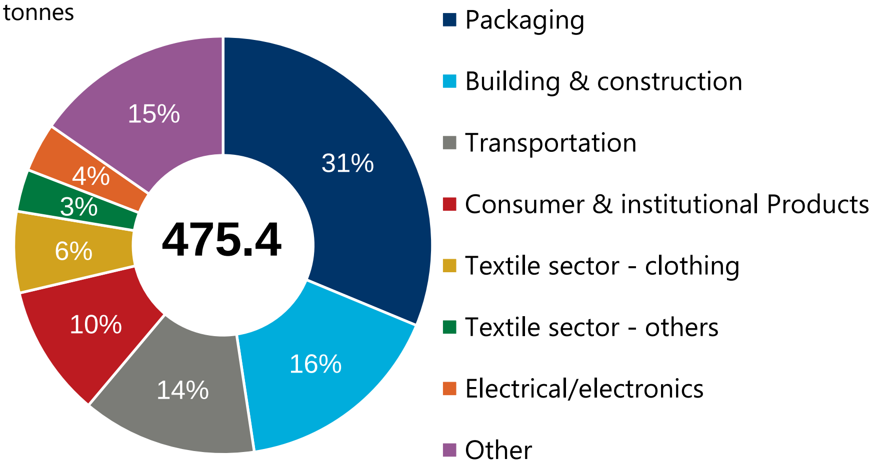
3. END USES OF PLASTICS

Core applications

Plastic products are then assembled with other inputs to manufacture finished goods that are eventually consumed by households and businesses. This represents the third level in our value chain. According to the OECD, a majority of plastics are currently used for packaging (31%), building and construction (16%), and transportation (14%), as illustrated in Fig. 15. Plastics are selected for use in each of these applications by product designers with the objective of meeting a range of product specifications, including light weighting, insulation, durability, flexibility, or to assist objectives of reducing waste, energy use, and emissions over the whole of the product's life cycle. The selection of the right material enables several plastic-containing products to remain in use for several years, with an average lifespan of 10 years, as illustrated later in this report (Fig. 18).

Fig. 15. Plastic use by application, 2022

million tonnes



Source: OECD

Rising living standards and industrialisation in developing countries is expected to drive a strong increase in the intensity of plastics use, as consumption leads to robust demand for plastics for construction and durables, such as cars. Plastics use for the production of transportation vehicles is projected to increase most over the coming decade, reflecting a rising demand for transport equipment as economies develop.[35] The production of motor vehicles is plastic intensive, especially in the context of e-mobility (see Box 2), and therefore the increase in the share of this sector in the economy also leads to an increase in economy-wide plastic intensity.

Another fast-growing category for plastics use is construction, especially in developing and emerging economies, as these activities are linked to investment in infrastructure, an essential part of economic development and urbanization.[36]

Key markets for plastic consumption

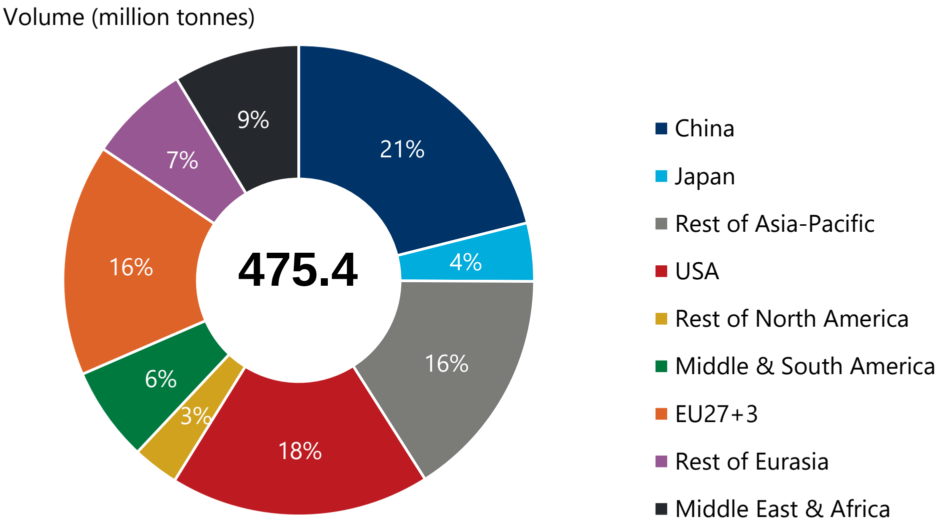
North America, Europe, and China are the primary consumers of plastics in absolute levels (Fig. 16), but when accounting for the size of their total consumer expenditure, Eurasia and China are large relative consumers of plastics, while the US consumes a relatively smaller fraction of plastics than would be implied by its share of global consumption.[37]

[35] OECD, Global Plastics Outlook: Policy Scenarios to 2060, 21 June 2022 (last accessed February 2024).

[36] OECD, Global Material Resources Outlook to 2060: Economic Drivers and Environmental Consequences, 12 February 2019 (last accessed March 2024).

[37] The economic value of the end-use industries has not been quantified in monetary terms at this stage.

Fig. 16. Volume of plastics used by region, 2022

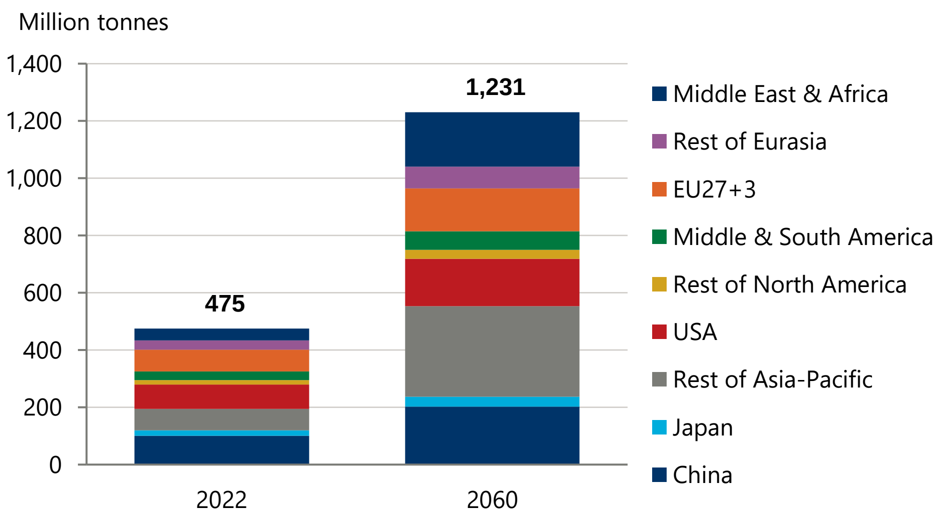


Source: OECD

Future trends

As a result of demographic shifts, combined with significant income growth, the OECD predicts that the share of plastics consumption in the Rest of Asia-Pacific will increase substantially (from 16% in 2022 to 26% of the total in 2060, see Fig. 17), mostly driven by India. The Middle East & Africa region is also projected to increase its relative consumption levels. On the other hand, developed nations such as the US and Europe are expected to see their relative contribution to global consumption decline over the next decade.

Fig. 17. Share of plastics used by region, 2022 vs 2060



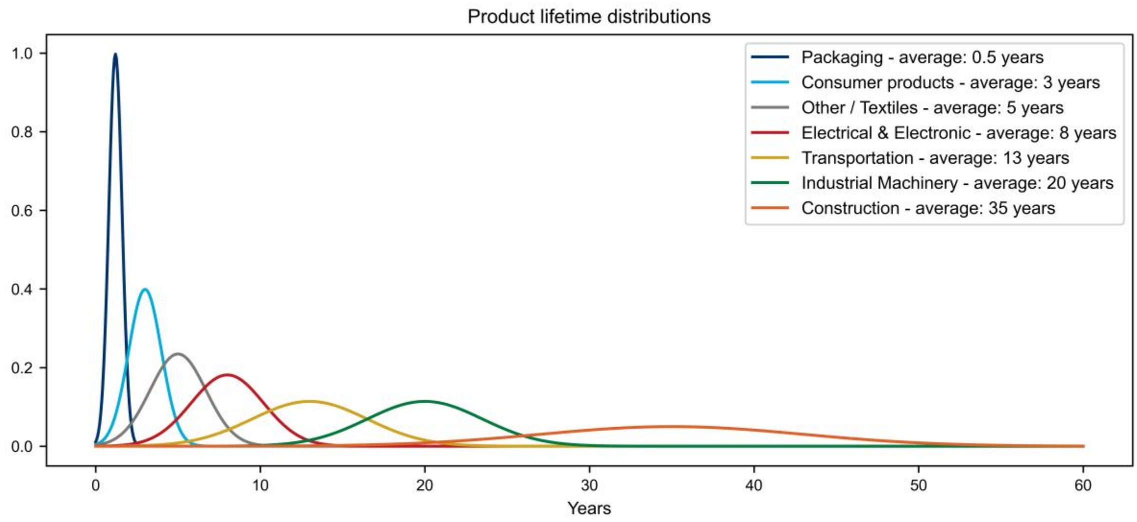
Source: OECD, Oxford Econ

4. PLASTIC WASTE AND RECYCLING

The fourth and last level in our value chain assessment is the plastics recycling sector. The size of this sector depends in large part on each country's capacity to collect and process plastic waste, so this chapter covers statistics and trends in both waste generation and recycling rates. The generation of plastic waste is strongly related to how plastics are used. The overall average lifespan of a plastic product is almost 10 years, though this ranges from the extremely short lifespan of packaging to many decades for plastic applications in the construction sector (Fig. 18).

Product lifespan significantly contributes to the prevalence of such product in the stock of pollution. For example, as a direct consequence of its short lifespan, packaging waste constitutes a large share (39%) of total plastic waste generated, and in turn pollution. In other words, packaging is characterized by a 99.6% waste-to-use conversion rate, i.e., 99.6% of the plastics used in a year become waste in that same year. This ratio is only 24.8% for plastics used in construction, for instance.

Fig. 18. Plastic products lifespan distribution

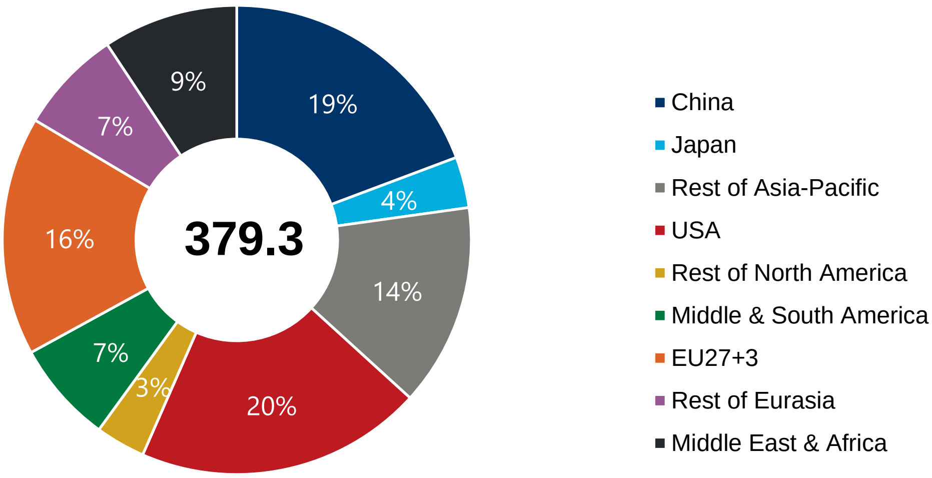


Source: Geyer, Jambeck, and Law (2017)

The OECD Global Plastics Outlook Database indicates that OECD countries generate almost half of all plastic waste, with the United States accounting for 20% and Europe for 16% of the world total (Fig. 19). To give a sense of scale, these regions account for 4% and 7% of global population, respectively. Outside the OECD, China produces 19% of global plastic waste, while making up 18% of the world's population. Consumption-to-waste ratios are fairly consistent across regions.

Fig. 19. Plastic waste generation by region, 2022

Volume (million tonnes)



Source: OECD, Oxford Economics

The end-of-life fate of plastic waste depends on local waste management capacities and regulations, which in turn are associated with the geographical, demographic, and economic characteristics of the country. Globally, 10%, or 38 million tonnes, of plastic waste was recycled in 2022.[38] EU countries, as well as Korea, Australia, and China all have above-average recycling rates.

Recycling rates for all material types, including plastics, are strongly positively correlated with GDP per capita, indicating that richer countries tend to recycle more (Fig. 20).[39] As noted previously, 3 billion people worldwide lack access to controlled waste disposal facilities. In these parts of the world, the informal economy is the main driver of recycling, incentivized by the value of some of the plastics recovered. Countries like Vietnam and the Philippines benefit greatly from the role of the informal sector to achieve their high recycling rates.

It is estimated that there are 11.4 million waste pickers worldwide.[40] For example, in Zingwangwa, Malawi, informal waste pickers recover a substantial amount of plastic, up to 20 kg per day, while in Tunisia 8,000 waste pickers collect for recycling about 5,000 out of the 8,400 tonnes per year of plastic.[41] The UN Treaty recognizes the significant contribution made by waste pickers and other workers in informal and cooperative settings to the collecting, sorting, and recycling of plastics in many countries, and one of the proposed interventions calls for improving their working conditions and integrating these workers into the plastics value chain.

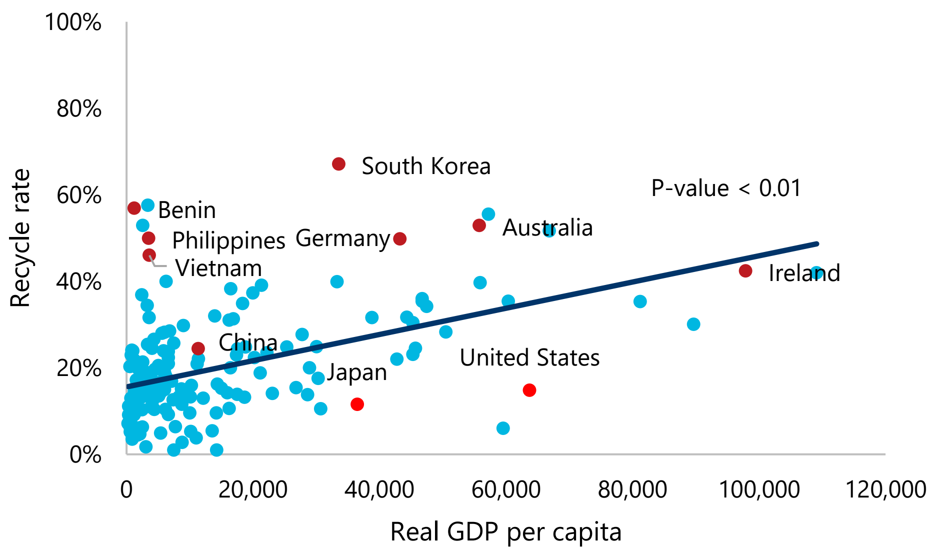
[38] OECD, Global Plastics Outlook - plastics waste by region (last accessed March 2024).

[39] Note: here we use data from the Environmental Performance Index (EPI), which measure recycling rates as the proportion of *all* recyclable materials (metal, plastic, paper, and glass) recycled in each country. This is therefore a broader concept than plastic recycling rates. These rates are computed in the country where the waste is collected and not where the waste is reprocessed, and these countries often do not coincide.

[40] Lau, W. et al., Evaluating scenarios toward zero plastic pollution. 2020, Science, 369(6510).

[41] Jandira Morais et al, Global review of human waste-picking and its contribution to poverty alleviation and a circular economy, 2022, Environ. Res. Lett. 17

Fig. 20. Recycling rate and GDP per capita[42]



Source: Oxford Economics, EPI Yale

Going forward, countries' commitments imply that recycling rates should rise steeply in Europe and Japan, with the share of plastic waste energy recovery projected to decline under a Business as Usual scenario (see Fig. 21).[43] The share of landfilling is set to increase in several non-OECD countries, especially in Asia-Pacific, thanks to better waste management and lower shares of mismanaged waste, which should translate into lower leakage. Despite this, mismanaged waste is set to remain a large portion of total plastic waste in many parts of the world.

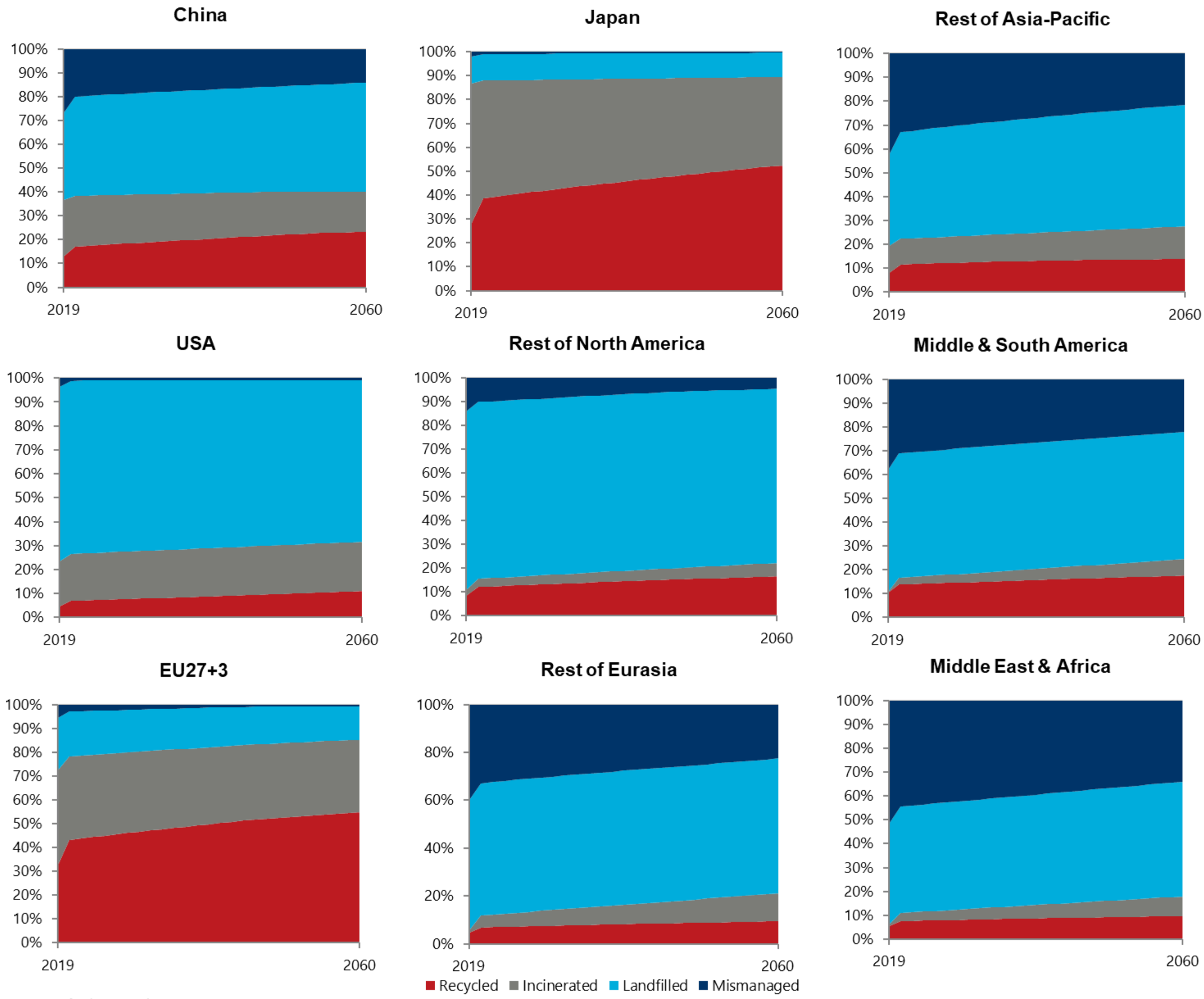
The International Labour Organization estimates that almost 6 million jobs can be created by 2030 by moving from a linear to a circular model for plastic, glass, wood pulp, metal, and mineral waste.[44] This would involve a reallocation of employment away from the mining and manufacturing sectors into waste management (recycling) and services (repair, rent). This sectoral reallocation would lead to different effects in the various regions, with employment growth estimated to be driven mostly by Latin America and the Caribbean (over 10 million jobs) and Europe (around 0.5 million jobs). In contrast, net employment losses are expected in Asia and the Pacific (around 5 million jobs), Africa (around 1 million jobs), and the Middle East (around 200,000 jobs).

[42] A p-value of 0.05 or lower is generally considered statistically significant.

[43] OECD, Global Plastic Outlook: Policy Scenarios to 2060, 21 June 2022 (last accessed March 2024). The OECD database uses the term incineration for waste that is incinerated in a state-of-the art industrial facility, either with or without energy recovery. In the developed world, however, incineration is primarily undertaken with energy recovery, which is why we have used this term in this context.

[44] ILO (2018). "World Employment Social Outlook 2018: Greening with Jobs" (last accessed March 2024).

Fig. 21. End-of-life fate of plastic waste by region, 2019 to 2060



Source: Oxford Economics, OECD

International trade in plastic waste can enable economic efficiencies by moving materials to countries with a comparative advantage in recycling plastic. For example, markets in Asia-Pacific—particularly China and India—can produce recycled material cheaply due to lower labour costs and a well-developed recycling infrastructure. On the other hand, trade in waste may lead to environmental leakage, if it is motivated by differences in the stringency or enforcement of environmental regulation.[45]

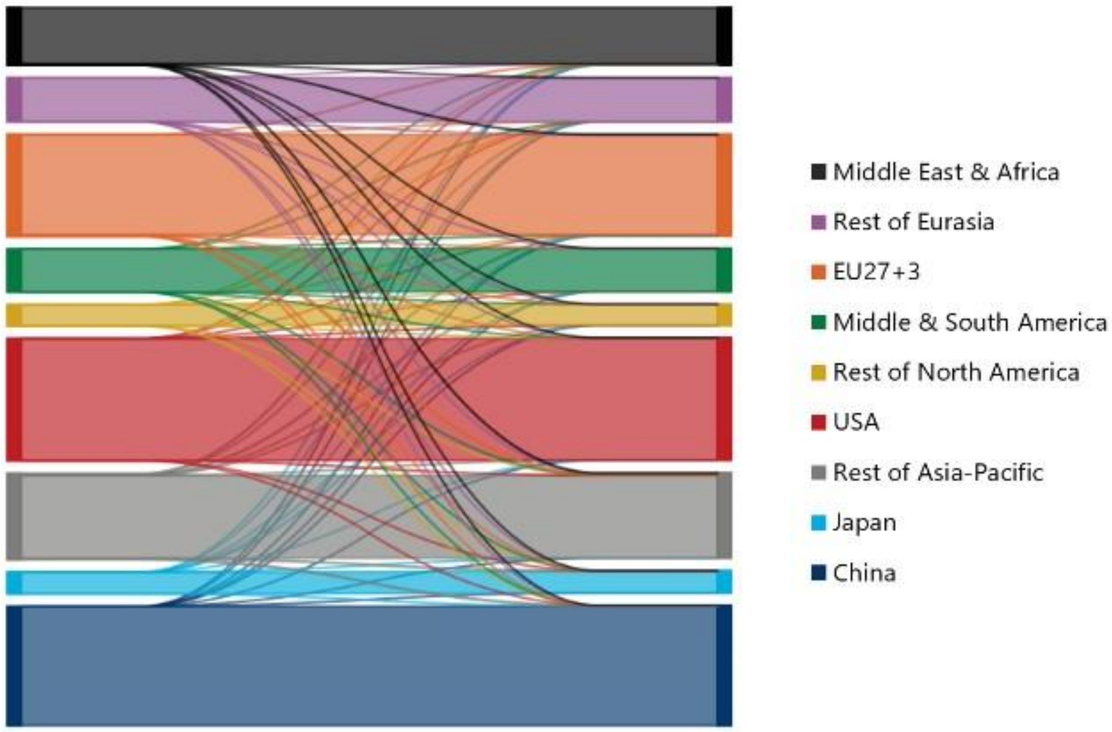
Global waste trade peaked in 2014, but then started to decrease following the introduction of strict import requirements by China, which have effectively banned the vast majority of waste exports to China from 2017. Even before this, the 1989 Basel Convention was signed to help regulate the trade of hazardous waste and to mitigate the unwanted transport of toxic shipments that governments did not consent to receiving. As a result, only about 2% of the plastic waste generated is currently traded

[45] OECD, "Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options", February, 22, 2022 (last accessed March 2024).

internationally, contrary to popular belief (Fig. 22).[46] These import restrictions have shifted trade away from traditional destinations to new markets, while simultaneously decreasing international trade volumes, and increasing the need for domestic recycling capacities.

The Rest of Asia region exports the largest portion of its plastic waste, or 4% of its total waste, with China and the European Union being the largest recipients. China, on the other hand, exports only 0.1% of its plastic waste.

Fig. 22. Visual representation of trade flows for plastic waste, volumes in metric tonnes



Source: UN Comtrade (2022)

LESSONS LEARNED FROM THE VALUE CHAIN MAPPING

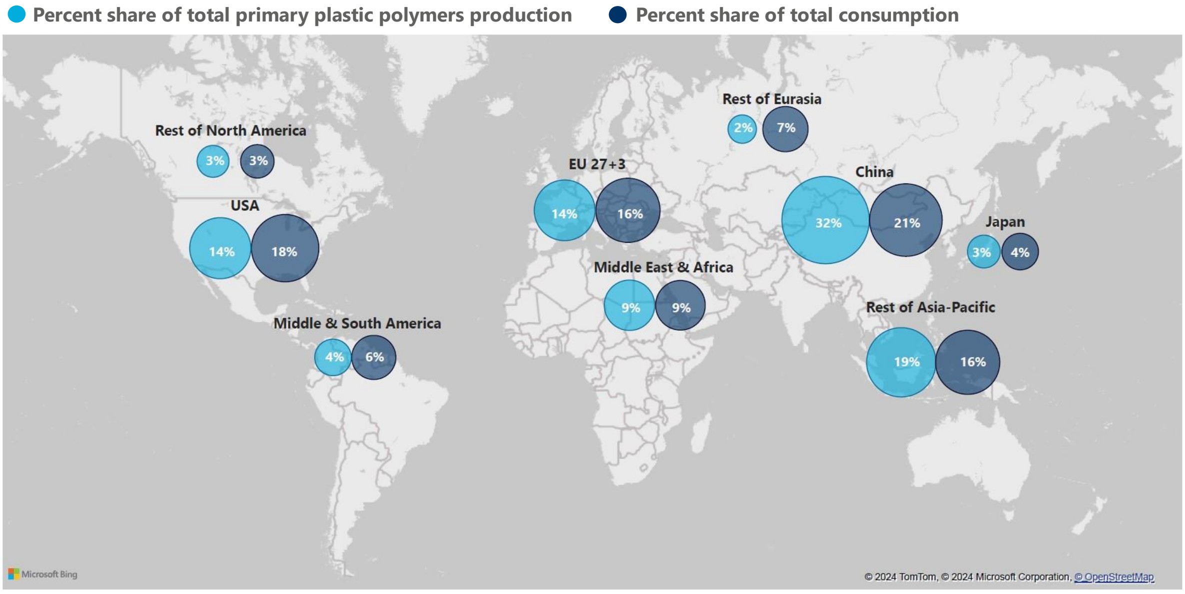
Final consumption of plastic products is much more internationally diversified than primary plastic polymer production.

A key takeaway from the analysis presented earlier in this chapter is that, while not all countries manufacture plastic polymers in primary form, each and every country consumes finished goods containing plastics. For example, the Eurasian region only produces 2% of plastic polymers in primary form, but its population consumes 7% of global plastics (Fig. 23). Similarly, the US, while being a large producer in absolute terms, is an even larger consumer of plastics. On the other hand, China produces about a third of primary plastic polymers, but "only" consumes 21% of the world total.

[46] World Economic Forum, "Charted: The key countries that trade in global plastic waste", March 15, 2023 (last accessed March 2024).

Not all economies have complete plastics value chains available to them, i.e., some countries have little or no manufacturing capacity. For example, Small Island Developing States (SIDS) are disproportionately impacted by plastic pollution, while not producing any plastics themselves. Due to their reliance on tourism as a source of income, these countries often display the same level of plastic use and waste per capita as high-income countries, without the same infrastructure of waste treatment.[47] Moreover, these islands often experience plastic pollution washing onto their shores, due to currents coming from several directions, which can hardly be controlled by these countries.

Fig. 23. Share of total plastics production and consumption by region, percentages of volumes produced/ consumed



Absolute production values do not map consistently to the relative importance of this type of economic activity.

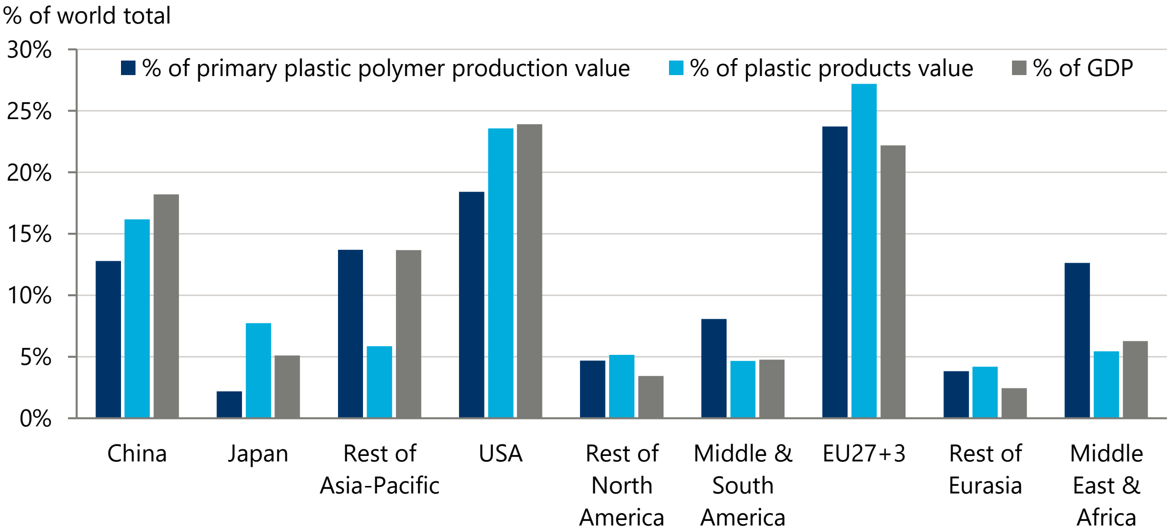
When describing the industry, emphasis is often put on large producers of plastic polymers in primary form in absolute levels, but our analysis shows some, perhaps unexpected, regions are particularly exposed to the industry when accounting for the size of their economy. For example, Fig. 24 shows that the Middle East and Africa region is responsible for 13% of the global value of plastic polymers in primary form, while creating just over 6% of global GDP.[48] On the other hand, Asia-Pacific countries (excluding China and Japan), produce about 6% of the world's plastic products in value terms, but their GDP makes up 14% of the world total. Notably, countries have different degrees of exposure to primary plastic polymer production and product manufacturing. For example, while Japan has little exposure to primary plastic polymer production, it is highly vulnerable to the plastic conversion

[47] Guillotreau P. et al., Quantifying plastic use and waste footprints in SIDS: Application to Seychelles, Journal of Cleaner Production, Volume 417, 10 September 2023

[48] As a reminder, the industry producing recycled plastics is also part of the sector manufacturing plastic polymers in primary form.

industry. This suggests that policies affecting the entire plastics value chain could also negatively affect countries that do not have a large primary plastic polymer production capacity.

Fig. 24. Percentage of world primary plastic polymers and plastic products value of production, compared with percentage of global GDP

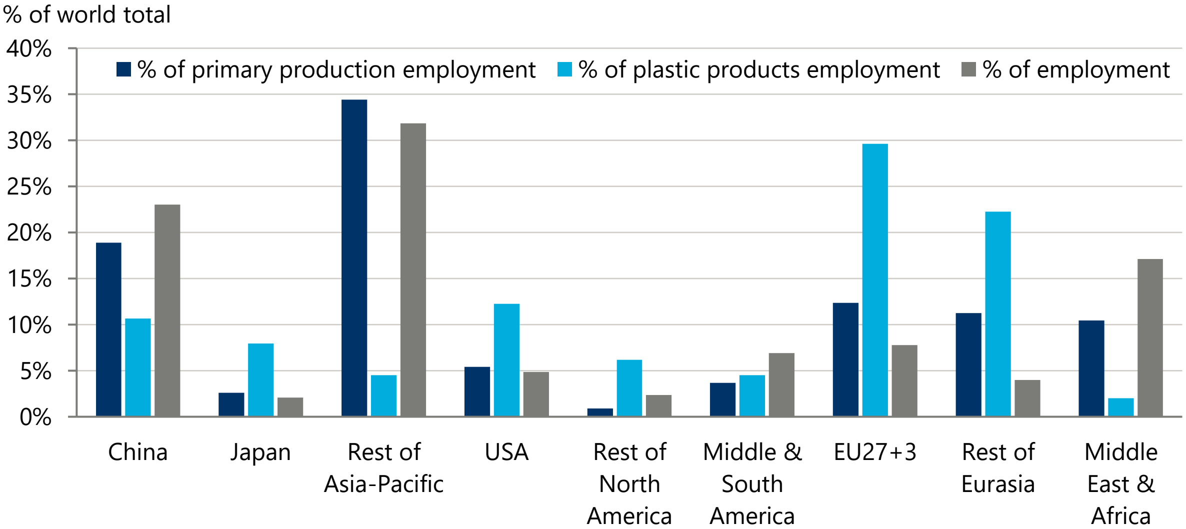


Source: Oxford Economics

The same analysis can be performed on the size of the industry workforce, by comparing it to the overall size of each region's body of workers (Fig. 25). Countries in the Rest of Eurasia region have a much greater share of workers employed in the plastics value chain (including both primary polymers and product manufacturing) than would be implied by the size of their total domestic employment. We estimate the Rest of Eurasia is home to 11% of all global workers employed in primary plastic polymer production and 22% of all workers in the manufacturing of plastic products, but its overall workforce only makes up 4% of world employment. On the other hand, Asia-Pacific (excluding China and Japan), Middle East and Africa employ a much smaller share of workers in the plastic products industry than implied by the size of their total workforce.

Due to data limitations, this study does not cover employment in plastic waste collection and sorting. However, even if we could quantify the size of this workforce globally, an important drawback of this analysis would stem from the limited ability to account for informal waste pickers, an estimated 11.4 million people worldwide, hence resulting in an underrepresentation of the global plastic-related workforce, particularly in the developing world.

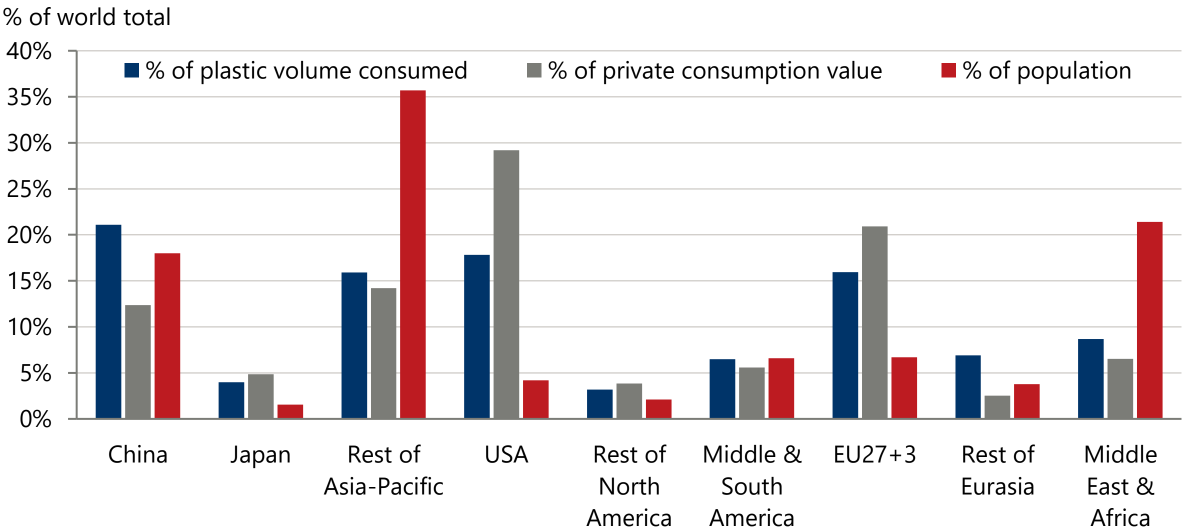
Fig. 25. Percentage of world primary plastic polymers and plastic products employment, compared with percentage of global workforce



Source: Oxford Economics

Finally, plastic consumption can also be contextualized using each region's share of global private consumption (Fig. 26). We find that the Rest of Eurasia region consumes 7% of the world's plastics in volume terms, but its private expenditure accounts for only 3% of the world total. On the other hand, the US consumes a significantly lower share of global plastics by volume compared to its (value) share of total private expenditure. When considering their population share, however, Japan, North America, and Europe are large per capita consumers of plastics, as indicated by the relative size of the blue and red bar in Fig. 26.

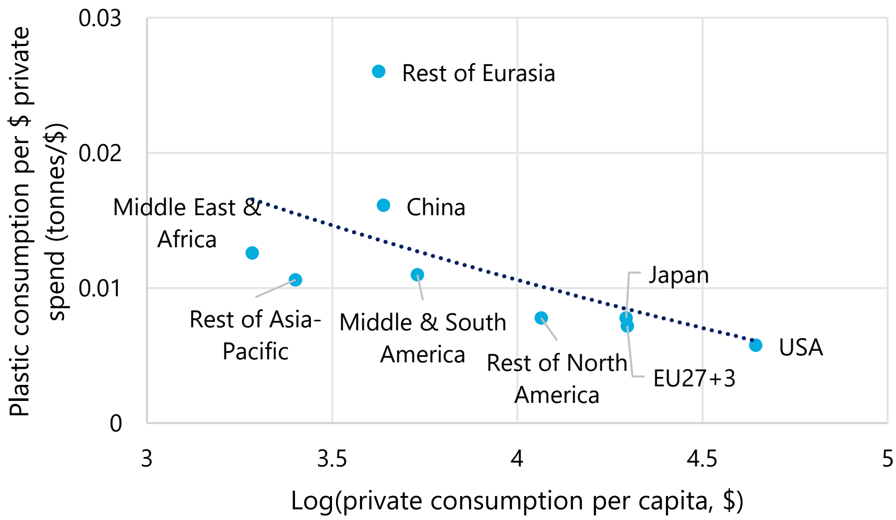
Fig. 26. Percentage of world plastic use, compared with percentage of global private consumption value and population



Source: Oxford Economics

This implies that, whilst wealthier regions of the world spend more per capita on plastic products, they spend significantly less on plastics as a share of their overall consumption. Fig. 27 illustrates that richer countries (those characterized by high private spend per capita, such as the US) tend to devote a smaller share of their total consumption to plastics.[49] This has important policy implications, some of which are discussed in chapter four for the production cap.

Fig. 27. Plastic consumption as a portion of total consumption



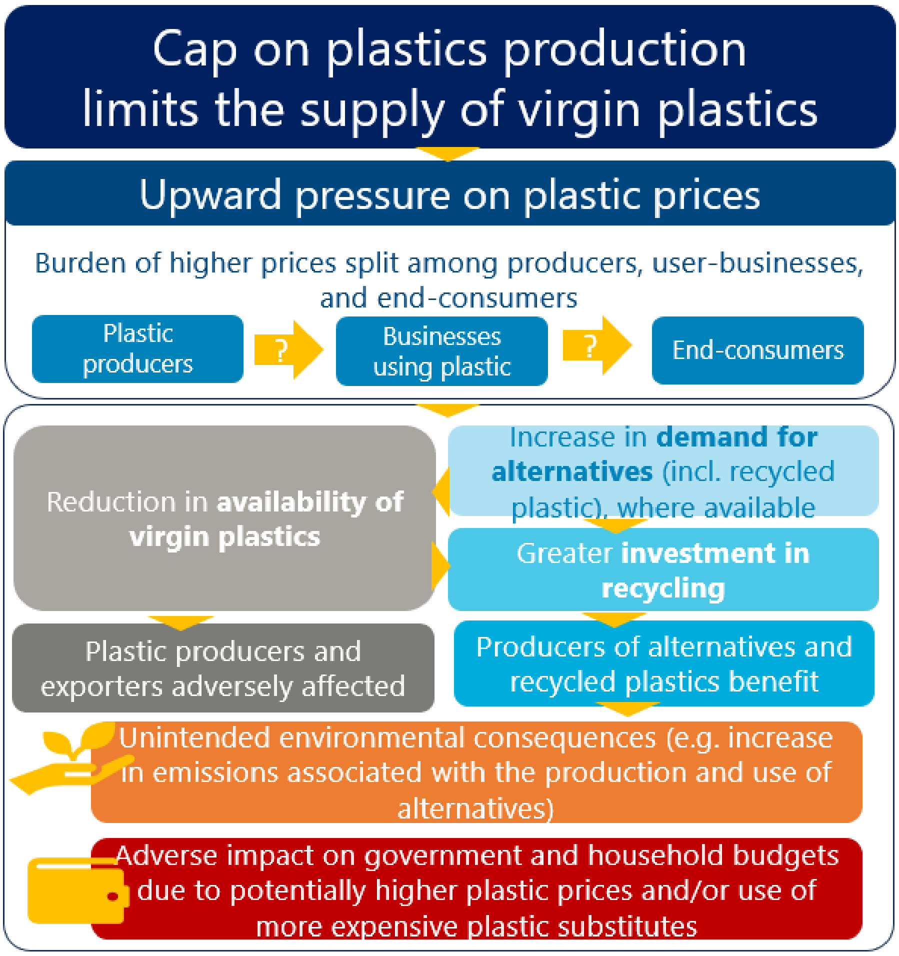
[49] Note: this assumes constant plastics prices across regions.

4. THE IMPLICATIONS OF A GLOBAL CAP ON VIRGIN PLASTICS

The increasing awareness of plastic pollution has prompted policymakers to explore potential ways to address this critical issue. One such effort at the international level is the UN resolution to end plastic pollution. As highlighted in chapter two, one of the key policies under consideration is a legally binding production cap on primary plastic polymers, the theoretical implications of which this chapter explores in detail.

As summarized in Fig. 28, a cap on virgin plastics production will constrain supply, putting upward pressure on plastic prices, which in turn may affect other businesses using plastic and also those in the production (and use) of alternatives, which could have adverse impacts on end-consumers. We discuss these impacts in more detail in the remainder of this chapter.

Fig. 28. The economic effects of a cap on the production of virgin plastics



A PRODUCTION CAP ON VIRGIN PLASTICS WILL DRIVE UP PLASTIC PRICES

A cap on production will, by design, limit the supply of plastics. Limiting supply will typically translate into higher prices, but to varying degrees depending on the severity of the production cap and other market-specific factors. The overall revenue impact on primary polymer producers remains unclear; under a production cap scenario, these companies would be selling lower volumes, but at higher prices, and the relative magnitude of these changes will determine the direction of the policy impact for producers. Primary polymer producers may also choose to prioritise the production of higher margin polymers. The technical explainer on the next page graphically illustrates how demand elasticity can affect the price impact of a cap for primary plastic polymer producers.

The availability of substitute materials is a key driver of the price increase. In applications where commercial alternatives are available, the price effects of a cap are likely to be smaller, and vice versa. For widely used polymers such as polyethylene, which is used to manufacture plastic bags as well as medical devices, limited supply and higher prices have the potential to create *competitive tension* among different industries, each trying to get hold of the remaining quantity available on the market. Similarly, polypropylene is used as a key material for motor vehicles to improve fuel efficiency, but is also used extensively in hygiene products, including baby diapers and medical personal protective equipment and gowns. It can be anticipated that industries with fewer available alternatives (e.g., medical applications) will experience higher bills to ensure access to the now scarce resource.

Another factor influencing the magnitude of the price change is the presence of scale economies of production. This refers to a situation where the average cost of production falls as production increases and can occur due to a wide range of factors. A production cap, therefore, could lead to a loss of economies of scale in production for polymer producers, which, in turn, would push up average production costs, likely exacerbating upward pressure on prices. This is a particularly acute concern for the primary plastic polymers manufacturing sector, due to its high capital intensity and large R&D investment.

In summary, we anticipate that production caps on various polymer types will affect their prices differently. The extent of the price increases depends on the factors illustrated in Fig. 29. As the cost of virgin plastics increases, alternative materials, including recycled plastics, become relatively more appealing and affordable for buyers, providing an economic incentive to switch.

Fig. 29. Factors affecting the magnitude of the price increase

Market/ policy feature	Magnitude of the price change
Severity of the cap	▲
Availability of substitutes	▼
Costly substitutes	▲
Economies of scale	▲

Economic theory suggests that the impact of the price increase is not necessarily shouldered entirely by the immediate customer (in this case manufacturers of plastic products). It is likely that the increase in prices is passed through to downstream users of the polymers, and eventually the end-consumer. In other words, the product manufacturers using plastics may face higher intermediate costs in order to continue producing their goods and may, in turn, individually choose to pass on price increases further down the value chain, and eventually to final consumers.

The extent to which the burden of higher prices remains with the producers or is shared and absorbed across the value chain depends on a range of factors, described below.

The degree of substitutability and bargaining power

The passing on of higher prices in the value chain depends on two main factors:

- the substitutability of the polymer; and
- the bargaining power of businesses and markets in global supply chains.

Producers of polymers with few substitutes have more leverage with customers, allowing them to pass on price increases more easily. The extent to which these customers, typically manufacturers using plastics as inputs, pass on the higher prices depends on their relationships with buyers and customers' demand elasticity. Generally, the less price-sensitive side of the market bears the burden of the impact. If buyers are highly sensitive to price changes, producers may absorb some costs to maintain demand. The elasticity of demand, which measures the sensitivity of demand to a change in price, is influenced by the availability of alternatives. Consumers are more price-sensitive when substitutes are readily available and inexpensive to switch to.

It should be noted, however, that even if substitutes are readily available, a shift to alternative materials often requires some form of recapitalisation (e.g., for milk packaging, replacing old filling lines with new equipment to make and then fill the new equipment). These fixed costs may result in some at least temporary cost shock for the producers.

Degree of competition

The intensity of competition among primary plastic polymer producers can be expected to influence the pass-through of costs. In more competitive markets, plastics producers would be incentivized to absorb any impact that the supply cap has on their average production costs to undercut their competitors and gain market share. However, in such highly competitive markets, businesses are often compelled to pass on these costs to their customers, as absorbing the price shock is not feasible due to tight profit margins resulting from intense competition.

TECHNICAL EXPLAINER: THE ECONOMICS OF A PRODUCTION CAP

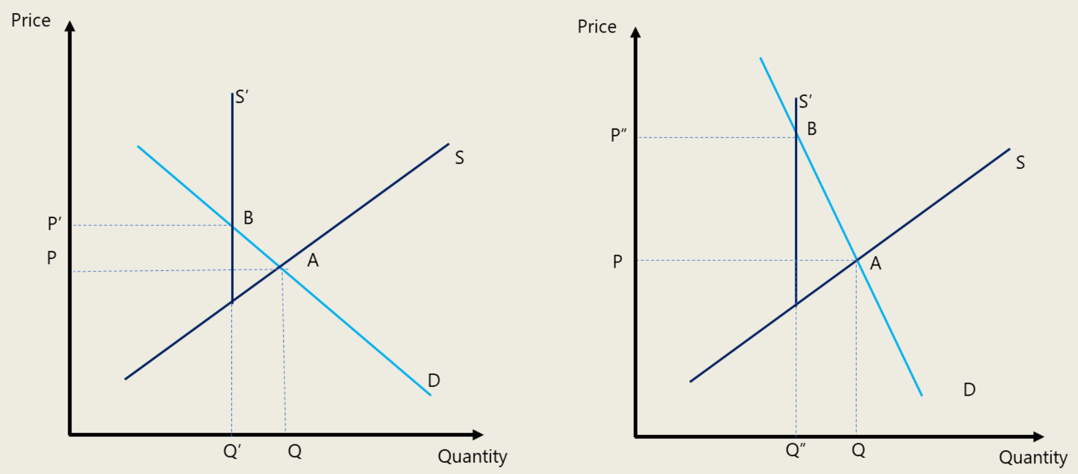
In order to explore its expected economic effects, the production cap can be conceptualized in a standard demand-supply framework, where price and quantity are determined by the intersection of these two curves. The demand curve represents the willingness to pay of buyers and is therefore downward sloping (in other words, for any price, P, the graph tells you how many people would be willing to buy the good—the higher the price, the fewer the buyers). On the other hand, supply depends on the sellers' willingness to accept money in return for the product, that is, their reservation price, and is therefore upward sloping (in other words, for any price, P, the graph tells you how many sellers would be willing to sell the good—the higher the price, the more the sellers).

The extent of the price increase depends critically on the elasticity of demand, i.e., the responsiveness of demand to changes in price. The left panel in Fig. 30 shows the conceptual framework in a hypothetical scenario with high demand elasticity, whereas the right panel shows the framework with low demand elasticity. Common examples of products with high elasticity are consumer discretionary items, such as brand-name cereal, which are easily replaced by lower-priced items. Inelastic products are usually necessities without acceptable substitutes, such as for example medical devices. In the absence of any government intervention, the market equilibrium is illustrated by point A in both elasticity scenarios.

Fig. 30. The effects of a production cap in the demand-supply framework

High demand elasticity

Low demand elasticity



Source: Oxford Economics

The introduction of a production cap can be expected to affect the supply curve. The new supply curve—denoted by S'—is now vertical at the target; no matter how high the price goes, supply will remain fixed at Q'. This will imply a shift in the market equilibrium to point B in both panels, at a lower quantity (the "capped" quantity, Q') and a higher price point (P'). In both elasticity scenarios, a more stringent supply will result in the new supply curve (S') intersecting the demand curve (D) at a higher point along the vertical axis. However, the scale of the increase will be higher in the low demand elasticity scenario (right hand panel) for any given supply cap (i.e., P" on the right-hand panel is higher than P').

HIGHER PRICES WILL INCREASE DEMAND FOR SUBSTITUTES

The higher price and lower availability of plastic polymers can be expected to push up both the price and supply volumes of alternative products.

The market for polymers does not operate in isolation; the higher prices of polymers will lead to an increase in demand for alternative materials, e.g., glass to replace plastic bottles or paper to replace plastic bags. These alternative materials are often more expensive than plastics. For example, a standard plastic grocery bag costs about a penny to produce, compared with 4-5 cents for a paper bag.[50] Similarly, aluminium is more expensive than plastic, with the raw material cost for a can about 25-30% higher than a PET bottle of a similar volume, according to consultancy Wood Mackenzie.[51] As demand shifts towards alternatives, economic theory implies that both the production volumes and the prices of these products will increase further, e.g., the price of glass bottles would rise.

This should in theory offer better margins to producers of alternative materials, including recycled plastics, and in turn improve the business case for these substitutes. In the case of recycled plastics, this should offer improved incentives to invest in waste collection and recycling technologies. However, the waste management infrastructure would need to in place and operating efficiently in order to successfully deliver this outcome. As noted, currently 3 billion people, or 38% of the global population, lack this capability.

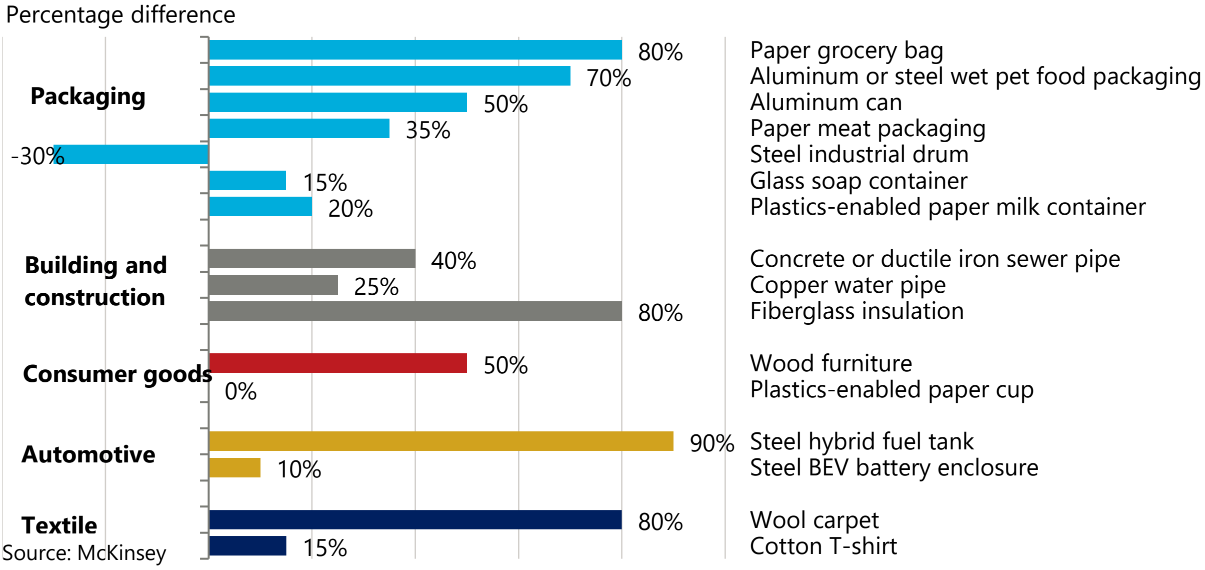
Switching towards alternative materials could have unintended consequences.

This switch to alternative materials in place of plastic can be expected to have wider consequences. The UN draft acknowledges the need to "consider possible unintended consequences and trade-offs". For example, swapping plastic for glass bottles in packaging will increase the weight of the packaged goods, which in turn will increase the transportation and climate costs. [52] Another example is the substitution of plastics in vehicles (also see Box 2), which could lead to an increase in the vehicle's weight, consequently reducing its fuel (or energy in the case of EVs) efficiency. Plastics also play a significant role in ensuring passenger safety within the vehicle and replacing them may pose safety risks.

Moreover, available evidence shows that switching towards alternatives is likely to put upward pressure on carbon emissions, certainly in the short-term. For example, plastics were found to have a lower total greenhouse gas contribution compared to alternatives in many applications, according to recent studies (Fig. 31).[53] Similarly, research by Trucost using "natural capital" valuation methods, found that the environmental cost of plastic in consumer goods is currently 3.8 times less than the alternative materials needed to replace plastic.[54] Additional examples, presented later in this chapter, highlight how plastic use can contribute positively to environmental outcomes. Lifecycle assessments can be a critical tool for policymakers looking to evaluate the merits of alternative materials and design evidence-based environmental policies.

[50] The New York Times, "Taking Aim at All Those Plastic Bags", April 1, 2007 (last accessed March 2024).
[51] Reuters, "Plastic bottles vs aluminium cans - who'll win the global water fight?", October 17, 2019 (last accessed March 2024).
[52] McKinsey & Co., "Climate impact of plastics", July 2022 (last accessed February 2024).
[53] Ibid. Meng et al., "Replacing Plastics with Alternatives Is Worse for Greenhouse Gas Emissions in Most Cases", Environ. Sci. Technol. 2024, 58, 6, 2716–2727.
[54] Lord, R. "Plastics and sustainability: a valuation of environmental benefits, costs and opportunities for continuous improvement." Trucost is an affiliate of S&P Global Market Intelligence (2020 S&P Trucost Limited, an affiliate of S&P Global Market Intelligence) (2016).

Fig. 31. Percentage difference in total greenhouse gas contributions in the US from switching from plastics to alternatives



Source: McKinsey

HIGHER PRICES WILL NEGATIVELY AFFECT CONSUMER WELFARE

Higher prices and production costs will push up the cost of living, negatively impacting consumers.

As was documented in chapter three, plastics play a fundamental role in various goods and services consumed globally, both directly and indirectly. To the extent that higher prices of plastic polymers are passed through to end users, consumers will, therefore, suffer a loss of real purchasing power. This could be exacerbated by transition costs that would be experienced by businesses that have been forced to switch away from plastics to alternative products. This effect would be especially strong for consumers of products for whom plastic alternatives are not commercially or technically viable (e.g., several medical applications, as well as many infrastructure and transportation use cases). While some may argue that such price increase will lead to a more conscious consumption, there are some important considerations to make on the distributional effects of these shifts.

In general, we can expect these effects to disproportionately affect low-income households and countries.

While this inflationary pressure would affect all consumers, we can expect that the burden of higher prices will fall disproportionately on low-income households and countries. This is because, as shown in chapter three, whilst wealthier regions of the world spend more per capita on plastic products, they spend significantly less on plastics as a share of their overall consumption. The latter is a more effective predictor of the *proportionate* burden that is imposed by an inflationary shock.

This has implications for policymakers evaluating these effects both across countries (we anticipate that the impact will be relatively more harmful to countries with lower-than-average incomes) and within countries (households with lower-than-average income will suffer relatively more). In other words, this finding suggests that the principle of a *just* transition advocated for in the current UN draft may not be satisfied with the implementation of a production cap.

Moreover, it can be expected that highly import-dependent countries, including SIDS for example, would be especially vulnerable to the introduction of policies curbing plastic supply, compared to plastic-producing economies. Indeed, the latter are better able to add recycled materials into their product manufacturing mix, while non-producing countries would necessarily need to rely on imported materials.

BOX 1: FOOD PACKAGING

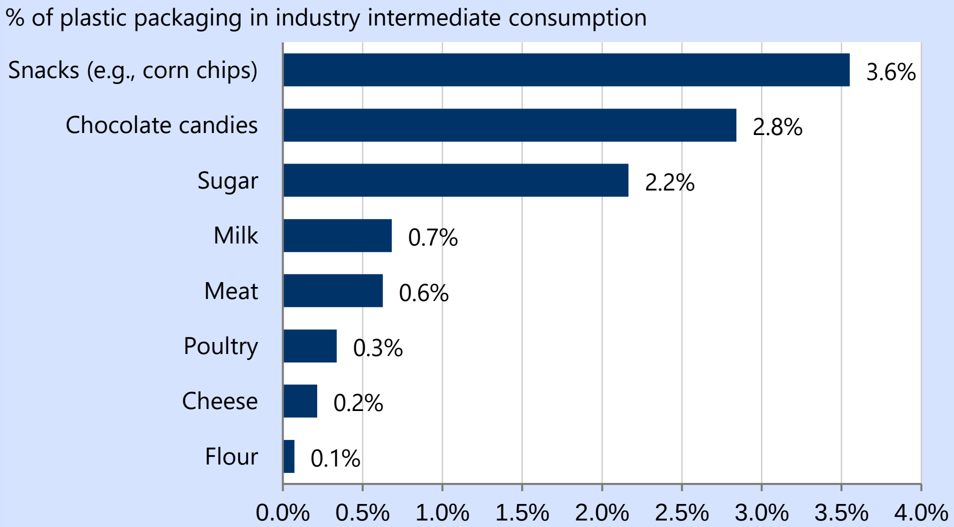
Plastics are widely used as packaging material in the food industry, from condiment bottles to grain bags used in humanitarian assistance. Their ability to protect the food from degradation, preserve it for longer, and make it easier to transport over great distances made plastics a first choice for many food manufacturers. Its relatively low cost further facilitated its widespread use.

A production cap would push up virgin plastic prices affecting businesses along the value chain.

A production cap on virgin plastics can be expected to affect all the polymers predominantly used in the food packaging process, including PET, PE, and PP. As described earlier in this chapter, there would be an initial *direct* effect of the cap on the food packaging industry itself. This would materialize as a cost shock due to the increase in the price of primary plastic polymers.

In addition, we would expect there to be an *indirect* effect along the value chain, as plastic packaging is used as an input into the food manufacturing industry. Fig. 32 displays US data showing the food sectors relying the most (and the least) on plastic packaging. This reveals significant variation in the share of intermediate costs that are accounted for by plastic packaging across different food product categories. For example, nearly 4% of snack manufacturers intermediate spending goes to plastic packaging producers, while for makers of flour, this is only 0.1%, on average. In general, we would expect that the impact on the final consumer prices of snacks will be larger, all else equal.

Fig. 32. Percentage of plastic packaging in intermediate consumption, US



Source: IMPLAN

The current availability of non-plastic packaging alternatives will influence the scale of the initial price increase.

As described, the extent of pass-through depends on a range of factors. For some foods, e.g., yogurt, alternative packaging materials are already used (albeit often at a higher price, e.g., glass jars). Due to greater substitutability, it can be expected that the initial price increase will be smaller, all else equal, with plastic packaging producers more likely to absorb the cost. For other food products, e.g., fresh meat, alternative packaging materials with similar qualities are much less widely available. As a result, it can be expected that packaging producers will pass through the price increase associated with the cap further down the value chain.

In addition, the limited supply may lead producers to prioritize the use of the remaining plastics in higher-value goods (e.g., steak packaging as opposed to minced meat packaging), which are typically consumed by higher income households/ countries. This has the potential to create competitive tension among different industries, each trying to get hold of the remaining quantity available on the market.

The scale of substitution to alternatives may also be affected by existing regulations.

The scale and type of substitution effects that can be expected to result from the production cap will also be influenced by non-commercial factors. For example, in the United States, the Food and Drug Administration (FDA) imposes very stringent conditions on packaging for food-grade products. The nature of these regulations currently creates substantial hurdles for producers seeking to use recycled or reused plastics in this manner. This implies that, in food contact applications, new technologies such as chemical recycling will need to be deployed at scale in order to create recycled materials for the food industry.

The scope for unintended consequences in the case of food packaging is relatively high.

Plastic packaging is known to preserve products for longer, which reduces waste by giving people more time to use or consume them before it is no longer suitable to do so. This implies that one of the *unintended consequences* of switching to alternative materials could be an overall increase in food waste, leading to substantial economic losses, lower productivity, economic inefficiency, and shoppers having to pay higher food prices to account for the inefficiencies that create this waste. Moreover, food waste has a significant environmental impact, particularly in the form of carbon footprint. This would also negatively contribute to Sustainable Development Goal 12.3, which aims to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" by 2030.[55]

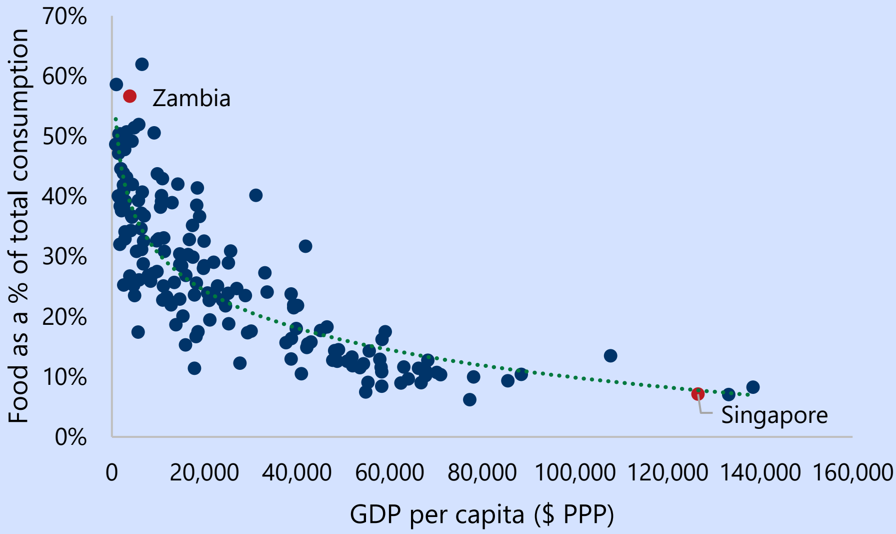
Other unintended environmental consequences of substitution may derive from non-plastic packaging being heavier and taking up more space than plastics. A study by McKinsey shows that plastic food packaging typically has lower GHG emissions over the life cycle, including both direct and value-chain emissions. For example, the study found that plastic wet food packaging supported a 70% lower GHG emissions than aluminium or steel packaging, and fresh meat plastic packaging was associated with a 35% emission saving compared to paper packaging (Fig. 31).[56] Within food packaging, a recent EU Commission report finds that single-use and reusable packaging demonstrate either lower or higher environmental impacts, depending on the use case and scenario considered.[57]

The impact on low-income households and countries should be a particularly acute concern for food packaging.

As noted, the overall impact of higher prices is expected to weigh disproportionately on below-average income *households* since available evidence suggests that these products are income inelastic on average. This issue can be expected to be particularly acute in the case of food packaging since food typically accounts for a significantly higher fraction of spending for lower income households. For example, the 2022 Consumer Expenditure Survey shows that, as their incomes rise, US households spend a smaller share of their income on food (31.2 % of income for the lowest income quintile vs 8.0% for the highest income quintile).[58] In addition to these within-country dynamics, lower income *countries* also spend a much higher share of expenditures on food than higher income countries, as illustrated in Fig. 33.

[55] UN SDG 12 Hub, "Target 12.3: Food loss & waste" (last accessed February 2024).
[56] McKinsey & Co., "Climate impact of plastics", July 2022 (last accessed February 2024).
[57] European Commission Joint Research Centre, "Exploring the environmental performance of alternative food packaging products in the European Union", February 2024 (last accessed February 2024).
[58] US Department of Agriculture, Food Prices and Spending, February 2024 (last accessed March 2024).

Fig. 33. Food expenditure as a share of total consumption, by GDP per capita



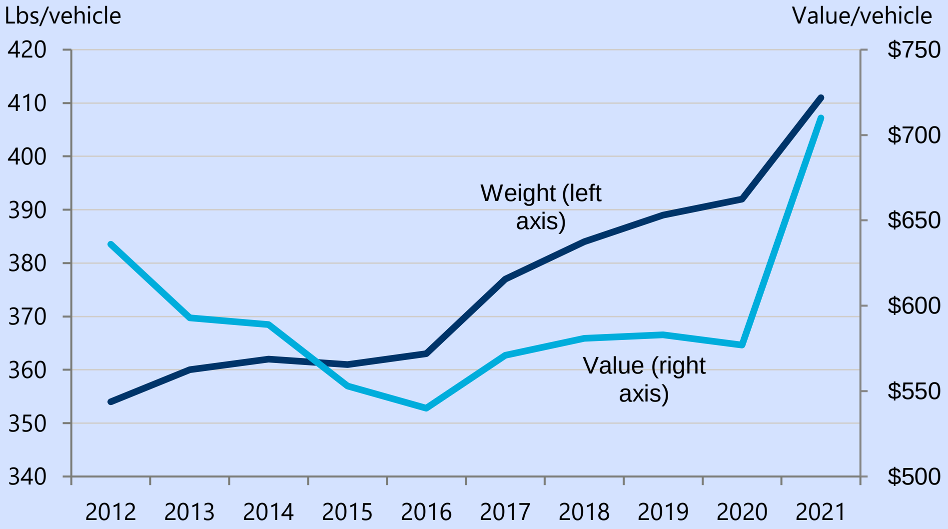
BOX 2: PLASTICS IN AUTOMOBILES

Automobiles owe much of their lightweight, fuel-efficient, and safe design to plastics. Plastics play a crucial role by reducing vehicle weight, enhancing fuel efficiency, and providing safety features including seatbelts and airbags.

According to estimates from the American Chemistry Council, each vehicle contains over $4,000 worth of plastics, synthetic, and other chemistry products. Plastics and composites constitute about 10% of the average vehicle's weight.[59] This share of plastics in both value and volume has been steadily increasing for the past few years (Fig. 34), and with the anticipated growth in automobile use, especially in emerging economies, and uptick in e-mobility, the reliance on plastics in vehicle manufacturing is expected to rise further.

[59] This includes $710 in plastics and polymer composites, $651 in synthetic rubber and elastomers, $540 in semiconductors and other electronic chemicals, $324 in fluids and lubricants, and $241 in textiles, along with hundreds of dollars' worth of other products of chemistry. American Chemistry Council, Chemistry and Automobiles, February 2023 (last accessed March 2024).

Fig. 34. Weight and value of plastics and polymer composites in the average vehicle



Source: American Chemistry Council

The burden of higher prices is likely to be borne most intensively by end-consumers.

A cap on the production of virgin plastics will limit the availability of plastics for use in the manufacture of automobiles and, therefore, increase the price of relevant polymers. Evidence from various studies indicates that industry-wide cost increases (such as would be imposed by a plastics production cap) have typically been largely passed through to end-consumers.[60] These will include both consumers who use automobiles for their own personal use and businesses across a wide range of sectors that use automobiles as part of their operations.

Moreover, as the quantity of virgin plastics available declines in the aftermath of a production cap, producers may choose to prioritize the use of the remaining plastics in higher-value products (e.g., luxury cars as opposed to sedans). Therefore, lower-income buyers could be expected to forego some of the safety and fuel efficiency advances enabled by plastics.

The importance of electric vehicles to the carbon transition underscores the risk of unintended consequences.

The limited availability of plastics will also encourage auto manufacturers to look for alternative materials. This could potentially reverse the gains in fuel efficiency and safety made by automobile manufacturers in recent years. Plastics play a crucial role in making vehicles lighter, thus reducing fuel consumption, a particularly pertinent factor for electric vehicles (EVs).

Market trends and policy initiatives in key car markets are supporting a positive outlook for electric car sales. According to the International Energy Agency (IEA), the global outlook for the proportion of EV sales based on current policies and definite goals is 35% in 2030, up from 13% in 2022.[61]

Industry sources suggests that EVs contain twice the amount of polymers compared to traditional automobiles,[62] suggesting that the impact of plastic price changes on the final consumer prices of EVs will be larger than for traditional cars, all else equal. Moreover, the use of polymers helps make the vehicle lighter, offsetting the weight of their batteries. Limits on the use of plastics have the potential, therefore, to hinder the progress to reduce automobile-related emissions by slowing the development of EVs. For example, McKinsey (2020) found that the use of plastics to make hybrid fuel tanks or EV battery top enclosure could help reduce GHG emissions by between 10% and 90% over the life cycle of these components (Fig. 31).[63]

60 Gron, Anne, and Deborah L. Swenson. Cost pass-through in the US automobile market. Review of Economics and Statistics 82, no. 2 (2000): 316-324.

[61] IEA, Prospects for electric vehicle deployment, April 2023 (last accessed March 2024).

[62] Estimates based on expert inputs provided for this project by the American Chemistry Council.

[63] McKinsey & Co., Climate impact of plastics, July 2022 (last accessed February 2024).

5. ALTERNATIVE POLICY OPTIONS

A range of other policy instruments, besides a production cap, could be used to influence the behaviour of market participants and in turn reduce plastic pollution. As a precursor to our future analytical work, this chapter introduces and discusses the advantages and disadvantages of a selection of these alternatives.

A framework to categorise policy options.

Combatting the issue of plastic pollution will require a multi-pronged approach. At a high-level, there are two main *channels* through which a reduction in plastic pollution can be achieved:[64]

- **Reduce demand for plastic**: this can be achieved by either increasing the price/ limiting the availability of plastics, or by increasing circularity (e.g., enhancing the rate at which plastic products are re-used, growing the share of recycled plastic used in production).
- **Close leakage pathways**: or decrease the rate at which plastic waste leaks into the environment. As noted, not all plastic waste transforms into pollution, hence this policy channel aims to target pollution directly, by reducing the share of mismanaged waste.

To facilitate these changes, policymakers have a range of tools or *instruments* available to them. Broadly, these can be grouped into three categories: **regulatory**, **economic,** and **informative/ behavioural**, as follows.[65]

1. Regulatory measures are those that impose a **legal restriction** on economic behaviour.[66] Examples include mandated product standards and production or consumption bans (or caps).
2. Economic instruments involve seeking to directly **change incentives** that are faced by producers and consumers and, therefore, their behaviour, through the working of the market. Examples include taxes, subsidies, fees, and deposit return schemes (DRS).
3. Informative and behavioural measures are designed to influence behaviour through the **provision of information** or other non-financial mechanisms. Examples include awareness campaigns, educational programmes, and product labelling.

Fig. 35 maps the impact channels to the policy instrument categories to design a framework that can be used to classify alternative policy tools. The matrix is populated with examples of policies that have been introduced or have been proposed.

[64] OECD, Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options, February, 22, 2022 (last accessed April 2024). It should be noted that these two channels only address *flows* of plastic waste, but no not deal with existing *stocks* of pollution, which would still need to be cleaned up. Removing plastic from the environment could entail for instance beach clean-up activities or installing river litter booms that capture plastics before they flow into oceans.
[65] World Bank Group, "Where Is the Value in the Chain? Pathways out of Plastic Pollution", 2022 (last accessed March 2024).
[66] As such, we would view policy targets as distinct from a regulatory instrument. Targets provide a quantitative definition of a policy objective. Through a signalling effect, target setting may influence economic behaviour but, without supplementary intervention, this effect can be expected to diminish over time.

Fig. 35. Selected policy examples by impact channel and instrument type

	Reduce demand		Reduce pollution incidence
	Increase price/ limit availability	Increase circularity	Close leakage pathways
Regulatory	Production cap as envisaged in the current draft UN treaty.	California mandate for plastic beverage bottles to contain an average of 25% recycled plastic in 2025 and 50% by 2030.	Basel convention to stop exports of waste to countries without environmentally sound waste management.
Economic	Levy on single-use polyethylene bags in Fiji.	France's modulated EPR fees paid by producers to subsidize circular product designs.	Financial support for new sanitary landfills from Brazil's federal government.
Informative and behavioral	Nudging behavioral changes (*#CutOutCutlery* campaign to change default settings so that plastic cutlery is provided upon request only).	Awareness-raising campaigns (EU *Be Ready to Change* campaign to deter the use of single-use plastic products and packaging).	Awareness-raising campaigns (*Keep plastics off our parks* campaign addressed to Kenya's national parks visitors).

Applying economic theory to this framework

While a formal evaluation of these alternatives is out of the scope of this study, we nonetheless can draw on economic theory to assess the expected relative pros and cons of different options.

Each policy *channel* comes with its own set of strengths and weaknesses.

- As highlighted in chapter four, policies aimed at curbing plastics demand through price increases or limits to availability are associated with **economic costs** and risks for potential **unintended environmental consequences**. Many of the economic costs are expected to be shouldered by consumers, especially lower income ones.
- Policies aimed at curbing demand through enhanced circularity, instead, would not suffer from these downsides, while still **boosting demand for recycled materials**.
- Lastly, closing leakage pathways can be regarded as a **necessary condition** to reduce pollution levels, and is therefore an essential component of any initiative targeting plastic pollution. However, in many parts of the world it may be prohibitively expensive, due to the vast need for infrastructure investment. As a result of this, public sector involvement is relatively more prevalent for this policy channel.

Similarly, **policy *instruments* have different pros and cons.**

- Compared to regulatory measures, economic instruments can be expected to deliver more **economically efficient** outcomes since they enable market participants to adapt their behavior according to incentives rather than enforcing change.
- For economic instruments, funds collected can also be **earmarked towards waste management** infrastructure enhancements, further contributing to achieving desired pollution reduction targets.
- Within regulatory instruments, **mandates**, which stipulate rules according to targets and penalize non-compliant parties with fines, can be expected to be **more economically efficient** than **bans or caps.** The latter wholly eliminate market mechanisms and prevent affected parties from adapting their behavior according to economic incentives, as well as not providing incentives to innovate.

- The **effectiveness** of **regulatory measures** in affecting behavioral change depends on the **strictness and severity of the enforcement mechanism,** e.g., the scale of penalties for non-compliance and the extent to which adequate monitoring systems are in place.
- **Informative tools have relatively limited applicability**, as they are mostly targeted at consumer-facing plastic uses and cannot reach other large categories of plastic applications. As a consequence, they tend to be insufficient as a sole policy response.

Concluding thoughts

In light of these advantages and disadvantages, **policymakers need to be open to applying multiple solutions** at once. For example, a multi-faceted policy response including awareness campaigns about recycling alongside with public investment in waste management can yield more positive results than the two policies in isolation. Similarly, policies aimed at curbing demand for plastics are more likely to be environmentally effective if accompanied by interventions to close leakage pathways. As all interventions within a policymaker's toolkit come with their own set of trade-offs, combining measures in different doses has the potential to dilute these and spread the burden more evenly.

More broadly, irrespective of the policy options implemented, our research has highlighted significant **deficiencies** in the **quality and depth of available data** describing the plastics value chain. This is currently a **barrier to good policymaking** since it undermines attempts to accurately assess *ex ante* the expected impact of any intervention affecting the industry.

Having access to data that enable **tracking and monitoring of progress versus targets is integral to effective governance**. While it remains challenging to attribute outcomes to individual interventions, especially when multiple policy levers are leveraged at the same time, having access to metrics to monitor changes across environmental, economic, and social dimensions is vital for policymakers.

Accurate data is an invaluable tool to policymakers both for informing decisions *ex ante* and evaluating the implications of policy reforms *ex post*. The latter is particularly important for policymakers seeking to understand whether and how they need to course correct. As such, **investments to enhance the quality of available data** on the plastics sector can be expected to have a relatively high rate of return given the prevailing policy context.

As highlighted in chapter four, the introduction of a production cap would carry risks—both in terms of **economic costs and unintended environmental consequences**. Policymakers will clearly want to **weigh these carefully against the expected benefits** created by the associated reduction in plastic pollution. As such, setting an appropriate *level* for any cap, particularly given data constraints, would be a highly complex task and fraught with complexity.

6. CONCLUSION

In most cases, the implementation of economic policies entails trade-offs and carries potential risks for unintended consequences. It is our strong belief that economic policymaking can be informed and enhanced by insights derived through high-quality economic modelling and analysis. Judicious application of these tools can help policymakers to gauge the likely direction, scale, and type of effects that result from interventions that are designed to distort market behaviour in pursuit of wider social objectives. This knowledge, in turn, can support more effective decision-making.

The type of policies that are contemplated in the draft UN instrument, including the production cap, are ambitious in scale and global in scope. All these policies, from limiting supply to introducing EPR programmes, foresee systemic changes that would affect the entire plastics value chain. Accordingly, they require a sophisticated and extensive modelling framework, the starting point for which is a database that describes the international structure of the global value chain, from production of polymers all the way to waste disposal. To our knowledge, such a dataset has not been developed previously. The very fragmented state of current data has perhaps contributed to a perception that the plastics industry remains somewhat misunderstood.

A key activity in this first phase of our research programme has, therefore, been to estimate such a database, drawing on information and intelligence from a very wide range of sources. We anticipate that this will act as a critical foundation for a model that will be used to quantitatively compare the consequences of alternative policy instruments across different verticals. For this report, we have combined the evidence from the value chain estimation with economic theory to derive a set of insights that we consider should be instructive for policymakers:

- Plastics are used in an extensive range of applications, from packaged groceries to state-of-the-art medical supplies. The overall average lifespan of a plastic product is almost 10 years, ranging from the extremely short lifespan of packaging to many decades for applications in the construction sector. Product lifespan significantly contributes to the prevalence of such product in the stock of pollution, with shorter-term applications constituting a relatively large share of waste generation.
- In addition to curbing availability, a production cap on virgin plastics can be expected to cause an increase in prices across all applications, from short-lived packaging to long-lasting applications in the construction sector. Price increases can be expected to be more significant for polymers that have fewer current commercial substitutes.
- While different polymers and applications will be affected to varying degrees by the introduction of a cap, it will be impossible to fully exempt specific applications from any pricing effects from a cap, including the 3 exemptions currently considered in the UN draft (medical, emergency relief, and scientific research). Indeed, the production cap would be imposed at the primary polymer level and polymers are not unique to specific applications. For example, polypropylene is commonly used to produce woven bags to store food such as beans, wheat, and other items in humanitarian assistance, but is also widely used in the packaging industry to make yogurt containers and hot beverage cups.

- Higher prices of polymers can be expected to ripple through the value chain, pushing up production costs for manufacturers and, eventually, contributing to increases in the end-use prices of the very large range of products that rely on plastics as an input.
- Although households in high-income countries consume significantly more plastics per capita, they spend significantly less on plastics as a fraction of total consumption. An implication of this is that the burden of higher prices will fall disproportionately on consumers in low and lower-middle income countries.
- This trend will be exacerbated by current variation in recycling rates internationally—these are typically much higher in high-income countries. It is also estimated that currently 3 billion people, or 38% of the global population, lack access to controlled waste disposal facilities.
- Higher prices and lower availability of virgin polymers would increase demand for and, hence, production of alternative materials, including recycled plastics. Our research has highlighted that these switching effects carry a risk for unintended consequences. Many of these relate to the fact that plastics are significantly lighter than alternatives, a property that entails various environmental benefits such as energy efficiency and lower GHG emissions (which would be put at risk). Their versatility, strength, and durability also offer various environmental benefits that other materials lack.
- Simply curbing demand is unlikely to solve the pollution problem. While increased consumption is certainly a major driver of plastic leakage, the World Bank identifies insufficient solid waste management capacity and formalised collection systems as contributing to the pollution problem, in addition to limited incentives to reuse or substitute plastic, and the high cost of recycling. Policies that incentivise circularity and close leakage pathways should therefore also be considered.

Ultimately, shifting towards a more circular economy model, essential for addressing current issues created by plastics pollution, will necessitate a reduction in virgin plastic production volumes. *How* this can most effectively be achieved and incentivised by policy is much more moot. In the second phase of our research programme, we plan to inform this debate by evaluating the implications of a selection of the wide range of policy instruments that could be used.

APPENDIX 1: INDUSTRY EXPOSURE MATRIX

Fig. 36 contextualizes a range of industry metrics to the size of the region under consideration to present a proxy for industry vulnerability in different markets. Values greater than one imply that the country or region ranks higher in that specific metric than one could have expected based on the size of its economy. This is an alternative representation of the content included in chapter three.

This index provides helpful guidance to determine the regions that are most likely to be affected by alternative policy options. For example, it suggests that some perhaps unexpected regions like the Middle East & Africa and Latin America could suffer more from upstream policies. Notably, however, these exposure indices do not capture the "enabling" role of plastics for other verticals. For instance, a country may not be very vulnerable to the plastic conversion sector itself, but many of its strategic sectors may heavily depend on plastic products, thereby increasing the country's exposure to any policy-related effects.

Fig. 36. Industry exposure matrix

	Primary production					Plastic products production				End use
	Primary production (volume)	Primary production (value)	Primary production (jobs)	Primary plastics exports (value)	Primary plastics imports (value)	Plastic products production (value)	Plastic products production (jobs)	Plastic products exports (value)	Plastic products imports (value)	End use (volume)
China	1.8	0.7	0.8	0.8	2.2	0.9	0.5	2.1	1.1	1.7
Japan	0.6	0.4	1.3	1.0	1.0	1.5	3.8	1.1	1.2	0.8
Rest of Asia	1.4	1.0	1.1	1.2	0.9	0.4	0.1	0.6	0.9	1.1
USA	0.6	0.8	1.1	1.7	1.2	1.0	2.5	1.2	1.5	0.6
Rest of North America	0.8	1.4	0.4	2.0	1.9	1.5	2.6	2.0	2.0	0.8
Middle & South America	0.8	1.7	0.5	1.8	1.3	1.0	0.7	1.2	1.2	1.2
EU27+3	0.6	1.1	1.6	0.4	0.4	1.2	3.8	0.4	0.5	0.8
Rest of Eurasia	0.8	1.6	2.8	2.4	1.4	1.7	5.6	2.4	1.6	2.8
Middle East & Africa	1.4	2.0	0.6	1.9	1.5	0.9	0.1	1.8	1.7	1.3
Reference metric	GDP	GDP	Employment	Exports	Imports	GDP	Employment	Exports	Imports	Consumption

APPENDIX 2: DATA SOURCES

Data series	Country	Source
Volume of plastics produced	World	Plastics Europe
	US	ACC
Revenue of manufacturers of plastics in primary form (NAICS 325211 Plastics material and resin manufacturing, or NACE 20.16 Manufacture of plastics in primary forms)	China	Market research
	Japan	2021 Economic Census for Business Activity, Ministry of Economy, Trade and Industry
	Rest of Asia-Pacific	UN Comrade, Oxford Economics
	USA	IMPLAN, Bureau of Economic Activity
	Rest of North America	UN Comtrade, Oxford Economics
	Middle & South America	Oxford Economics estimate
	EU27+3	Eurostat, Office for National Statistics (UK), Statistics Norway, Plastics Recyclers, Oxford Economics
	Rest of Eurasia	Oxford Economics estimate
	Middle East & Africa	Market research
Employment of manufacturers of plastics in primary form (NAICS 325211 Plastics material and resin manufacturing, or NACE 20.16 Manufacture of plastics in primary forms)	China	Oxford Economics estimate
	Japan	2021 Economic Census for Business Activity, Ministry of Economy, Trade and Industry
	Rest of Asia-Pacific	Oxford Economics estimate
	USA	IMPLAN, Bureau of Economic Activity
	Rest of North America	Statistics Canada, National Institute of Statistics and Geography (Mexico)
	Middle & South America	Oxford Economics estimate
	EU27+3	Eurostat, Office for National Statistics (UK)
	Rest of Eurasia	Oxford Economics estimate
	Middle East & Africa	GPCA
Revenue of manufacturers of plastic products (NAICS 3261 or NACE 22.20)	China	National Bureau of Statistics China, Oxford Economics
	Japan	2021 Economic Census for Business Activity, Ministry of Economy, Trade and Industry
	Rest of Asia-Pacific	Oxford Economics estimate
	USA	IMPLAN, Bureau of Economic Activity
	Rest of North America	Statistics Canada, National Institute of Statistics and Geography (Mexico)
	Middle & South America	Oxford Economics estimate
	EU27+3	Eurostat, Office for National Statistics (UK), Statistics Norway, Oxford Economics
	Rest of Eurasia	Oxford Economics estimate
	Middle East & Africa	Oxford Economics estimate
Employment of manufacturers of plastics in primary form (NAICS 3261 or NACE 22.20)	China	Statista
	Japan	2021 Economic Census for Business Activity, Ministry of Economy, Trade and Industry
	Rest of Asia-Pacific	Oxford Economics estimate
	USA	IMPLAN, Bureau of Economic Activity
	Rest of North America	Statistics Canada, National Institute of Statistics and Geography (Mexico)
	Middle & South America	Oxford Economics estimate
	EU27+3	Eurostat, Office for National Statistics (UK)
	Rest of Eurasia	Oxford Economics estimate
	Middle East & Africa	Oxford Economics estimate
Plastic use by application and region, waste by region	World	OECD Global Plastics Outlook
Trade data (volume and value)	World	UN Comtrade, Oxford Economics

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