

From Guangzhou to Naples: French exports of plastic waste

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FROM GUANGZHOU TO NAPLES: FRENCH EXPORTS OF PLASTIC WASTE

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In this note, we use China's ban of plastic waste imports in 2017 as a natural experiment of a sudden drop in the world demand for plastic waste. We study how French exporters have adjusted, both in terms of quantities exported, destinations, and prices. After the ban, exports to other Asian countries increased sharply, but this redirection appears to be short-lived, unlike redirection towards other EU countries. In addition, there is suggestive evidence of a polarization of the quality of plastic waste exports between destinations. In light of our findings, we discuss the possible impact of new European regulations that will drastically reduce European exports of plastic waste.

- Since January 1st 2021, the European Commission has i) banned exports of hard-to-recycle plastic waste to non-OECD countries, and ii) introduced a "prior notification and consent procedure" on all other transactions involving hazardous or hard-to-recycle plastic waste.
- This regulation is akin to a sizeable demand shock in European markets for plastic waste.
- We discuss the potential impact of this shock using insights from a comparable natural experiment, namely the China ban on imports of plastic waste in 2017.
- Before the ban, China imported 85% of the volume of plastic waste traded in international markets. The ban severely hit the international trade of plastic waste that shrunk by 55% between 2017 and 2018. A substantial volume of trade has however been diverted to alternative destinations.
- French exporters directly exposed to the China ban increased exports to other countries, notably Malaysia and Turkey, but also other EU countries such as Spain.
- We discuss suggestive evidence of a specialization of intra-EU trade after the ban, with some countries like Germany and Belgium absorbing relative low-quality plastic waste when other countries, Spain and Italy, import higher-price products.
- Such specialization may be efficient, but anecdotal evidence suggest illegal activities also participate to explaining observed patterns.
- Absorbing the shock induced by the 2021 EU regulation requires immediate investments in sorting and recycling capacities, to avoid the development of illegal trade.



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Introduction

Geyer, Jambeck, and Law (2017) estimate 8.3 billion tons of plastic have been produced between 1950 and 2015, which has generated 6.3 billion tons of plastic waste. About 20% of this waste has been recycled or incinerated, the rest being accumulated in landfill or the natural environment. The ecological consequences of the presence of plastic debris on coastlines, in the ocean, or in wild environments are a major source of scientific and public concerns.[1] Plastic waste management is first and foremost an engineering problem. Yet, the current technological frontier is still very inefficient and as of today, the main producers of plastic waste, the US, the EU, India and China, cannot absorb all the waste that they generate. For lack of a better solution, international trade of plastic waste, by taking advantage of countries' comparative advantage, may be part of a global solution.

Plastic waste is a traded commodity, with mostly two usages: i) **Energy recovery**: plastic waste can be burnt and profitably substitute fossil fuel to produce energy, thanks to its high heating value. ii) **Recycling**: some types of plastic or polymer can be recycled and contribute to the global circular economy that the European Green Deal is willing to foster. Both usages require infrastructures to collect, sort (by polymers, chemical composition, color, etc.), transport (to dedicated recycling plants or incinerators) and treat large volumes of plastic waste. The value of plastic waste, which can be measured by the unit price at which a ton is traded, is therefore determined by i) the **type of polymer**, ii) the **quality of sorting**, but also iii) the **demand for green energy**, and iv) the **demand for recycled plastic**.

One can roughly distinguish between **three main types of international trade flows**: first, to countries with high recycling capacities;[2] second, to countries with a large demand of green energy such as the Netherlands or Germany. Yet, up until 2017, these two first types were relatively minor compared to the third type, to low labor-cost countries, and China in particular, because sorting plastic waste remains an extremely labor-intensive task.[3]

While in principle, export of plastic waste to developing countries can generate both economic and environmental gains, in practice, most receiving countries do not have proper infrastructure and just landfill the waste. In order to protect them against ecological dumping, the Basel convention on the Control of Trans boundary Movements of Hazardous Waste and their Disposal was signed in 1989 (See Box 1 for institutional details). However, the impact of multilateral discussions has been slow to materialize into actual trade figures. As a consequence, some emerging countries have decided to take unilateral actions. The most transformative regulation occurred in 2017 when **China, then the main importer of plastic waste, banned plastic waste imports**, in a context of growing environmental awareness as well as more structural shifts toward less plastic-intensive production such as textile.

The 'China ban' has highlighted domestic deficiencies in terms of waste management and triggered several policy responses, from the European Union, but also the OECD, or individual countries (notably in Southeast Asia). In particular, **since January 1st, 2021, the European Commission has adopted new rules on the trade of plastic waste**, both within the EU and between the EU and the rest of the world. The export of plastic waste from the EU to non-OECD countries is now banned, except for clean plastic waste sent for recycling.[4] Plastic waste exports to OECD countries and intra-EU trade will also be more strongly regulated. These rules are likely to have a deep impact on the market for plastic waste, although there is still a substantial degree of uncertainty regarding how this market will evolve in the coming years.

These regulatory changes have an impact on individual firms. To understand adjustments to new regulations, it is therefore necessary to have access to data on individual firms' exporting behavior, which is possible for France. In this note, we use the China ban as a natural experiment of a sudden drop in the world demand for plastic waste and study how French exporters have adjusted, both in terms of quantities exported, destinations, and prices. We then discuss the possible impact of new European regulations in light of our findings.

[1] Jambeck et al. (2015) estimate that 5 to 13 million tons of plastics, 1.5 to 4% of global plastics production, end up in the oceans every year.

[2] Within the EU, the five largest countries in terms of their recycling capacities are Germany, Italy, Spain, the UK and France.

[3] These flows were all the more profitable that shipping containers toward China is almost costless given the imbalance between the demand for transport services from China to Europe and the other way around.

[4] https://ec.europa.eu/environment/news/plastic-waste-shipments-new-eu-rules-importing-and-exporting-plastic-waste-2020-12-22

Box : Institutional context

The regulation of plastic waste management and international trade of plastic waste has changed a lot over the past decades. We distinguish between multilateral, European and unilateral regulations.

Multilateral regulation:

- The Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal followed the discovery, in several parts of the developing world, of deposits of toxic wastes imported from abroad. Its overarching objective was to protect human health and the environment against the adverse effects of hazardous wastes. It was signed by 53 countries in 1989 and became active in 1992.
- A ban amendment against hazardous waste movement from OECD countries to non-OECD countries was further adopted in 1995 but was only implemented in 2019. A specific plastic waste amendment, introducing further regulation of non-hazardous and non-recyclable plastic waste flows, was adopted in 2019 and became active in 2021.

EU regulation:

- The Basel Convention and its amendments were incorporated into the European legal system through the 2006 European Waste Shipment Regulation (EC N 1013/2006). An amendment, adopted in 2014 and active in 2017, reinforced inspections of waste shipments through the definition of stringent inspection plans meant to reduce illegal trade of hazardous waste.
- The most recent amendment, adopted in 2020 and active in 2021, 1) extends the regulation to cover non-hazardous waste by introducing three categories of plastic waste: hazardous waste, plastic waste that is hard to recycle, and clean, non-hazardous waste; 2) bans exports of hazardous and hard-to-recycle plastic waste from the EU to non-OECD countries and authorizes exports of clean plastic waste under specific conditions; and 3) introduces a "prior notification and consent procedure" involving both parties to each trade transaction involving hazardous or hard-to-recycle plastics, for exports from the EU to other OECD countries, imports from outside the EU and intra-EU trade. The purpose of this amendment is thus to compel each EU member to internalize the sorting of plastic waste and restrict trade to products that will actually be recycled or used for combustion.

Examples of unilateral regulations:

- *China ban* – China introduced the 'Green Fence' policy in 2013 to limit low-quality plastic waste imports. In February 2017, as part of the "National Sword policy", China switched to a permanent ban on non-industrial plastic waste imports, effective in 2018.
- *Land-filling regulation* – As of today, 16 EU countries have implemented landfill bans: Austria (1997, full implementation in 2004), Belgium (partial since 1998), Denmark (since 1997 on recycling and combustible waste), Estonia (since 2004 on untreated waste), Finland (2016), France (2002), Germany (1993), Hungary (2002), Lithuania (2000), Luxembourg, the Netherlands (1995), Norway (2009), Poland (2013), Slovakia (2016), Slovenia (2011).

An anatomy of (legal) world trade of plastic waste

We describe the composition and the evolution of world and EU plastic waste trade, using UN Comtrade data. Analysis on France builds on a dataset of French exports provided to us by the French Customs.[5] It is important to keep in mind that these official data miss underground trade flows and are subject to non-random measurement error. Estimating the level of illegal activities in this sector is obviously difficult, but anecdotal evidence suggests that fraud is a major concern.[6] Fraud involves a combination of non-declared trade flows, falsification of legal trade documents, and misreporting of the actual content of the containers, e.g. hard-to-recycle plastic waste declared as sorted plastic waste.

The different types of plastic waste

There are different kinds of sorted or unsorted plastic waste. The international trade nomenclature breaks down plastic waste into four product categories: waste of ethylene polymers (PE), of styrene polymers (PS), of vinyl chloride polymers (PVC), and plastic waste non elsewhere classified (nec), which notably includes polyethylene terephthalate (PET). PE and nec are the most traded at the world level, accounting respectively for 32% and 59% of the quantity of plastic waste traded internationally between 2010 and 2018 (against 5% and 4% for PVC and PS, respectively).

[5]We use data covering the period 2010-2019. The data include information on the value and quantity of monthly exports disaggregated by firm and destination across 8,000 product categories of the European nomenclature. The analysis is restricted to the four 6-digit product categories under the heading "plastic waste" (HS 3915).

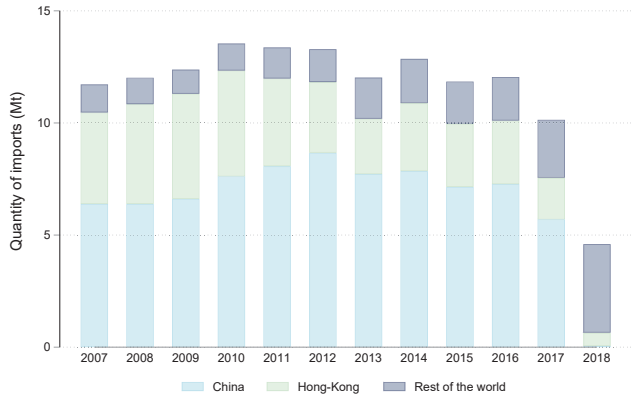
[6]As an example, out of all 1,095 plastic waste containers imported by Indonesia and all manually inspected in 2019, 433 were declared illegal by Indonesian authorities (Interpol, 2020).

Main importers of plastic waste

Until 2018, about 12 million metric tons (Mt) of plastic waste were traded annually. **China and Hong-Kong imported 85% of plastic waste** (Figure 1). The central role of Hong-Kong may appear surprising at first, but a closer look at the data reveals that most of Hong-Kong imports during this period were re-exported to China. Hong-Kong was virtually the only country of re-export, and its re-exporting activity accounted for 15% of world trade.

The central role of China as an importer and Hong-Kong as a re-exporter brutally dropped by 99% in 2018 when China imposed a ban on plastic waste imports. The shift was announced in February 2017 and seems to have had some effect in anticipation, as shown in the first drop from 2016 to 2017. **In 2018, China and Hong-Kong reduced their imports of plastic waste by almost 7 Mt** and the quantity of plastic waste traded internationally shrunk by 55%. In the meantime, the rest of the world increased plastic waste imports by 1.4 Mt. A substantial part of exports that used to be directed to China and Hong-Kong has thus been managed domestically or shipped, sometimes, illegally to other countries (Interpol, 2020).

Figure 1: Global imports of plastic waste



Source : UN Comtrade data.
Note: Quantity of imports of plastic waste (HS3915) in million metric tons.

EU trade of plastic waste

As the US or Japan, **the EU is a net exporter of plastic waste**. For instance, in 2016, the EU exported 3 Mt of plastic waste but imported less than 0.09Mt. Following the Chinese ban, extra-EU exports have shrunk overall, despite trade being partially diverted to Malaysia and Turkey. The bulk of the volume of trade that is no longer exported to China is now treated within the EU. However, EU countries had different levels of reliance on extra-EU exports, and have thus adjusted their trade after the 2018 ban in different ways. For example, Belgium seems to be an important export hub of plastic waste, as shown by large net imports from the rest of the EU, large net exports outside of the EU and strong adjustments in the volume and geography of these trade flows after the ban. Instead, Germany and the Netherlands appear to absorb important volumes of plastic waste produced in the rest of the EU, through recycling or energy recovery. As for France, the EU country with the largest trade deficit with other EU countries, it is a key player in intra-EU trade.

French exports of plastic waste

France had exported 4 Mt of plastic waste between 2010 and 2019. Its exports have been fairly stable between 2013 and 2017. About a quarter of exports were sent directly outside the EU – mainly to China and Hong-Kong, while the rest was exported to EU countries. **After the Chinese ban, France has increased its exports to Malaysia and other Eastern-Asian countries**. On the contrary, exports have not increased toward other EU countries and altogether, French exports have dropped by 30,000 tons in 2018, which suggests that more plastic waste had to be managed domestically.

The impact of the China ban on French exporters

Following the ban, French exports dropped and French exports to the EU remained constant, which suggests that the EU market was already saturated. However, these aggregate findings are difficult to interpret because they may hide interesting reallocation dynamics within the EU. In addition, they may not be directly linked with the China ban because of other changes that occurred in waste management or production at the same time.

To get a sense of the causal impact of the China ban, we use firm-level information. We compare the evolution of firms that were exporting to China or Hong-Kong in 2016 or 2017 (hereafter, 'treatment group') to the evolution of firms that were not (hereafter, 'control group').[7] We re-

[7]However, one should bear in mind that exporters from the control group may also have been affected, for example if they used to export to reexporting countries such as Belgium or, more generally, if the ban has had general equilibrium consequences.

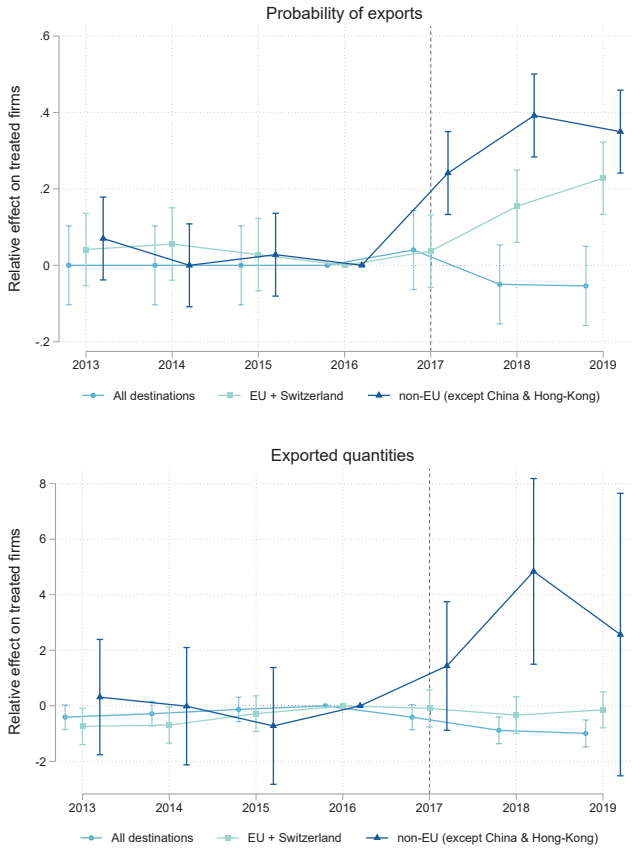
strict the sample to observations after 2012 and to a balanced sample of continuous exporters, that is, firms that exported every year from 2013 to 2016.

This sample is composed of 154 firms, which account for 91% of all exported quantities over the period. 57 firms belong to the treatment group, and 97 firms belong to the control group. Firms are different in the two groups: the treated firms are much larger exporters, that account for three quarters of exports in the sample over the period. For this reason, we estimate a difference in differences specification at the firm-year level, using firm and year fixed effects that control for firms' permanent characteristics and aggregate macroeconomic conditions. We consider 2017 as first year of treatment because of possible anticipation effects.

The results from the estimation are displayed in Figure 2. The outcome variables are the probability that the firm exports plastic waste (or alternatively, exports to the EU or exports outside the EU) in the top graph and the corresponding (log of the) volume of exports in the bottom graph. The estimates represent the relative evolution of the treated group compared to that of the control group, for each year between 2013 and 2019.

The probabilities of exporting to any destination do not evolve differently for firms that used to export to China and for firms in the control group (top panel, "all destinations" line): starting in 2018, there is a small drop, but it is not statistically significant. The lack of a differentiated effect is surprising given that treated firms have lost access to one of their markets, China. This can be explained by **the treated firms reallocating exports previously directed to China in other destinations**. The reallocation is illustrated in the additional two lines of the graph. For treated firms, the China ban translates into an additional 15 p.p. probability of exporting to the EU in 2018 and the effect reaches 22 p.p. in 2019. The effect is even larger for outside of the EU, with an additional increase of 39 p.p. in 2018 and 37 p.p. in 2019. The dynamics are quite different for both sets of destinations: the announcement of the ban in 2017 triggered a **very quick reaction for the probability of exporting outside the EU**, which increased substantially in the treated group in 2017, contrary to exports to the EU, which took more time to adjust. However, **the effect of the ban on the probability of exporting to the EU seems to keep increasing between 2018 and 2019**, contrary to what happens outside the EU. Although we would need a longer period to confirm these trends, these results are suggestive evidence that i) firms directly exposed to the China ban redirected part of their exports to other destinations and that ii) the adjustment was much faster toward non-EU countries, although firms end up reallocating some of their plastic waste surplus toward the EU.[8]

Figure 2: Impact of the China ban on French plastic waste exporters to China



Source : French Customs data at the firm and year level for years 2013 to 2019.
Note: Coefficient estimates on year fixed effects for the treated group. The segments display 95% confidence intervals.
Interpretation: In 2018, the probability of exporting to EU countries increased by 15 p.p. more for firms that were exporting to China in 2016-2017 than for firms that were not.

The top graph describes the impact of the China ban on firms' propensity to export in various destinations. We complement the analysis with a description of adjustments at the intensive margin, on traded quantities (conditional on trading). The picture is quite different: first, the light blue line shows that treated firms reduced the overall volume of their exports after the ban, in comparison with the control group. This implies that the redirection of exports illustrated in the top panel is not sufficient to compensate for the drop in the volume of exports induced by the China ban. The effect is quite large, since in 2019, the drop was twice larger for treated firms.

[8] This is also indicative of the policies adopted by other Eastern-Asian countries, which put a hold on plastic waste imports in 2018 after their harbors were flooded with plastic waste that was originally imported by China (Interpol, 2020).

Part of the plastic waste which firms used to export to China thus ends up being treated domestically. Whereas treated firms are now more likely to sell their plastic waste in the EU, those that were already exporting part of their products there have not increased the volume of their exports (light green line). Finally, exported quantities to non-EU countries have increased more for treated firms after the ban (dark blue line), although this increase is not enough to make up for the direct loss from the China ban because these firms did not export much outside China and EU before 2017.

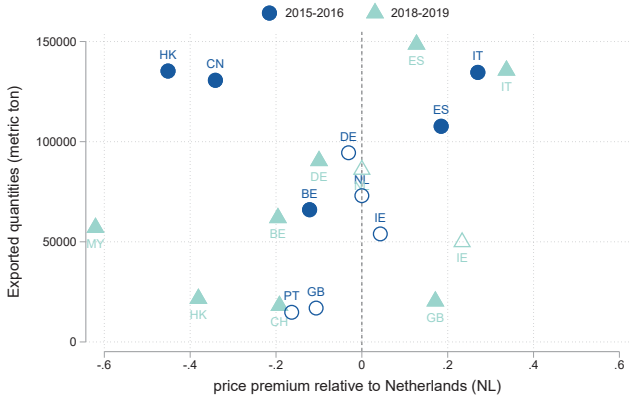
These various findings at the firm level corroborate the aggregate results whereby total quantities of plastic waste exported decrease after the ban, but not the quantity of waste exported to the EU and that the adjustment took place through non-EU exports in 2018 but less so in 2019, resulting in further decrease in total exports. This symmetry suggests that the aggregate dynamics are first driven by the firms that were initially exporting to China and had to adjust their exports after losing one important destination for their production of plastic waste. The adjustment has combined a diversion to other destinations, first outside of the EU, but more and more within the EU, with a decrease in the volume of their trade.

The quality of French exports: insights from price data

We now turn to the possible consequences of the China ban on the type of plastic waste exported by France to different countries. In the absence of additional data on recycling activities, it is difficult to provide more than indicative evidence. We use information on the unit value of exports at the firm level, which shall depend on the quality of exported products and market prices. Controlling for unobserved heterogeneity across products and firms, we study the dispersion in firms' unit values across destination countries.

We regress the logarithm of unit values on product fixed effects, firm fixed effects, and (destination) country fixed effects.[9] The country fixed effects can be interpreted as the price premium of each destination independent of any composition effect that would bias the computation of average prices by destination. Figure 3 plots the price premium of French exports to France's 10 main partners, before and after the China ban. The premiums are evaluated relative to the Netherlands, a sizable trading partner for which prices stayed constant before and after the ban.

Figure 3: Price premium of French exports: 2015-2016 and 2018-2019



Source : French Customs data at the firm, 6-digit product, destination, and month and year level for years 2015-2016 and 2018-2019.
Note: Price premium recovered from a regression of the log of unit values (at the firm-product-destination level) on firm fixed effects, product fixed effects, time fixed effects, and country fixed effects. Country fixed effects are estimated in relative terms with respect to the Netherlands. Each dot is a country. Circles are the countries' values for years 2015-2016, triangles are for years 2018-2019. Lighter shade indicates no statistically significant difference with the Netherlands.
Interpretation: controlling for product and firm characteristics, the price of French exports to Italy is 32% higher than to the Netherlands in 2018-2019.

Two main conclusions emerge from Figure 3. First of all, the geography of low-price trade flows has been deeply affected by the Chinese ban. Whereas China and Hong-Kong were the major destinations of low-price products before the ban, **Malaysia has now become the main destination of poor-quality waste**, that are sold at a price which is on average 60% lower than the average price charged on exports to the Netherlands for the same product categories. This finding is consistent with the Chinese ban inducing a diversion of trade to Malaysia and other non-OECD countries, for hard-to-recycle plastic waste. This trade diversion is the main rationale for the new EU regulation, which is meant to reduce the volume of trade of such low-quality products by banning exports to non-OECD countries.

Second, Figure 3 also shows interesting changes in the structure of intra-EU trade before and after the ban, that hint towards **a possible reorganization of plastic waste management within Europe**. When comparing estimates for the two periods, one can see that, before the ban, most European countries, except Spain and Italy, were charged similar prices. French exports to Spain and Italy instead displayed a "price premium" that was as large as 25% for exports to Italy, in comparison with the Netherlands. Het-

[9]We restrict the analysis to the sample of the 20 largest importing countries of French waste, which make up for 98% of exports. In the full 2010-2019 sample, 50% of the variation in prices is explained by firm effects, while product type does not explain prices at all, unlike country effects that still account for an additional 5% of variation.

erogeneity in prices seems to have increased after the ban, with relative prices towards Belgium and Germany now slightly lower, whereas the relative price of exports towards the UK and Italy has increased. In 2018-2019, Italy is the destination where French exporters charge the highest prices, more than 30% above prices set on exports to Netherlands. In terms of exported quantities (y-axis), the most striking increase concerns Spain, which already imported high-price plastic waste prior to the ban.

Combined together, these patterns may be indicative of a polarization of exports, with low-quality waste being increasingly exported to non-OECD countries, and clean plastic waste being sent to other European countries, notably Italy and Spain, which may have had non-saturated recycling capacities at the time of the ban. Note that **the specialization of European countries into specific recycling activities may be efficient**, if recycling involves highly-specialized investments and displays economies of scale. But in the short run, and to the extent that recycling capacities do not adjust very quickly, the arrival of larger quantities of high-quality waste in countries such as Spain may have had negative consequences, by crowding out domestic waste in the recycling sector after the ban.

However, one must keep in mind that the above interpretation relies on the assumption that export prices convey valuable information on the quality of plastic waste, with high-price exports being associated with clean, easy-to-recycle products. In practice, **anecdotal evidence suggests that illegal activities may affect our measure of prices**, e.g. if some hard-to-recycle products are declared under the wrong product code. From this point-of-view, it is striking that the countries that appear to absorb large quantities of high-price products are also countries in which illegal activities have reportedly increased after the ban (Interpol, 2020). Disentangling between these interpretations would require product classifications to better account for the level of the recyclability.

Conclusion

The significant impact of the China ban on French exports, both within the single market and with the rest of the world, can provide valuable insights about the future consequences of the new regulation that strongly limits EU's exports of non-recyclable plastic waste. Since January 1st 2021, extra-EU exports to non-OECD countries of hard-to-recycle plastic waste are banned. To give a sense of the size of the shock, the volume of French exports to these countries amounted to 0.05 Mt (or 14%) of French exports in 2019, which is the last year of available data. This represents half of the quantities affected by the China ban. As illustrated in Figure 3 in the case of exports to Malaysia, these trade flows are still associated with low unit values, which is indicative of hard-to-recycle plastic waste. Since diverting these products to other OECD countries will also be difficult, **a large proportion of hard-to-recycle waste will have to be absorbed domestically**.

In the short-run, adjusting to this demand shock requires **a massive investment in sorting and recycling capacities**. Any delay will open the door to more illegal activities, which have proven reactive to changes in environmental regulations after the China ban. The French recovery plan notably includes 84 Million euros to be shared between increasing sorting infrastructures on public space and investing into public and private sorting factories. **Investing in modern, efficient sorting infrastructures is the only way to prevent illegal activities from settling in this apparently lucrative sector.**

Whereas sorting is a key element for households' waste management, collecting clean, easy-to-recycle plastic products is relatively easier when targeting individual firms, for which waste production is usually more homogeneous. **Collecting plastic waste generated by the construction sector, the second largest producer of plastic waste after households, should become more systematic.** To that end, public contractors could be asked to belong to a recycling network like a "Filière à Responsabilité Elargie des Producteurs", as promoted by the French Agency for Ecological Transition.[10]

In the longer-run, it may be important to think about the timing and coordination of the various actions that the European Union and its member states are taking to improve the footprint of Europe's plastic consumption. Current European plans, notably within the European Green Deal, aim at recycling 50% of plastic waste generated by Europe by 2030. In conjunction with these actions, one can only advocate the creation of an efficient internal market for plastic waste, where the supply of recycled plastics can adjust to the demand from the industry, through a specialization of recycling companies. Such specialization will be all the easier since the industry can benefit from economies of scale within the Single Market. With

[10] https://www.ademe.fr/expertises/dechets/elements-contexte/filieres-a-responsabilite-elargie-producteurs-rep

a European coordination on member states' recycling investments, intra-EU trade in plastic waste could become a source of economic and environmental gains by 2030.

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