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Waste-to-Energy in the EU: The Effects of Plant Ownership, Waste Mobility, and Decentralization on Environmental Outcomes and Welfare

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Abstract: Waste-to-energy (WtE) could prevent the production of up to 50 million tons of CO_2 emissions that would otherwise be generated by burning fossil fuels. Yet, support for a large deployment of WtE plants is not universal because there is a widespread concern that energy from waste discourages recycling practices. Moreover, incineration plants generate air pollution and chemical waste residuals and are expensive to build compared to modern landfills that have appropriate procedures for the prevention of leakage of harmful gasses. In the context of the EU, this paper aims to provide a picture of the actual role of WtE as a disposal option for municipal solid waste (MSW), enabling it to be utilized as a source of clean energy, and to address two important aspects of the debate surrounding the use of WtE; namely, (i) the relationship between WtE and recycling, and (ii) the effects of decentralization, waste mobility, and plant ownership. Finally, it reviews the role of the EU as a supranational regulator, which may allow the lower government levels (where consumer preferences are better represented) to take decisions, while taking spillovers into account.

Keywords: WtE technology; waste mobility; welfare

1. Motivation and Scope

As the world population grows and living standards continue to rise, the consumption of goods and energy is increasing too, which has important environmental consequences [1,2]. On the one hand, higher per capita consumption has led to an increase in the generation of waste. On the other hand, the correlation between income and energy consumption remains very strong [3,4]. Given that the average heating value of municipal solid waste (MSW) is approximately 10 MJ/kg, the use of waste to produce energy could contribute to solving the dilemmas of waste management and energy demand, and it could ease the transition to a more sustainable model of production and consumption [5,6]. Indeed, the diversion of waste from landfills prevents the production of methane emissions, which have an effect on global warming up to 86 times higher than CO_2 over a 20-year period [7]. Moreover, with around 39 TWh of electricity and 90 TWh of heat produced in Europe annually, waste-to-energy (WtE) could prevent the production of up to 50 million tons of CO_2 emissions that would otherwise be generated by fossil fuels. Yet, support for a large deployment of WtE plants is not universal [8–11]. There is a recurrent concern that energy from waste may discourage more extensive recycling practices. Moreover, incineration plants generate atmospheric emissions and chemical waste residuals and are expensive to build compared to modern landfills that have appropriate procedures for the prevention of leakage of harmful gasses. Therefore, the main issues in this debate can be summarized as follows:

(a) What is the impact of WtE technology on recycling and decoupling from an empirical point of view? (b) How do waste mobility and decentralization of government regulation affect waste disposal choices? (c) Who benefits from waste mobility?

This paper offers practical answers to these questions through a critical review of the most important theoretical and empirical contributions in this field. With a focus on the EU, Section 2 provides a picture of the actual role of WtE as a disposal option for municipal solid waste (MSW), which would allow it to be used as a source of clean energy. In Section 3, we analyze the relationship between WtE and recycling and the theory and evidence on the effects of WtE plant ownership, waste mobility, and decentralization on welfare and environmental damage. In Section 4, we discuss the policy implications of our analysis and the role of supranational authorities, such as the EU, in this process. Section 5 concludes the paper.

2. Figures and Facts

2.1. The Role of WtE in Waste Management Strategy

Municipal solid waste (MSW) is waste that is collected by or on behalf of municipal authorities and is disposed of through waste management systems. It is mainly generated by households, although it also includes similar waste from other sources, such as shops, offices, and public administrations. Our analysis does not consider the industrial type of waste (hazardous or non-hazardous, agricultural, commercial, from craft and industrial activities, demolition and construction, machinery, used equipment, etc.) and is limited to the main countries of the European Union because we feel this can highlight key issues in MSW management that are also relevant to other industrialized areas of the world.

Gross solid waste (GSW) is the MSW that is generated at the source, ahead of separate collection and any type of treatment or disposal. In other words, GSW breaks down into two flows: Separate collection and unsorted residual waste (URW). Drop-off collection is the collection of recyclable materials carried out through bins that are placed in the streets or at specially equipped areas. Door-to-door or curb-side collection is the separate collection of recyclable materials carried out through bins placed at each single property. Secondary waste is waste resulting from the treatment of waste, e.g., ash from incineration or sorting residues.

The Waste Framework Directive [12] and the recent Circular Economy Package [13] re the two most important reference legislations on waste in the EU. They have defined four main methods for treating waste: Incineration with energy recovery, incineration without energy recovery, material recovery (excluding energy recovery), and recycling. We will borrow this classification to describe the treatment of waste that has undergone separate collection.

Final disposal of URW, as an alternative to incineration or material recovery, may occur via landfill, deep injection, surface impoundment, permanent storage, or release into waste bodies. For simplicity, our study incorporates all the above categories into one: Landfill dumping.

Table 1 shows the per capita municipal solid waste (MSW) generated in 1995 and 2018 in the EU, according to Eurostat data [14]. In 2018, MSW amounted to 250 million tons, which corresponds to about 10% of the total amount of waste generated in the EU. Each person produced, on average, almost half a ton of waste per year (470 kg per person in 1995 and 488 kg per person in 2018). The highest amount of MSW per capita was generated in Denmark (766 kg per person), followed by Cyprus and Germany. In contrast, Romania (272 kg per person) generated the lowest per capita amount of MSW, preceded by Poland and the Czech Republic. There are differences in how countries collect and manage waste from commerce, trade, and administration.

Table 1. EU28+, municipal waste generated, 1995–2018 (kg per capita).

	1995	2018	% Change 2018/1995
EU28	470	489	4.0
Belgium	455	411	−9.7
Bulgaria	694	423	−39.0
Czechia	302	351	16.2
Denmark	521	766	47.0
Germany	623	615	−1.3
Estonia	371	405	9.2
Ireland	512	:	:
Greece	303	:	:
Spain	505	475	−5.9
France	475	527	10.9
Croatia	:	432	:
Italy	454	499	9.9
Cyprus	595	:	:
Latvia	264	407	54.2
Lithuania	426	464	8.9
Luxembourg	587	610	3.9
Hungary	460	381	−17.2
Malta	387	640	65.4
Netherlands	539	511	−5.2
Austria	437	579	32.5
Poland	285	329	15.4
Portugal	352	508	44.3
Romania	342	272	−20.5
Slovenia	596	486	−18.5
Slovakia	295	414	40.3
Finland	413	551	33.4
Sweden	386	434	12.4
United Kingdom	498	:	:
Iceland	426	:	:
Norway	624	739	18.4
Switzerland	600	703	17.2
Montenegro	:	530	:
North Macedonia	:	301	:
Albania	:	462	:
Serbia	:	319	:
Turkey	441	424	−3.9
Bosnia and Herzegovina	:	:	:
Kosovo	:	:	:

(:) data not available. Source: Eurostat.

In 2018, 247 million tons of MSW were treated in the EU. Of this, 23% was disposed of through landfill dumping, 30% was sent to recovery operations for recycling, and 17% to composting operations. A further 47% of the waste was disposed of through incineration, either simple incineration or incineration with energy recovery. Figure 1 summarizes the evolution of the different options between 1995 and 2018.

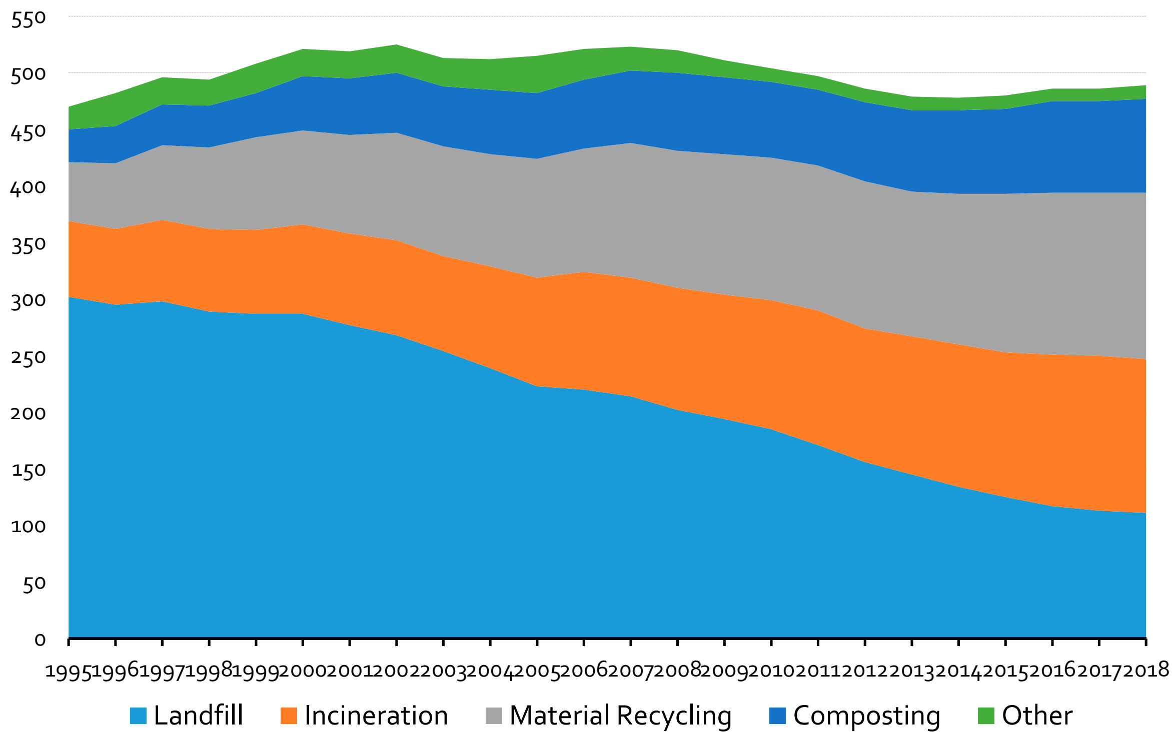

Figure 1. MSW, EU28, 1995–2018 (kg per capita). Source: Eurostat.

The table above shows that although at the end of the period considered, more waste is generated in the EU28, the total amount of MSW sent to landfills has diminished. Between 1995 and 2018, the total MSW landfilled in the EU28 fell by 61%, an average annual decline of 4%. As a result, the landfilling rate has dropped from 64% in 1995 to 23% in 2018. The Directive 31/1999 on landfilling had stipulated, among other things, that member states should have reduced the organic fraction of municipal waste sent to landfill. As a result, the share of MSW recycled (material recycling and composting) has increased from 17% to 47%, as shown in Figure 1.

Waste incineration has also grown steadily over the same period, but less than recycling and composting. Table 1 shows another interesting feature, i.e., significant cross-country differences in MSW outcomes.

EU member states use heterogeneous strategies to deal with waste. While recycling, composting and waste-to-energy are on a robust, rising trend, and landfilling is shrinking, in several countries the latter is still the preferred or the second most important option. This picture is the result of past legislative innovations and institutional differences that we aim to analyze. Figure 2 shows the treatment shares as a percentage of generated MSW in 2018 across the EU.

The average share of recycling and composting in the EU28 is 47%. Germany leads the way, and Italy, the Netherlands and Belgium have an above-average rate among the largest countries. These good results are associated with high shares of incineration for Germany, the Netherlands, Belgium, Denmark, Austria, and with relatively low shares of incineration for Italy, where landfill dumping is still about 22% of final disposal. The UK, France and Finland are in between, with declining shares for landfilling and rising shares for incineration. In Spain, Portugal, Greece and most eastern countries, landfill dumping still dominates. These data should be read jointly with those on per capita MSW generation (see Table 1). Germany, Finland, Denmark, Austria, the Netherlands (and Switzerland, not part of the EU) attain above-average per capita levels. In some countries (Italy among the largest, for instance), there is a large difference between generated and treated MSW. According to Eurostat, such a gap is due to several factors, such as misreporting, international waste flows, weight losses, time lags, and, increasingly, the use of pre-treatment, for instance mechanical biological treatment (MBT) and preliminary treatment of sorted waste. In particular, residues from the latter activities are no longer classified as MSW, although they are incinerated in WtE plants. This effect should *reduce* the gap between waste generated and treated, rather than the other way round. Indeed, there might be some loopholes in the legislation that (de facto) circumvent the proximity and the self-sufficiency principles. However, there are also signs that the misreported amounts reflect, to some extent, illegal dumping in the environment.

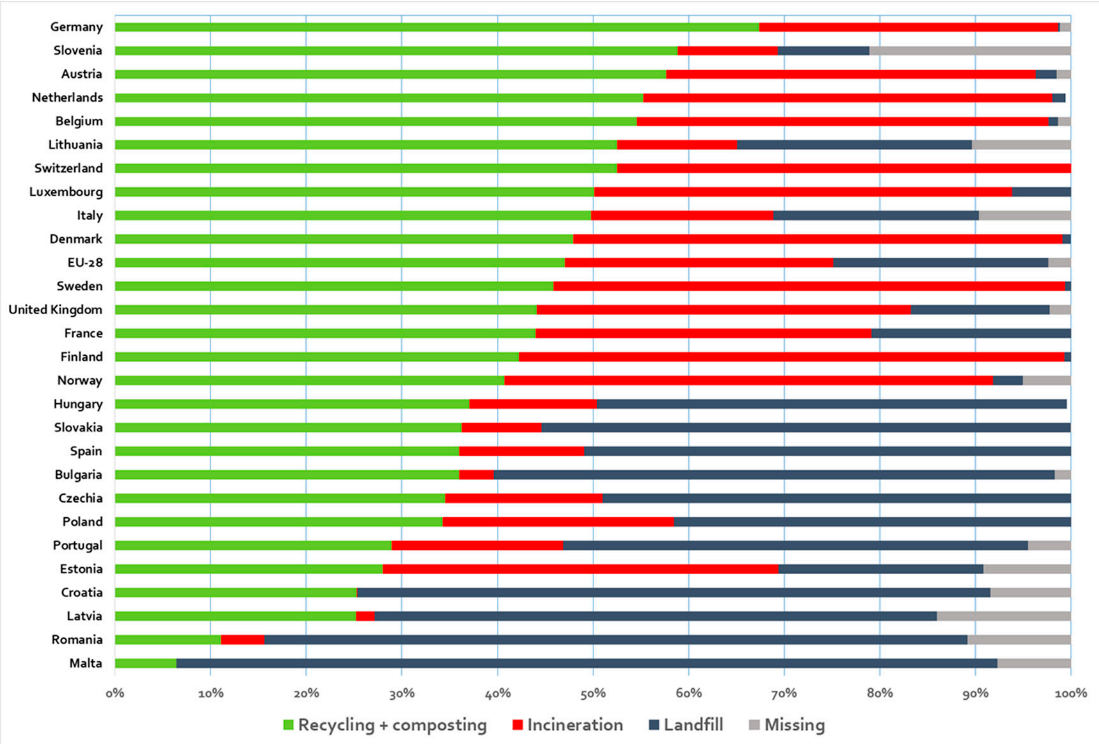

Figure 2. EU28+, treatment modes as a percentage of generated waste, 2018. Source: Authors' calculations using Eurostat data [14,15].

2.2. Contribution of WtE to Total Energy Production

The quantity of MSW incinerated in the EU has risen from 32 million tons (67 kg per capita) in 1995 to 70 million tons (136 kg per capita) in 2018, an increase of 117%. In the same period, landfill dumping has declined by 61% and material recycling has increased by over 200%. These changes and the new legislation on renewable energy and waste, have produced a significant growth in energy generation from MSW.

The production of primary energy in the EU28 in 2017 was spread across a range of different energy sources, the most important being, in terms of their contribution, the renewable ones, with more than one quarter (29.9%) of the bloc's total supply. Nuclear energy was second, with 27.8% of total primary energy generation. The share of solid fossil fuels (16.4%, largely coal) was just below one fifth, and that of natural gas was somewhat lower (13.6%). Crude oil (8.8%) was the only other major source of primary energy production.

Primary energy supply from waste is on an upward trend, albeit from a very low base. According to Eurostat, in 2018, overall energy production from waste (industrial waste, renewable and non-renewable MSW, non-renewable waste) amounted to 40.4 MTOE (million tons of oil equivalent), with MSW roughly accounting for half of that quantity. This figure is about 2.4% of the total energy supply in the EU. Energy recovery from renewable MSW in the EU is directed mainly toward electricity generation (22.7 MWh in 2018, according to the International Energy Agency - IEA), in combined heat and power (CHP) or electricity-only plants. Data on electricity generation of waste plants show significant differences between EU member states. Generation from waste is the highest in Germany (7.1 MWh in 2018), followed by the UK (4.4 MWh), France (2.5 MWh), Italy (2.4 MWh) and the Netherlands (2.2 MWh). Total energy production also shows significant differences between EU member states. Germany is the leading country, followed by France, the Netherlands and Sweden [16].

3. Key Debates around WtE

Data for MSW incineration highlight several important facts. First, countries that have substantially reduced landfill dumping adopt a balanced mix of WtE and material recycling, while those that do not incinerate still depend on landfill dumping for the disposal of at least 30% of their MSW. Second, systems that are characterized by a high share of incineration experience a "standstill" both for recycling and waste generation, meaning that they struggle to succeed in waste prevention and attaining higher recycling rates. For instance, only few of the countries with high shares of MSW treated in WtE plants, such as Finland, Norway, and Sweden, have below-average recycling rates and high per capita quantities of generated waste. Denmark is a champion of WtE and recycling, but it also has the highest per capita production of MSW in the EU. These countries also have high WtE capacity (see [14]). The OECD notes that if government subsidies support profits in the WtE market, the risk of over-investment grows. This can also happen when the local incumbent is a vertically integrated monopoly that jointly operates street collection and pre-treatment services. We draw on this evidence to highlight the most important contributions in the empirical and theoretical literature, with the aim to provide some novel policy indications on optimal waste disposal strategies.

3.1. WtE and Recycling

From an empirical point of view, there is some evidence of a Kuznets curve for the GDP-waste volume relationship [1,4,17,18], but little evidence of a permanent decoupling. For this reason, it is important to study the incentives for recycling activities (for a general integrated assessment proposal for urban systems, see [19]). The role of WtE has sparked an interesting debate in the literature among policy-makers and citizens alike.

The operation of large and efficient WtE facilities involves complex political-economy interactions. At a theoretical level, the relationship between recycling and waste-to-energy is debated amongst opposing views. Viscusi et al. [20] argue that, since recycling activities respond to economic incentives, studying the incentives and social norms that drive recycling should be a priority. Cecere et al. [3] show that waste reducers are different from recyclers and that for them intrinsic motivation is a more important driver than economic incentives. D'Amato et al. [21] recognize that recycling and waste reduction are driven by different motivations, but incentives to recycle may affect both behaviors. These articles seem to suggest that WtE may affect both recycling and waste generation. This view is shared by Dijkgraf et al. [9], who use private and environmental cost data for the Netherlands to evaluate the social cost of landfilling versus incineration through WTE plants. WtE should be preferred from an environmental point of view; however, when private costs are considered, landfilling emerges as the best option.

Supporters of incineration argue that recycling and waste-to-energy are complementary and that the presence of WtE plants is often accompanied by high recycling rates in communities [22]. It should, however, be noted that some countries' national statistics include in the recycled fraction also waste sent to energy recovery (hence this relationship is likely to be spurious).

In Sweden, but also in Denmark, Norway and the Netherlands, the prevailing view is that WtE facilities are a safe and efficient way to produce energy. In 2018, nearly 2.4 million tons of household waste was burned into energy, but local WtE plants had to import about the same amount from abroad (the UK and Ireland, for instance). The UK is a large exporter of valuable, to-be-incinerated waste towards continental Europe. Besides the recurring concerns about the environmental impact of waste shipments and WtE activities, the effects on recycling rates are ambiguous. At the national level, countries with strong incineration capacity tend to have higher-than-average recycling and composting rates. However, cities and regions that host large WtE facilities often display lower recycling rates [23].

For WtE and recycling, it is useful to think that trade-offs arise because of increasing marginal costs. Beyond a certain threshold, both technologies tend to exhibit higher unit costs. The well-known waste hierarchy states that recycling is superior to incineration or landfilling (but not to waste prevention). However, beyond some threshold, the costs of recycling rise steeply and can more than offset the marginal benefits of further separation and material recovery. This effect depends essentially on the marginal costs of collection, the quality of collected materials and/or costlier processing and re-sale. The quality of separately collected materials and, therefore, the possibility to extract re-sale value, are usually declining with the separation rate. Given the similarly increasing marginal costs of landfill dumping, the optimal strategy likely implies a balanced combination of material and energy recovery, a conclusion that is shared by most authors [24].

3.2. Waste Mobility and the Institutional Setting

One additional aspect of this complex picture is the role played by WtE plants' ownership. The actual institutional settings are rather diverse across Europe and beyond [24]. In Germany, both public and private ownership solutions can be found. In Denmark, most incinerators are owned by local authorities. In Sweden, private, listed firms control the largest and more efficient WtE plants, and the decisions on their size are taken either at the national or municipal government level. Instead, municipalities hold minority stakes of Italian, formally private utilities that run the largest incinerators. Municipally-controlled firms run Austria's major WtE plants too, including Vienna's Spittelau landmark incinerator.

Regulatory and governance issues, along with technological knowledge spillovers (see [25]), are crucial in determining social welfare and market outcomes. A competitive market is likely to produce second-best results, given the externalities that waste management tends to create. However, since government interventions may introduce or consolidate distortions, it is important to determine: (i) Which level of government is more suitable to regulate waste disposal, and (ii) the role of institutional settings in reducing the negative externalities produced.

WtE plants play a double role: they produce energy, which can be sold on the market, and are an efficient technology for waste treatment. The presence of a plant influences the quantity of waste incinerated, which in turn determines the overall environmental impact.

Despite a growing applied literature, only a few theoretical models have rationalized the welfare implications of MSW mobility and of the extensive use of WtE [22]. Levaggi et al. [26] provide a two-region model that allows to investigate the joint effects of waste mobility and WtE plant ownership on incineration, recycling rates, environmental damage, and welfare. The model starts from a very simple setting: The two regions have identical energy requirements and generate the same level of waste, but differ in the technology they use for waste disposal. In Region 1, waste is incinerated (with energy recovery) whereas in Region 2, it is landfilled. Both technologies produce an environmental impact, which increases with the quantity of disposed waste. However, since energy produced from waste incineration reduces the depletion of the environment (as less energy from non-renewable resources is required), the environmental effects of incineration in Region 1 may be quantity-dependent. Recycling does not create any additional environmental damage, but has a monetary cost that is increasing and convex in the recycled quantity. The incineration plant maximizes profit, and can be owned either by the local authority (LA) or by private investors.

This framework is used to study two different aspects related to WtE: The role of institutional settings and that of waste mobility. The authors find that, when waste cannot be shipped (waste autarky scenario), the institutional setting of the WtE plant (i.e., who decides how much waste to burn) is irrelevant: The quantity of burned waste is the same. The recycling effort of both regions is not optimal: Region 1 recycles too little (the net benefit from incineration is rather high), while Region 2 recycles too much (the cost of landfilling is very high). Also, the quantity of waste to be incinerated is not optimal. Hence, the environmental damage is not necessarily minimized.

Allowing for mobility when the local authority controls the plant leads to an equilibrium outcome that is both globally efficient and Pareto-improving for both regions. In this case, it is possible to reduce the cost of waste disposal in Region 2 and the opportunity cost to recycle in Region 1. Compared to the no-mobility case, the optimal level of recycling is higher in the region that hosts the WtE plant and lower in the other, while the total amount of waste incinerated is larger. This solution too, which allows to maximize social welfare, may not minimize the environmental damage. In fact, while the environmental damage only takes into account the effects of waste disposal and energy production on the stock of natural resources z, total welfare also considers the profit produced by the WtE plant.

Finally, the scenario with mobility under private ownership may not be welfare-improving for all parties. Region 2 is always better off compared to waste autarky, as regardless of who owns the plant, waste mobility extends the set of disposal options available to the region. Region 1 instead has no say in the quantity of waste imported (it is set by the plant owners) and has simply to respond to this decision by setting its recycling rate. The quantity of waste incinerated is suboptimal, but it is not necessarily larger. In fact, if the net environmental benefits were higher than the profit derived from selling energy, Region 1 would be better off by increasing incineration. On the other hand, when the quantity is too large, Region 1 will find its stock of natural resources depleted in spite of its recycling efforts.

These results appear to be confirmed by a cross-country comparison of data on institutional settings and public support for WtE. The countries where the control (direct or indirect) by local municipalities over WtE facilities is stricter are in fact those where the public attitude towards WtE is more favorable. Therefore, allowing the local community to have the final say over what should be recycled, could be used to ensure public support for the planning of new WtE.

Another inference is that waste mobility may be beneficial only if all the associated advantages and costs are taken into account. In the recent past, most countries have experienced some devolution of responsibilities for environmental protection: Environmental governance is now split between national and local governments. The question of which government level should be responsible for waste mobility decisions is then quite relevant.

Since the seminal works by Oates [27,28], this is the general, central question of fiscal federalism. Local jurisdictions, municipalities or regions, are likely to take into account local conditions, but ignore inter-jurisdictional spillovers; central governments may internalize those spillovers but are likely to neglect local conditions. Both dimensions appear to be empirically relevant in environmental and waste management applications, where the literature seems to agree that centralized decision-making is more efficient in reducing the level of pollution [29–31].

Levaggi et al. [32] analyze incentives, equilibria and implications of the governance rules of municipal solid waste in an N-region model where waste mobility is allowed. The key decisions revolve around the flow of waste between the regions and the externalities associated with its final disposal. Two different governance schemes are considered: A central planner that makes all the decisions, and a decentralized setting where each local authority decides on waste flows. As mentioned above, it is assumed that each region is endowed with a fixed income y and an environmental good z (e.g., clean air, unspoiled land). Income generates a quantity of waste equal to w, net of the amount that can be recycled, which can be disposed of in the same region, or it can be exported. Waste disposal creates two types of environmental damages: Local damage that is proportional to the quantity to be disposed of, and a spillover effect on regions that are close by. The latter effect is inversely related to the distance between the regions. In this respect, this model adds an important spatial dimension to the literature on waste mobility. When waste is disposed of, it produces a reduction in the environmental good, which may be mitigated by investing in costly technology. On the other hand, when waste is shipped outside, the exporting region has to pay a cost for its disposal and transportation, which depends on the quantity and the distance. The key decisions in this framework are the quantity of waste to be disposed of locally (whether produced locally or imported by other regions) and the level of investment in technologies that may reduce the environmental impact of waste disposal.

Each region maximizes welfare, which is a linear combination of disposable income and the net utility associated with the environmental good. In a centralized setting, both the flows and the disposal price are set by the government. In the decentralized one, this is the outcome of bargaining between the regions.

This framework allows to study the effects of decentralization, i.e., the discretion each region enjoys in determining its level of waste-disposal activities and the implications of paying for exporting waste. The preference parameter is region-specific, so that the model also allows for communities to value waste treatment differently. The centralized solution maximizes total welfare, but the distribution of benefits among the regions depends on the price set for waste disposal across regions. The ensuing distribution may have important impacts on both the overall outcome and the regulatory choices.

In general, when the regions are characterized by different levels of efficiency in the final treatment of waste, mobility might allow the benefits of higher efficiency to be reaped. However, when coupled with decentralization, waste flows may produce sub-optimal outcomes that undermine environmental protection. This is because if regions are not equidistant, some of them may reduce the investment in cleaner waste disposal methods, and ship their waste toward far-away regions.

In this setting, regulation of the disposal price for waste shipped across borders, as well as the proximity principle, can be used as welfare-improving tools.

4. Discussion and Suggestions: What Role for the EU?

The literature presented in the previous section allows some important policy implications to be drawn. One of the most important results is related to the relationship between the institutional setting (WtE plant ownership in particular) and the optimal quantity of waste burned. The models reviewed show that, unless the region endowed with the WtE plant could control the quantity being incinerated, an optimal solution cannot be reached. When the decision is left to a private firm that runs the plant, the latter will not take into account all the spillovers created by incineration, and the quantity will not be optimal. This may explain the differences in the support for WtE across countries and in the attitudes towards circular-economy principles [5]. In general, the support is higher where the local authority either owns the plant or can decide on the quantity to be burned. Plant ownership is the key factor, because if the LA can decide on the quantity, WtE is always optimal and a win-win solution can be reached, all the regions (those with an incinerator and those without it) are better off. If this is not the case, mobility may have asymmetric effects; the regions with a landfill will always be better off, while those receiving the waste flows may be worse off (hence lower support for WtE). However, no mobility may not be the best alternative either. This solution makes the regions that dispose through landfills inefficiently increase recycling, while also suffering from a high level of pollution.

In addition to the institutional settings, the price for waste disposal is another key variable that can be used to improve welfare. A stricter regulation on the price of waste shipped could be put in place.

When the decisions are left to a decentralized level of government, waste shipment across countries may lead to inefficiency and high environmental costs. A higher government tier may use the price as an indirect policy instrument: By setting the price at a level that takes into account the negative spillovers generated by this trade, the quantity will be reduced and the right incentives to recycle will be made effective. This shows that legislation at the supranational level of government (such as the EU in Europe and the federal government in the US) may play a more proactive role in promoting efficient WtE solutions. The EU Waste Framework Directive has built a comprehensive legislation on the matter [13,33–38], with objectives and targets aiming to improve waste management, as well as to reduce GHG emissions and adverse health and environmental impacts. Waste management in the EU derives from a hierarchy of management options, which includes a legally binding prioritization of waste management activities. Reducing the need for new materials should be the top priority, followed by reuse, recycling, waste-to-energy incineration and placement in a landfill. The legislation, at both the EU and member states levels, has shifted from disposal of MSW to its prevention and recycling, and public authorities advocate a consistent ranking of MSW management practices.

The new Green Deal [13], with its ten pillars, represents the long-term evolution in the EU framework to tackle these issues. It focuses on developing a low-carbon, low-energy economy and proposes a new resource and energy transition that foresees massive investment in clean, safe energy and energy efficiency as an explicit basis for sustainable growth across EU member states.

5. Conclusions

WtE as a means to dispose of waste is a controversial theme across industrialized countries. New-generation WtE plants are efficient for larger volumes of waste to be treated, hence demand for waste to be incinerated is increasing. As a result of this growing demand, waste disposal is rapidly changing shape. Waste reduction seems to have slowed its pace, while waste disposal and its mobility across regions and countries is rising. In principle, countries or regions in which disposal through landfill dumping presents higher costs should develop their WtE facilities only if population density warrants both sufficient waste "fuel" and a local market for generated heat and recovered materials. On the other hand, MSW shipping would instead become the alternative route, up to when transportation costs become dominant. However, this ideal outcome is not always reached. Several market and regulatory failures can generate illegal dumping, "pollution havens" and more generally a "race-to-the-bottom" distortion that prevents efficient solutions. For instance, regions where available sites for landfilling are perceived as relatively cheap may postpone the construction of less impacting facilities and the adoption of tighter MSW regulation. The same effect may operate if the costs of waste shipments to far-away WtE facilities are artificially lowered by direct or indirect government subsidies.

In this contribution, we have provided a broader perspective on these problems by analyzing jointly all the above issues. We have shown that some aspects normally disregarded by existing analyses, such as the appropriate level of centralized regulation, its principles, the institutional settings and the degree of waste mobility, all have critical bearings on final outcomes. For instance, plant ownership, if it allows the regional decision maker to control the quantity to be incinerated, is likely to produce better outcomes and to fully yield the benefits of waste mobility. As for decentralization, devolving some decision-making power to local authorities may allow to reach outcomes that are more in line with local preferences, but in this case a national or supranational regulatory framework becomes desirable. In this respect, the institutional architecture of the EU, whose legislation is based on the waste hierarchy, proximity and self-sufficiency principles, seems broadly appropriate. The main challenges concern heterogeneity within the EU and call for fine-tuning interventions. On the one hand, a few member states no longer rely on landfill dumping and attain satisfactory levels of both recycling and energy recovery. However, although they are stuck at very high levels of per capita waste generation, their WtE capacity exceeds actual and projected requirements. For these cases, policies should strengthen incentives for waste prevention and tighten waste flows from regions or countries with insufficient WtE capacity.

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