



Editorial

Costs and benefits of packaging waste recycling systems

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ABSTRACT

This Special Issue provides several different perspectives on the complex issue of packaging waste recycling. It comprises a diverse and rich set of contributions with insights from very different disciplines that range from economics to engineering. All types of “costs and benefits” are addressed in this collection of articles. In addition to the economic and strictly financial impacts of selective collection and sorting of packaging waste, several authors discuss other types of impacts, such as the environmental and social ones. The reader will find articles that address recycling systems as a whole, pieces that focus on specific impacts and detailed discussions of particular material streams or waste management strategies. The Special Issue represents an indispensable resource for academics, policy-makers and practitioners with interests in recycling and packaging waste management.

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1. Introduction

During the last decades, the waste sectors of many countries throughout the world have been experiencing significant changes. Among the several international developments, the European Union (EU) case is particularly interesting given the great efforts that have been undertaken in order to harmonize national legislations and enhance the environmental protection. Indeed, at the European level, most of the changes regarding waste management operations were rule-driven (i.e. triggered by EU legislation). Regarding the specific case of “waste from consumer goods” the Packaging and Packaging Waste (PPW) Directive (94/62/CE) stands out among the many rules and strategies (European Commission, 2006). This EU law imposed challenging targets for the recycling rates of packaging waste to be attained by the various member states. Although limited for the countries that already had national policies for packaging waste recycling/recovery, the impacts of the PPW Directive were significant and of different types (Cruz et al., 2013).

First, there were institutional impacts arising from the structuring of the “recycling systems”. Entities from the public and the private sectors had to develop and coordinate their efforts in order to create the proper legal framework and monitoring systems. The waste market structure in each member state was necessarily impacted by this Directive since new activities had to be carried out (ARGUS, 2001). Moreover, national and EU decision-makers had to address the potential conflicts among the legal and economic mechanisms devised by each country to respect both the operation of the single market and the environmental protection objectives (Bailey, 1999).

Second, there were financial impacts arising from the “extra costs” that were incurred by waste management operators (e.g. the costs involved with the selective collection and sorting of packaging waste). The Extend Producer Responsibility (EPR) principle,

clearly embedded in the PPW Directive, led to a complex situation where the industry (private sector) is responsible for an activity that is traditionally carried out by local authorities (public sector). The industry had, therefore, to reimburse waste management operators (local authorities) for the costs of managing packaging waste (Cruz et al., 2012). The problem is that these costs are hard to determine and sometimes it is difficult to differentiate a “cost” from a “price”. Whereas the industry should not be responsible for the possible cost-inefficiencies of waste management operators, the spirit of the Directive is that it should be responsible for the costs involved with the recovery of packaging waste.

And third, there were environmental impacts (mainly) arising from the conservation of raw materials and the diversion of waste from landfills. Evidently, it is expected that the recycling of packaging waste will have a positive balance between positive and negative environmental impacts. Accounting for these impacts is an extremely complex research topic as their magnitude is contingent upon several external factors and assumptions.

Performing an assessment of the impacts of the Directive within the EU is a topic of great importance for academics and policy makers. In fact, several research questions still do not find satisfactory answers in the literature. For instance: are the current recycling targets optimal (globally and per material)? Should all member states have the same targets (and all the regions within the member states)? Is the EPR being effectively applied in all cases? What mechanisms should be devised to prevent the inefficiency of waste management operators? Attempts to answer these and other pertinent research questions require multidisciplinary research.

The research agenda of packaging waste recycling is indeed a complex one. It involves both theoretical (e.g. on the efficiency of EPR economic instruments, environmental valuation methods, etc.) and empirical investigations (e.g. country case-studies on the financial, social and environmental impacts). Moreover,

all case-studies ought to take into account the specificities and institutional features of the respective countries. The financial costs and benefits of collecting, sorting, storing and recycling packaging waste need to be accurately estimated and allocated to the various stakeholders. And, finally, for a credible cost–benefit analysis of recycling, the externalities need to be factored in.

This special issue intends to approach these subject matters and contribute positively to the research agenda. It draws on an International Congress held under the same theme and integrated in a R&D Project sponsored by the European Investment Bank Institute (the EIMPack Project – Economic Impact of the Packaging and Packaging Waste Directive) led by Instituto Superior Técnico from the University of Lisbon in Portugal. The issue gathers selected research papers from the EIMPack Congress that was held in Lisbon, Portugal, on the 29th and 30th of November 2012.

2. The contributions of this Special Issue

The Special Issue begins with an article by [Kinnaman \(2014\)](#) who addresses one of the above-mentioned prominent research questions. To estimate the “optimal recycling rate” this author argues that one must determine the value that minimizes the overall social costs involved in municipal waste management. According to him, these social costs are the net value that results from the sum of all operational costs and revenues associated with municipal waste and recycling programs, all costs associated with preparing and storing recyclable materials for collection (household costs), all costs associated with waste disposed at landfills or incinerators, and all external benefits associated with the provision of recycled materials. Professor Kinnaman tests this model using data from Japanese municipalities (and external costs and benefits from Europe and the U.S.) and suggests an optimal recycling rate of 36% for this country.

In the second article, [Massarutto \(2014\)](#) challenges the merits of the EPR principle to divert waste from landfill (i.e. to promote recovery). For instance, it is argued that the signals from EPR policies have been somewhat feeble in promoting green innovation. On the other hand, the creation of powerful Producer Responsibility Organizations, which was an indirect effect of the EPR approach, facilitated the creation of recycling markets that were unconceivable a few decades ago. It is expected that further institutional developments (e.g. competition in the market) may also allow for cementing long-term results concerning waste prevention.

More focused on the actual implementation of the EPR principle in recycling systems, the article by [Marques et al. \(2014\)](#) addresses the Belgian and Portuguese packaging waste management schemes. Here, the authors compare the costs and benefits undertaken by waste management operators due to the selective collection and sorting of packaging waste. This exercise allows them to determine whether or not the industry is taking on the full (financial) responsibility for the recovery of its packaging waste. The answer, however, is not straightforward. Whereas, in Belgium, the extra-costs of recycling seem to be fully supported by the industry (through Fost Plus, the national Green Dot agency), in Portugal, the fairness of the recycling system depends on whether or not the costs avoided with refuse collection and other treatment are taken into account.

As just mentioned, confronting the financial costs and benefits of collecting and sorting packaging waste is important to discern the operational interpretation of the EPR principle embedded in the PPW Directive. However, accounting for these costs and benefits is not enough if one wants to carry out an assessment from a “general welfare perspective”. Above all, the environmental impacts need to be considered in this type of evaluation (enhanced environmental

protection was the main driver behind the enactment of the PPW Directive). In this regard, Sofia [Ahlroth \(2014\)](#) discusses several valuation techniques and weighting sets that have been developed in recent times to present the results of environmental impact assessments in a comprehensible and easily comparable way. The article shows how different sets may influence the results and why it is important to use several weighting sets and discuss the results thoroughly.

Before the environmental impacts may be valued, one must conduct a Life Cycle Assessment (LCA) of the packaging waste recycling system. In the fifth article of this Special Issue, [Rigamonti et al. \(2014\)](#) modelled a LCA of five different scenarios focusing on the plastic stream (perhaps the most debated material in the literature, especially on the material *versus* energy recovery issue). This study provides a good example of the difficulty in determining the best strategy from an environmental point of view (even without trying to monetize the impacts). The assumptions required for carrying out the LCA and the trade-offs between impact categories pose a real challenge to policy makers.

[Arena and Di Gregorio \(2014\)](#) combine the results of LCA studies with thorough material and substance flow analysis to inform municipal waste management planning. The authors point out the relevance and interplay between all waste management options, the source separation and collection levels and the sorting efficiency and effectiveness. Nevertheless, the results obtained in this analysis merely represent part of the problem. Decision-makers still need to consider social and economic aspects to compare different scenarios.

In contrast to the other contributions, the article by [Ferrão et al. \(2014\)](#) add the “social” dimension to the “economic” and “environmental” dimensions to assess the sustainability of the Portuguese packaging waste management system organized by Sociedade Ponto Verde (the Portuguese Green Dot Agency). As usual, the environmental dimension is analyzed through a LCA. To estimate the economic impact of the system, the authors adopt an input–output model. Finally, for the social dimension, the number of direct jobs created due to the implementation of the system is estimated. It is argued that the net results are positive for all dimensions and that, for this country, moving up the waste hierarchy has been a globally positive policy.

The eighth article by [Groot et al. \(2014\)](#) directs the focus once again towards the plastic packaging waste case. This time the authors develop a model to estimate and analyze the costs associated with different collection strategies (post-separation, source separation via curbside collection or source separation via drop-off containers). In addition to fixed and variable costs per vehicle, personnel costs and container or bag costs, the authors also estimate emission costs and include them in the model. The model is applied to all Dutch municipalities taking into account their different characteristics and the impact of local tax schemes. This tool helps to assess the potential impacts of shifts in input variables (e.g. changes in the carbon pricing used by the authors would result in higher impacts than equivalent changes in fuel prices for collection trucks) and the results of its application show that there are interesting differences for different urbanization levels.

[Luijsterburg and Goossens \(2014\)](#) continue the research on the plastic stream and carry out a more technical investigation. Rather than focusing on the economic, environmental or social costs and benefits, these authors focus on the quality of the recycled material. It is suggested that the main differences are related to the sorting and reprocessing steps (rather than contingent upon the collection method). Notice that technological advances in this area are vital for the future of recycling and have a direct impact on markets, waste management strategies and collection and sorting technologies.

The contribution by [Dias et al. \(2014\)](#) looks into a different waste stream and a different component of the integrated municipal waste management system. Mechanical and Biological Treatment (MBT) facilities have proliferated in several European member states. This waste management strategy intends to minimize the quantity of biodegradable waste landfilled. Nevertheless, when these facilities receive mixed waste (from undifferentiated collection) they also end up with a significant amount of recyclable packaging waste (which depends on the awareness and effort of the served population). The pre-treatment of mixed waste in MBT facilities allows for recovering some packaging waste which is generally redirected to the recycling system. However, as the authors argue, MBT plants that process mixed municipal waste produce an inert residual fraction composed mainly of packaging glass. Currently, in Portugal, this residual fraction is landfilled. Dias et al. estimate that, in 2014, Portuguese MBT facilities will deal with about 48,000 tons of glass; if this material could be salvaged and sent to recycling, the glass recycling rate would increase by 4.4%.

In addition to the environmental, social and technical issues that were discussed above and are certainly crucial for the planning and improvement of the packaging waste management and recycling systems, one other issue is relevant for the effective implementation of the EPR principle: how efficient are the costs reported by waste management operators? The article of [De Jaeger and Rogge \(2014\)](#) addresses this issue for the case of Belgium municipalities. The authors reveal that there are indeed variations in the cost-efficiency of packaging waste management operators. Along with the quality of service level, these variations could be due to several exogenous factors (beyond managerial or technical capacity). However, even the influence of these determinants should continue to be researched in all countries and/or regions. Whereas, according to the Directive, the industry should fund the optimal (or at least the best possible) system for recovering its packaging waste, the EPR principle does not compel waste producers to cover sub-optimal or unnecessary costs (especially if they do not have the power to organize the waste management and recycling systems themselves).

Evidently, the “efficiency” subject unfolds into many others. One has to do with the optimization of the packaging waste collection routes. In the twelfth article of this Special Issue, [Ramos et al. \(2014\)](#) deal with this issue suggesting a methodology that minimizes the total distance travelled and the number of vehicles required. The authors developed mathematical programming models for four different scenarios (i.e. different constraints) using a real case study involving seven municipalities. They argue that their solutions could reduce the total cost of collection considerably (especially if some political constraints related to the municipalities’ boundaries are lessened).

The final article leads the reader to a different continent. [Campos \(2014\)](#) provides an interesting description of the challenges faced by Brazil in setting up the national recycling system. Indeed, the path taken by EU member states during the last decades provides a rich body of knowledge to other jurisdictions currently weighting the pros and cons of ambitious recycling regimes. However, local history and conditions are key decision factors. In Brazil, despite the advances in the legal framework towards recycling and recovery, the informality of the operations and the precariousness of labor conditions (especially for waste pickers) remain troublesome. The focus, therefore, must be on developing institutional capacity and raising awareness.

3. Concluding remarks

The European PPW Directive had the key objective of protecting the environment by reducing the impact of packaging waste

disposal while ensuring the free movement of packaged goods by harmonizing national legislations. To a great extent, this objective has been met. The question remains, however, of whether the imposed recovery and recycling targets are optimal from a welfare point of view and whether or not EPR systems are the best way of achieving this enhanced environmental protection. Although this Special Issue does not provide a definite answer to these concerns, it certainly contributes positively to getting closer to it.

The complexity of the theme has its origin on the interdisciplinary nature of the problem and the interconnectedness of the specific components of the packaging waste recycling systems. Technological innovations influence the economic viability of different waste management and recycling activities, environmental impacts constrain the available options, the introduction of economic instruments has an impact on the whole waste management system and on the recycling and packaged goods markets, local conditions (e.g. territory, demography, citizens’ awareness, climate) affect the cost structures of waste management operations, and so on. With so many variables changing, it is difficult to implement a long-term plan and devise a wide-ranging policy (e.g. applicable to all European member states and regions).

As can easily be seen, the current research topic is far from being exhausted. In fact, packaging waste recycling presents us with a dynamic research agenda that feeds into policy-making. More theoretical and empirical work on the different (social, environmental, economic) costs and benefits of recycling systems is therefore expected and desired.

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