

LSE

THE LONDON SCHOOL
OF ECONOMICS AND
POLITICAL SCIENCE ■

LSE Research Online

Nuno Ferreira da Cruz, Sandra Ferreira, Marta Cabral, Pedro Simões, Rui Cunha Marques Packaging waste recycling in Europe: is the industry paying for it?

Article (Accepted version)
(Refereed)

Original citation:

da Cruz, Nuno Ferreira, Ferreira, Sandra, Cabral, Marta, Simões, Pedro and Marques, Rui
Cunha (2014) *Packaging waste recycling in Europe: is the industry paying for it?* [Waste
Management](#), 34 (2). pp. 298-308. ISSN 0956-053X

DOI: [10.1016/j.wasman.2013.10.035](https://doi.org/10.1016/j.wasman.2013.10.035)

© 2014 [Elsevier Ltd](#)

This version available at: <http://eprints.lse.ac.uk/59755/>

Available in LSE Research Online: November 2014

LSE has developed LSE Research Online so that users may access research output of the School. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LSE Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain. You may freely distribute the URL (<http://eprints.lse.ac.uk>) of the LSE Research Online website.

This document is the author's final accepted version of the journal article. There may be differences between this version and the published version. You are advised to consult the publisher's version if you wish to cite from it.

Packaging Waste Recycling in Europe: Is the Industry Paying for It?

Nuno Ferreira da Cruz*, Sandra Ferreira, Marta Cabral, Pedro Simões, Rui Cunha Marques

CEG-IST, ULisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal

*Corresponding author. Email: nunocruz@ist.utl.pt; Tel. +351 963975200 ; Fax: +351 218417979

Abstract

This paper describes and examines the schemes established in five EU countries for the recycling of packaging waste. The changes in packaging waste management were mainly implemented since the Directive 94/62/EC on packaging and packaging waste entered into force. The analysis of the five systems allowed the authors to identify very different approaches to cope with the same problem: meet the recovery and recycling targets imposed by EU law. Packaging waste is a responsibility of the industry. However, local governments are generally in charge of waste management, particularly in countries with Green Dot schemes or similar extended producer responsibility systems. This leads to the need of establishing a system of financial transfers between the industry and the local governments (particularly regarding the extra costs involved with selective collection and sorting). Using the same methodological approach, the authors also compare the costs and benefits of recycling from the perspective of local public authorities for France, Portugal and Romania. Since the purpose of the current paper is to take note of who is paying for the incremental costs of recycling and whether the industry (i.e. the consumer) is paying for the net financial costs of packaging waste management, environmental impacts are not included in the analysis. The work carried out in this paper highlights some aspects that are prone to be improved and raises several questions that will require further research. In the three countries analyzed more closely in this paper the industry is not paying the net financial cost of packaging waste management. In fact, if the savings attained by diverting packaging waste from other treatment (e.g. landfilling) and the public subsidies to the investment on the “recycling system” are not considered, it seems that the industry should increase the financial support to local authorities (by 125% in France, 50% in Portugal and 170% in Romania). However, in France and Portugal the industry is paying local authorities more than just the incremental costs of recycling (full costs of selective collection and sorting minus the avoided costs). To provide a more definitive judgment on the fairness of the systems it will be necessary to assess the cost efficiency of waste management operators (and judge whether operators are claiming costs or eliciting “prices”).

Keywords: extended producer responsibility; green dot; packaging waste; Europe; recycling.

1. Introduction

Waste is defined by the Waste Framework Directive (75/442/EEC), as “any substance or object which the holder disposes of or is required to dispose of”. This Directive was last amended in 2008 (2008/98/CE) where the definition of waste remained the same. With the amount of waste accumulating in dump sites, European Union (EU) authorities realized that new waste management strategies were required to protect the environment and public health. However, due to the many tasks involved (e.g. collection, transportation, sorting, storing, treatment and/or final disposal), the several origins of waste (e.g. households, small and medium-sized businesses, healthcare premises, industry and agriculture) and the vast array of stakeholders (e.g. local and national authorities, manufacturers, packers and fillers, retailers and citizens/customers), waste management is a fairly complex issue (Walls 2005; Lavee 2007). In 2010, the EU member states produced over 252 million tons of municipal solid waste¹, representing around 502 kg *per capita* (Eurostat 2012).

The rise in the rate of waste production over the last decades has had strong implications in the European waste management policy (e.g. see Bailey 1999). In fact, European member states have been dedicating special attention to diverting waste from landfills. The particular case of packaging waste was emphasized due to the escalating tipping fees, the environmental impacts of landfilling this type of material (e.g. a significant portion of packaging waste is non-biodegradable) and the possibility of using this waste as a resource (avoiding the consumption of raw material).

Since the publication of Directive 94/62/EC on packaging and packaging waste (PPW), practically all member states have been undertaking major investments in their recycling systems (e.g. in selective collection and sorting equipment and infrastructure). One should note, however, that some countries already had national legislation on recycling/recovery of packaging waste (e.g. Germany was the forerunner on producer responsibility schemes). Furthermore, the particular case of Denmark, where no Extended Producer Responsibility (EPR) system is enforced and a deposit system runs for beverage packaging, should also be highlighted.

¹ “Municipal waste consists, to a large extent, of waste generated by households, but may also include similar wastes generated by small businesses and public institutions and collected by the municipality” (Eurostat 2012).

According to the EPR principle (an overriding principle of the PPW Directive), all economic operators placing packaging on the market are responsible for their management and recovery (OECD 2001). In addition to the possibility of developing their own packaging waste management system (this must be approved by each National Waste Authority) to comply with the recycling and recovery targets laid down by the European law, producers of packaging waste can transfer their responsibility to another entity (e.g. a Green Dot company). Traditionally, Green Dot companies are created as an initiative of the industry (e.g. see ARGUS 2011). In general, these entities are responsible for managing the logistic chain of packaging waste. The producers of packaged products pay a financial contribution for their packaging and, in return, transfer away their responsibility to manage and recover the waste (and, in most cases, they earn the right to put a “green dot” trademark on their packaging).

Although the ultimate goal (the recovery and recycling targets as described in the PPW Directive) is similar for all member states, the operational strategies for achieving the targets vary considerably from country to country (European Commission 2006). Taking this into account, this paper looks into the institutional frameworks and recycling systems of five European countries, namely, France, Germany, Portugal, Romania and the UK. Currently on different “maturity stages”, these five cases are representative of the overall reality in the European Union. Most countries have publicly-owned utilities responsible for the collection, sorting, treatment and final disposal of urban waste (including packaging waste). Municipalities or regional authorities are generally in charge of waste management. These public authorities might, nevertheless, contract out these services. In any case, the ultimate responsibility lies with the public sector (as the provider of this essential service, Okuda and Thomson 2007).

Usually, the waste management operators receive a financial support from the Green Dot company to compensate for activities such as selective collection and sorting. The unit values of the financial support and the overall functioning of the systems are often prone to some criticism (Cruz et al. 2012). To address this issue, we carry out an economic analysis on the costs and benefits of recycling in France, Portugal and Romania for the year 2010. By comparing and contrasting the costs and benefits undertaken by waste management operators in these countries, we are able to assess whether the net costs of the recycling system are being covered by the industry and to find out who is paying for the incremental costs of recycling (either the industry, i.e. the consumer, or the local authorities, i.e. rate-payers or tax-payers).. As

discussed in the following section, due to the competitive nature of the recycling schemes in Germany and the UK, it was not possible to obtain reliable data regarding financial costs and benefits of recycling for these countries.

It is interesting to note that while the PPW Directive urges the industry to be responsible for their packaging end-of-life, the polluter-pays principle is often not followed when income from local taxes is used to finance waste management. In other words, whereas the costs of recycling packaging waste ought to be included in the retail price of the products (and that exact moment of taxation in the life cycle of a product can have an impact on consumer behaviour,) the same diligence is not forced upon all member states when it comes to mixed waste management pricing.

The paper is organized as follows: after this introduction the main figures of packaging waste recycling are presented in the second section. The broad description of the national EPR schemes for the five countries studied is provided in the third section. The methodological approach adopted in the estimation of the costs and benefits of recycling for France, Portugal and Romania (which have similar EPR schemes) is introduced in the fourth section. The fifth section contains the results, their discussion and some normative stances that derive from the analysis. The concluding remarks are presented in the sixth and final section.

2. Packaging Waste Recycling in Numbers

A generalized drop in landfill capacity combined with a high volume of household waste in Europe led to a “silent revolution” of EU waste legislation starting in the 1970s (Hansen et al., 2002). The waste hierarchy (prevention, reuse, recycling, energy recovery, and, at last, disposal) was first introduced by the Waste Framework Directive (1975). It was also during this decade that several important concepts, such as the “polluter pays” principle, were set as major guidelines of the EU waste management policy. However, it was in the 1990s (and early 2000s) that several decisive Directives were published to frame waste management in Europe. The PPW Directive (94/62/EC) was perhaps the one that had higher impacts both for the industry (manufacturers, packers, fillers, etc.) and waste management operators. The development of this piece of legislation was, to a great extent, influenced by the German Packaging Waste Ordinance (Eichstadt et al. 2000). Indeed, the PPW has two main drivers: (1) reduce the impact of packaging waste on the environment, while (2) ensuring the functioning of the European market (both of

packaged products and of packaging waste). The first version of the Directive (published in 1994) stated that, by the end of 2001, all countries should, at least, have recovered 50% (with a maximum of 65%) and recycled 25% (with a maximum of 45%) of all packaging waste. The minimum recycling rate for each type of material was 15%. The PPW Directive and the targets set for all member states were updated in 2004 (Directive 2004/12/EC). According to this version (currently in force), by the end of 2008, the member states should have recovered a minimum of 60% by weight of packaging waste, whereas the recycling targets for each material were 60% by weight for glass, paper and board, 50% by weight for metals, 22.5% by weight for plastics and 15% by weight for wood (the overall target for recycling was 55%, with a maximum of 80%).

The maximum recovery and recycling rates were set to avoid distortions of the internal market and not hinder compliance by other Member States (caps can be exceeded if provisions are taken to prevent this). There were also exceptions to the deadlines mentioned above for Greece, Ireland and Portugal (mainly due to their specific features, such as the large number of small islands or the presence of rural and mountain areas). For these three countries the 2001 targets should be attained by the end of 2005, while the de 2008 targets should be attained by the end of 2011. The new European member states were allowed to postpone the targets of PPW Directive.²

The variation of municipal solid waste produced in European countries is substantial, ranging from 304 *kg per capita* in Latvia up to 778 *kg per capita* in Cyprus (2010 data). For the countries analysed in this paper the municipal solid waste generated per person in 2010 was the following: 532 kg in France, 593 kg in Germany, 514 kg in Portugal, 365 kg in Romania and 521 kg in the UK. To some extent, the European policies aimed at dissociating waste production from economic growth have been successful. In 10 years (1998 to 2008, just before the economic crisis) waste generation only grew 9% while GDP increased 53% (nominal value) for the EU-27 (Eurostat) which suggests that relative decoupling has been achieved.

In 2010, a total of 147,5 million tons of municipal solid waste was landfilled or incinerated in the EU-27 (see Table 1). Of that amount of waste generated, only 25% was recycled. Of the five countries analysed

² No later than 31 December 2012 for the Czech Republic, Estonia, Cyprus, Lithuania, Hungary, Slovenia and Slovakia; 31 December 2013 for Malta and Romania; 31 December 2014 for Bulgaria and Poland; and 31 December 2015 for Latvia.

in the present paper, Germany achieved the highest recycling rate (around 44,6%) and the lowest landfill rate (only 0,4% of all municipal solid waste was landfilled).

[Insert Table 1 here]

Table 2 contains data on the generation of packaging waste for the EU-27 and for the five countries analysed in this paper. Some of the official figures presented for the case of Romania are somewhat unexpected. For instance, there is no clear explanation for the difference observed for the quantity of packaging waste as a fraction of municipal solid waste. Could it be the case that the data available for this country is being biased due to the “free-riding” problem? Packers/fillers or other economic operators covered by the EPR principle that do not declare their packaging (and do not pay the license fees to the entities in charge of managing the logistic chain of packaging waste recycling, e.g. Green Dot companies) are commonly called free-riders. This phenomenon undermines the whole economic sustainability of the systems and creates market distortions (Yau 2010).

The PPW Directive led to an impressive increase of the recycling rates of all Member states. For example, in the UK the recycling rate increased from 35% in 1999, to 50% in 2004 and 62% in 2009. In fact, all countries have transposed this directive into national legislation. The actual operational approaches, however, can differ significantly from country to country. The countries that already had recycling legislation in force before the enactment of the PPW Directive are easily recognized (the ones with high recycling rates early on, for instance, Germany or the Netherlands).

Most countries comply with the overall recycling target. Details regarding recycling in the five countries analysed in this paper are presented in Table 2. Note that these figures include packaging waste originating from both households as the industrial flow. Germany is a recycling “champion”, France, Portugal and the UK are “average” countries, and Romania is a “newcomer” (note that the most recent data report to 2009 and the deadline for this country is 2013).

[Insert Table 2 here]

3. Institutional and regulatory framework of the case-studies

3.1 France

In France the PPW Directive was transposed into national legislation in 1994. According to this legislation, each producer/importer placing packaged goods in the market had to inform the Agency for Environment and Energy Management about the quantity of packaging waste generated each year. Moreover, these economic operators had to (1) carry out collection through a deposit system, (2) carry out collection and treatment of their packaging waste by themselves, or (3) transfer their take-back obligation to a compliance scheme (EIMPack 2012b). Indeed, most producers of fast moving consumer goods opt to transfer away their responsibility for managing packaging waste to the Eco-Emballages group (the French Green Dot company).

Eco-Emballages is a non-profit organization that manages the logistics chain of household packaging waste on behalf of producers (packers, fillers, importers, etc.). Unlike other Green Dot agencies, Eco-Emballages does not have any intervention on packaging waste of industrial products (Eco-Emballages, 2011).³ Eco-Emballages supports the selective collection and sorting of household packaging waste through contracts with the local authorities that are responsible for waste management operations. In 2010, this company had firmed contracts with 1.167 local authorities representing 36.312 municipalities. The financial support provided to local authorities comes from the financial contributions of economic operators (the Green Dot fee). The Green Dot fee has a variable component (weight fee) and a fixed component (unit fee). The weight fee is determined by multiplying the total weight of each packaging placed on the market by the respective fee (that differs with the type of material, as table 3 shows). In 2010 the unit fee depended on the value achieved for the weight fee. If the weight fee was greater than or equal to 0,0014€, the unit fee was a flat rate of 0,0014€. If the weight contribution was lower than 0,0014€, the unit fee was equal to the weight contribution and the total fee was twice the weight fee. When packages weighted more than 1kg their contribution to the “weight fee” was limited to 1kg. The unit fee had the goal of reinforcing the incentive already provided by the weight fee for the industry to produce more environmental friendly packages.

³ The non-household packaging waste flow has been supported directly by recyclers (ADEME 2008). In 2008, around 63% of the packaging placed on the market was non-household packaging and more than 50% was recycled.

[Insert Table 3 here]

According to the French system in 2010, the financial support for local authorities (FSLA) should cover 60% of the efficient benchmark costs of the selective collection and treatment services carried out by waste management operators (Eco-Emballages 2011). During this year, the FSLA was calculated based on their performance (i.e. amount of packaging waste selectively collected per capita) and on the take-back quantities for different packaging materials. Table 4 presents the financial support model (where S_b , S_i and S_p refer to the unit support for each material and N_b , N_h and N_p refer to different thresholds designed to encourage higher performances).

[Insert Table 4 here]

In addition to this main financial instrument, other complementary supports are paid to local authorities by Eco-Emballages (e.g. for incineration with energy recovery). The remaining costs (the other 40%) should be covered by the sale of sorted materials and local taxes. The take-back prices for 2010 are presented in Table 5 according to the type of trading system chosen by the local authorities (who own sorted packaging waste). In the option “Filières”, or the guaranteed recovery, the local authorities are assured that the materials are removed and recycled (being the price the same nationwide) under the agreement between the certified companies (Eco-Emballages and Adelphe) and the materials companies, In the option “Federations”, or the guaranteed removal, the operators that are members of FNADE (Fédération Nationale des Activités de la Dépollution et de l'Environnement) and FEDEREC (Fédération de la Récupération, du Recyclage et de la Valorisation) guarantee the recovery and recycling of packaging waste; the price is negotiated between local authorities and the operators. Finally, in the option “Individual” the local authority negotiates directly with the purchaser.

[Insert Table 5 here]

3.2 Germany

The PPW Directive was transposed into German legislation by the Packaging Ordinance of 21 August 1998. However, Germany had already packaging legislation in force before the Directive was enacted (the Ordinance on the Avoidance of Packaging Waste of 1991). Germany has set higher targets than the

PPW Directive regarding household sales packaging through the 5th amendment of the Packaging Ordinance in 2009. The minimum recycling targets for each material of household sales packaging established in the Packaging Ordinance are the following: paper/cardboard (70%), glass (75%), aluminium (60%), tinplate (70%), plastic (36%), and composites (60%). Sales packaging is defined in the Packaging Ordinance as “the packaging that is made available as a sales unit and arises at the final consumer (...) shall also include such packaging provided by retailers, restaurants and other service providers as facilitates or supports the transfer of goods to the final consumer”.

In Germany, packaging manufacturers and distributors of packaging are completely liable for their waste and have to comply with a system that ensures its recycling and recovery operations. In this regard, the Der Grüne Punkt – Duales System Deutschland GmbH (DSD, the German Green Dot company and the first of its kind) was created in 1990 as a non-profit agency (DSD 2011). The recycling system is 100% financed by the industry. There is no public money financing the selective collection and sorting of packaging waste (EIMPack 2012a). A dual (separate) system for the collection was established for managing packaging waste. Until 2004, DSD coordinated the packaging waste collection with the local authorities across the country and was responsible for the sorting and recovery of all sales packaging. DSD has been carrying out this activity by contracting private and municipal solid waste management companies (PRO-Europe, 2010). In 2004 the market was liberalized and DSD was privatized (i.e. producers are no longer the shareholders, as in most Green Dot companies). The objective was to introduce competition in the recycling market. Currently, there are a total of nine (for-profit) dual systems companies licensed to manage packaging waste. DSD continues to be the major player with the highest market share (EIMPack 2012a).

The packaging waste management operations are financed by the compliance fees paid by the dual systems' clients. DSD only issues current price information to actual customers, however, the last published list of fees, corresponding to the year 2007, is the following (PRO-Europe 2010):

- Glass – 74 €/ton;
- Paper / cardboard – 175 €/ton;
- Tinplate – 272 €/ton;
- Aluminium, other metals – 733 €/ton;

- Plastic – 1.296 €/ton;
- Composites cartons with special acceptance and recycling guarantee – 752 €/ton;
- Other composites – 1.014 €/ton;
- Natural materials – 102 €/ton.

DSD is the Green Dot company, however with nine dual system companies the use of the Green Dot marking is not mandatory and companies which want to use the symbol on their packaging have to pay a trademark fee in addition to the fee based on the weight and material of the packaging (see EIMPack 2012a). Note that, currently, compliance fees are not known for any of the dual systems for competition reasons. Likewise, the costs of managing packaging waste are also unknown to the general public.

Since 2004, DSD has tendered collection services and organized the collection infrastructure in three-year contracts which have been shared by the remaining dual systems. The cost sharing regarding packaging waste collection is performed on a market share basis. After collection, the waste is delivered to each dual system company (being processed in a transfer station), according to the corresponding market share. The costs with containers and with communication are supported by the compliance schemes (also based on the market share). In Germany, unlike the other countries analysed in this paper, all the costs and the responsibility for the packaging waste management were transferred to the industry.

3.3 Portugal

In Portugal, the PPW Directive was first translated into national legislation during 1997-1998. As in the other case-studies, the economic operators' responsibility can be transferred to a licensed company. The Sociedade Ponto Verde (SPV, the Portuguese Green Dot company) is a non-profit private entity responsible for the packaging waste management. This company was licensed in 1997 by the Ministers of Economy and the Environment to act on behalf of the economic operators regarding the management of municipal packaging waste. Later on, SPV extended its reach to the trade and industry packaging waste (the industrial flow).⁴ However, the Portuguese law states that municipalities are the competent

⁴ The intervention of SPV on the industrial flow is only indirect (it mainly entails the collection of data through an “information and motivation fee”, see EIMPack, 2011).

authorities regarding municipal solid waste management. In most cases, selective collection, sorting and waste treatment activities are carried out by public regional companies (Cruz et al. 2013). Economic operators pay a Green Dot fee that supports SPV's financial scheme. The Green dot fees are contingent on the material, weight and packaging classification (primary, secondary and tertiary). Regarding the municipal flow, in 2010, the Green Dot fees for primary packaging in Portugal were as follows (SPV 2011):

- Glass – 18,3 €/ton;
- Paper and cardboard – 86,3 €/ton;
- Plastic – 228,2 €/ton;
- Composite Packaging – 129,4 €/ton;
- Steel – 96,0 €/ton;
- Aluminium – 164,4 €/ton;
- Wood – 15,4 €/ton;
- Others – 260,0 €/ton.

The value paid by the SPV to the local authorities (FSLA) in 2010 is displayed in Table 6. This payment is calculated according to the material and the *per capita* quantities of packaging waste selective collection and sorting by local authorities. The FSLA model is based on the efficiency of the waste management systems and their *per capita* potential (SPV 2010). In Table 6, P1, P2 and P3 represent the values paid by the SPV; X1 represents the national average of waste taken back carried out by the local authorities; X2 corresponds to the take-back *per capita* required to comply with the targets of the PPW Directive; X3 is the potential market for packaging (total packaging produced in Portugal divided by the population). There is one crucial difference on the Portuguese Green Dot system: once SPV pays the FSLA, it owns the packaging waste. Hence, SPV deals directly with recyclers regarding the selling of sorted packaging material.

[Insert Table 6 here]

3.4 Romania

In Romania the PPW Directive was implemented through the Government Decision (GD) no. 621/2005 (amended by the GD no. 1872/2006 and GD no. 247/2011) on PPW management and through the Order no. 927/2005 on data reporting procedures regarding PPW. According to the legislation, “economic agents that place commercial packaging on the market are responsible for these packaging”. The recycling and recovery objectives can be achieved by the economic agents individually, through the collection of packaging waste produced or, once again, by delegating their responsibilities to an authorized company (compliance scheme).

Currently, there are seven companies licensed for the management of packaging waste and to comply with the recycling and recovery targets. Eco-Rom Ambalaje (ERA) is the non-profit Green Dot company operating in Romania and is also the company with responsibility over the biggest share of the packaging placed on the market. ERA has been supporting the implementation of a selective collection system at the national level through contracts established with local authorities and municipal solid waste management operators. In order to achieve the national recycling and recovery targets, ERA also firms contracts with private companies that collect and recycle industrial and commercial packaging waste. All contracts entail a financial support for the packaging waste management services carried out. In exchange, they have to declare all the quantities of packaging waste collected and sent to recycling and recovery. In the household flow, a three-party agreement has been established between ERA, waste management operators and local authorities. The compliance schemes activity is financed by the license fees which are paid by the industry. The Green Dot fees charged by ERA for the year 2010 are presented in Table 7. These fees should cover the costs of collection and recycling/recovery services performed by authorized public and private companies.

According to the model adopted by ERA for financing packaging waste management, the companies performing the waste management operations receive a financial support (called bonus payment). Table 7 presents this financial support for 2010. The costs of selective collection and treatment (including sorting and baling operations) are only partially supported by the Green Dot fees. It is quite interesting to note that, unlike other countries, there is a lack of significant variation of green dot fees and bonus fees depending on material. This may be partially explained by the fact that most of the packaging waste recycled in Romania comes from the industrial flow (and also due to the presence of waste pickers).

Waste management companies also rely on the sales of sorted packaging waste material. These companies receive the payment directly from the recycling industry (see Table 7 for the average price of recyclables in 2010).

[Insert Table 7 here]

3.5 The United Kingdom

The goals of the PPW Directive were transposed into the UK legislation through the Producer Responsibility Obligations Packaging Waste Regulations in 1997. These regulations introduced the concept of shared responsibility by all economic operators involved in the life cycle of packaging. This includes importers of packaging, manufacturers of packaging and packaging materials, packers, fillers and retailers (thus, significantly different from what happens in other countries). This country has set more ambitious targets than the PPW Directive. Currently, the objective is 74% for overall recovery. The minimum recycling rates are 69,5% for paper and cardboard, 81% for glass, 40% for aluminium, 71% for steel, 32% for plastic and 22% for wood.

Once again, in the UK, local authorities are responsible for the collection of municipal solid waste and the development of waste management plans that encourage waste prevention and recycling (Adams et al., 2000). The producers of packaging and/or packaging materials can transfer their responsibilities to an authorized company (compliance scheme). There is a total of 22 compliance schemes in the UK, where Valpak (the Green Dot company) is one of many players. The economic operators (or the compliance schemes) have to prove that they respect the recovery and recycling obligations by submitting yearly certificates/statements of compliance and operational plans through an electronic database (the National Packaging Waste Database). Operational plans must contain information demonstrating that “sufficient financial resources and technical expertise will be available to enable the performance of the recovery and recycling obligations of the producer” as well as “how the recovery and recycling obligations will be performed as regards each of the packaging materials relevant to those obligations”.

Certificates/statements of compliance are obtained through the Packaging Recovery Note (PRN) system. The PRNs are issued by accredited reprocessors of packaging material. The economic operators which

fail to meet their recovery and recycling obligations individually can “outsource” these obligations paying for an equivalent amount of packaging. The Packaging Export Recovery Notes (PERNs) are certificates issued by companies which export packaging waste to be treated abroad and they are also accepted as compliance proof regarding recovery and recycling obligations. At the beginning of each year, demand for PRNs is fixed and supply depends on the amount of packaging materials to recycle. The UK recycling system was thought to rely on competition. When the recycling capacity is reaching its maximum, the PRN price tends to increase and demand exceeds supply. This encourages more suppliers to enter into the market, increasing supply. Thus, it will also increase the collection and recycling rates, reducing the PRN price again. Average PRN prices, by type of material, predicted by Valpak in 2010 are as follows (PRO-Europe 2010):⁵

- Paper – 3,80 €/ton;
- Plastic – 5,00 €/ton;
- Glass – 23,29 €/ton;
- Steel – 21,82 €/ton;
- Aluminium – 16,10 €/ton;
- Wood – 1,20 €/ton.

4. Methodology implemented

The methodology applied to analyse the recycling systems of France, Portugal and Romania is based on an economic-financial model which compares the costs and benefits undertaken by local authorities and associated with selective collection and sorting activities. As mentioned above, due to the competitive nature of the systems in Germany and the UK, it was not possible to retrieve the necessary data for these countries. Given the purpose of the current paper, environmental externality costs/benefits were not considered. In fact, our major aim is to answer the following question: are the extra-costs arising with the recycling of packaging waste being recovered via the sale of sorted packaging waste materials (i.e. by the market), or is it being supported by the consumer (i.e. by the industry which reflects its costs on the price of the products) or by citizens in general (i.e. through higher waste management fees of local taxes)? Another interesting query is to determine if the industry is paying for the net financial cost of packaging waste management. The data concerns household packaging waste with the exception of Romania where

⁵ These prices are subject to change and represent the best-case scenario costs.

the industrial flow was also considered (since it represents the biggest share of packaging waste managed by ERA).

Regarding the financial benefits, the items taken into account were: the FSLA (carried out by the compliance schemes), the sale of packaging materials, the sale of non-packaging materials (as non-packaging paper) and Government grants (where applicable). We also include in the analysis a benefit usually disregarded in strictly financial analysis (Pires, 2011): the savings that derive from the diversion of waste from refuse collection and landfilling activities (“other benefits” or avoided costs). This last component was calculated according to equations 1 and 2. Note that since we did not consider any possible benefits that might arise when packaging waste is collected together with the non-recyclable waste materials as a single waste fraction and sent to treatment (other than recycling), these are not net avoided costs. The incineration with energy recovery of plastics, for instance, could be an interesting source of revenue. Therefore, the “avoided costs” figures might be slightly overestimated. The values used in these equations are presented in Table 8.

$$\text{Costs avoided with refuse collection (€/year)} = \frac{\text{Quantity of waste selectively collected (ton/year)}}{\text{Unit cost of refuse collection (€/ton)}} \quad (1)$$

$$\text{Costs avoided with waste treatment (€/year)} = \frac{\text{Quantity of waste recovered (ton/year)}}{\text{Unit cost of treatment and disposal (€/ton)}} \quad (2)$$

[Insert Table 8 here]

Regarding the financial costs, the items taken into account were: the costs of operation and maintenance, and the depreciation of fixed assets (in both cases, only concerning the selective collection and sorting activities). Once again, we include in the analysis a cost that is not always considered when public entities (in our case, local authorities) are carrying the investments (Pires, 2011): the return on capital employed (debt and equity) in the financing of fixed assets allocated to selective collection and sorting.. Equation 3 was used to determine the return on capital employed (local authorities should be compensated for employing their capital on the recycling system) and equation 4 was used to estimate the weighted

average cost of capital (WACC, i.e. the average cost local authorities are expected to pay to finance the assets; the formulation below is on a pre-corporate tax basis).

$$\text{Return on capital employed } (\text{€/year}) = [\text{Depreciation - subsidies}] (\text{€/year}) \times \frac{\text{Useful life of the assets}}{2} (\text{years}) \times \text{WACC } (\%/ \text{year}) \quad (3)$$

$$\text{WACC } (\%) = \text{Cost of equity } (\%) \times \frac{\text{Equity } (\%)}{[1 - \text{corporate tax } (\%)]} + \text{Cost of debt } (\%) \times \text{Debt } (\%) \quad (4)$$

The estimated “Useful life of the assets” is 9,6 years; this value was achieved considering the assets and its depreciation and was weighted by the waste selectively collected. The “Cost of equity is 6,0%”; this value takes into account a non-risk (of 3%, related to the German Treasury Bonds) and a risk premium. The “Equity in the capital structure” estimate is 19,0%; this value was defined taking into account the weight that equity has on the capital structure of the utility (i.e. in relation to the liabilities) and was weighted by the waste selectively collected. The “Marginal corporate tax” value varies among the case studies (see EIMPack 2011c and EIMPack 2012a,c). The “Cost of debt” was estimated to be around 4,6%; this value was achieved considering the average interests paid for the utilities’ loans and was weighted by the waste selectively collected.

If one interprets the EPR policy present in the PPW Directive in a strictly manner (i.e. the industry should pay the net cost of packaging waste recycling), it seems that the first three parcels of the benefits (FSLA plus sale of sorted packaging waste plus sale of non-packaging material) should match all the (efficient) costs. The costs and benefits were calculated based on quantities of packaging waste collected (i.e. unit costs and benefits).

All data were collected through surveys and the annual account reports of waste management operators reporting to the year 2010. Our sample includes a total of 45 French local authorities in charge of selective collection and sorting of household packaging waste. These local authorities are supported by Eco-Emballages and cover about 20% of the French population (see EIMPack 2012b). In Portugal the data refers to all 27 regional operators covering the entire population (see EIMPack 2011). In Romania

the data were obtained from the waste management operators belonging to the ERA system (EIMPack 2012c).

5. Results and discussion

We applied the methodology described in the previous section to Portugal, France and Romania. The sale of packaging material was not considered for Portugal because SPV owns the packaging waste once it pays for the FSLA (that is why the magnitude of this parcel is higher for this country). Government grants (subsidies to the investment) were not considered in Romania due to the fact that the waste management operations are mainly performed by private companies. One should note that in this country most of the packaging waste collected comes from the industrial flow which is significantly less complex (and costly) than the household packaging waste flow (industrial packaging waste is usually much better separated at the source and the frequency of collection is optimized). Fig. 1 illustrates the balance between the unit costs and benefits (regarding aggregate tons, i.e. the values represent the mix of packaging materials for each country) of selective collection and sorting activities performed by waste management operators.

[Insert Fig. 1 here]

Any assertions regarding the adequacy of the financial transfers carried out by the Green Dot companies depend on the perspective adopted. The percentages in between bars in Fig. 1 represent the costs coverage attained by local authorities considering the avoided costs with other treatment and also excluding these savings. If one accepts that the savings attained by diverting waste from landfills (and incineration, etc.) should be accounted for as a benefit of recycling, then the financial support by the industry could be reduced (except in Romania). On the other hand, if the EPR principle was to be strictly followed, perhaps the transfers should increase. However, there is no indication about the cost-efficiency of waste management operators (De Jaeger et al. 2011). In fact, it could be the case that operators are “dislocating” mixed waste management costs, expecting more funding from the industry. Furthermore, in most cases it is difficult to ascertain if operators are declaring “costs” or “prices” regarding selective collection and sorting activities. The costs of packaging waste management (preparation for recycling) are shown in Fig. 2. One should bear in mind that glass is usually not sorted and has a high density (thus, sorting costs are mainly divided by the quantity of paper/cardboard and plastic packaging waste collected).

[Insert Fig. 2 here]

Based on the authors' survey and Eco-Emballages (2010), the unit costs (per ton collected) of selective collection per type of household flow are as follows: in Portugal, 64 €/ton for glass, 147 €/ton for paper and cardboard, and 314 € for plastic and metals; in France, 72 €/ton for glass, 167 €/ton for paper and cardboard, and 788 €/ton for plastic and metals. Indeed, plastic and metal household packaging waste is much more costly in general. For Romania it was possible to report the operational costs (collection and sorting) for each type of packaging waste material, namely: 27 €/ton for glass, 165 €/ton for PET, 139 €/ton for other plastics, 88 €/ton for paper and cardboard, 303 €/ton for aluminium, 129 €/ton for steel and 41 €/ton for wood.

In international comparisons, it is important to take into account the purchasing power parity (PPP) of each country. Hence, we also computed the costs and benefits of recycling with the adjusted values using World Bank indicators for 2010 (0,63 for Portugal, 0,88 for France and 0,38 for Romania). These coefficients transform local currencies in international dollars taking into account the purchasing power of each country (thus correcting for some structural differences and rendering fairer results). As one can see in Fig. 3, the PPP adjustment indicates that actually costs are higher in Romania and lower in France. Conversely, benefits (and the financial support from the industry) seem to be higher in Portugal. It would seem that waste management operators are more cost efficient in France than the ones in Portugal and Romania (nevertheless, a different type of analysis would be required to confirm this). However, this is not totally unexpected given different maturities of the national systems. Local authorities need some time to adapt to new requirements and technologies and the sophistication of the financing mechanisms may also play an important role. In fact, incentives for good performance should be embedded in these mechanisms to push waste management operators to improve over time.

[Insert Fig. 3 here]

For comparison reasons, we also mention the collection costs in Germany as reported in BMWI (2009) and BMU (2011). On average, the cost of kerbside collection of dry recyclables is around 265 €/ton

(minimum 200 €/ton and maximum 300 €/ton). Sorting seems to be around 150 €/ton. Apparently, in this country, the introduction of competition on the market was beneficial since waste management costs have decreased.⁶ Since 2004, when DSD started to put waste collection services out to tender, the collection costs decreased about 30% (Bundeskartellamt 2011). One should note that this cost reduction can also be associated with the innovation and the development of the recycling industry and technology.

6. Concluding remarks

The for-profit or non-profit nature of the entities that take on the responsibility of recovering packaging waste (on behalf of the industry) has some implications on the overall functioning of the recycling systems. Competition seems to enhance cost efficiency (at least if the case of Germany can be generalized). However, the lack of transparency is a negative externality of setting up a competitive environment among these entities or producer compliance schemes. In simple terms, our major research questions were: (1) “Who is paying for the added costs of recycling”? (2) “Is the industry paying for the net cost”? For the case of Germany, the answer to this question is quite clear. The industry endures all the costs (selective collection, transport, sorting and storing) and collects all the benefits (selling of recyclables). Arguably, in the UK, the same happens because guarantors and recyclers (who sell the PRNs) have to purchase the packaging waste from waste management operators (demand increases the value of packaging waste). The problem is that one is not able to estimate the actual cost of selective collection and sorting due to competition (and “trade secret”). In fact, although the EPR principle is respected with these strategies, it would still be interesting to determine if this type of policy maximizes public welfare (i.e. minimizes the overall cost of recycling).

Covering several countries, this paper is not concerned with the details and specificities that should be considered if the objective was to criticize each system individually. Comparing different frameworks and approaches is crucial for the EU policy makers and also other countries that may be considering their options regarding the management of packaging waste in an environmentally (and financially) sound manner (Lavee 2007).

⁶ However, as many factors influence these costs (Chen, 1010) a more detailed analysis should be carried out to confirm this stance.

Adopting an “economic perspective”, Portugal and France have a (packaging waste management) cost coverage of 128% and 135%, respectively (benefits over costs, see Fig. 1). However, excluding the costs avoided with the disposal (or other treatment) operations and the subsidies to the investment (public grants), we conclude that, in 2010, only 68% and 56% of the costs are being supported by the industry in Portugal and France (respectively). From this perspective, the financial sustainability of the services would require an increase of respectively 50% and 125% of the FSLA in Portugal and France. In Romania the costs are (in both approaches) higher than the benefits. In this country, 93% of the packaging waste managed by the ERA recycling system comes from the industrial/commercial flow, being collected and processed directly by the industry.

In summary, the financial support from the industry has been enough to compensate for the incremental costs of recycling; that is, except for Romania, local waste management prices/taxes did not have to increase so that selective collection and sorting could take place (because the financial benefits plus the savings attained by diverting packaging waste from the undifferentiated flow compensated for these). However, the industry is not paying for the full costs of packaging waste management in any of the countries (i.e. the transfers plus other financial benefits are not enough to cover the costs of local authorities).

Local authorities must be efficient in order to reduce the household packaging waste management costs (De Jaeger et al. 2011). Arguably, both the SPV and Eco-Emballages financial models used in 2010 were set up to encourage the efficiency of the local authorities. However, the FSLA supported by SPV depends only in the performance of the local authority expressed in kg per inhabitant per year of packaging waste taken back. In France, the FSLA was calculated according to the *Barème D* (transfers increased with the selective collection performance). Most recently, a new financing scheme (called *Barème E*) was developed entailing several different types of financial supports with the objective of promoting the overall efficiency of the systems and the disclosure of information.⁷ This model, concerning the period between 2011 and 2016, was introduced to achieve the new goals (e.g. 75% of recycling and coverage of

⁷ For instance: selective collection support, citizen awareness support, support for the sustainable development of the performance of the selective collection service, support for the performance of recycling, and support for other types of recovery.

80% of local authorities' efficient costs). The German and the UK financial models are based on the market competition and on the market prices of the packaging waste materials.

One crucial issue for all recycling systems has to do with free-riders (producers that introduce packaged goods into the market without contributing financially for packaging waste recovery operations). On the one hand, the local authorities and the compliance schemes are supporting the waste management operations with no contribution from those producers (which distorts the market). On the other hand, the packaging waste is recovered through the systems, contributing for the recycling and recovery targets, resulting in unrealistic rates. In Germany, for instance, the proportion of packaging waste considered to be free-riding is around 23% (Koesegi 2011) and the recycling rates, in some packaging waste materials exceeds 100%. This problem could be much worse in Romania where the proportion of packaging waste declared (in relation to total municipal solid waste) is unexpectedly low.

Finally, the citizens' awareness of the environmental problems should always be encouraged by public authorities (Garcés et al. 2002). The citizens' participation in the life-cycle of packaging waste is important for the efficiency and effectiveness of recycling, especially in Romania where the selective collection is quite recent (and coverage is still very low). All the stakeholders involved in the recycling process are important to its success and economic sustainability (Ezebilo and Animasaun 2011).

Acknowledgments

This paper has been carried out with the financial support of the European Investment Bank University Research Sponsorship (EIBURS) Program. Any errors remaining are responsibility of the authors. The findings, interpretation and conclusions presented in this article are entirely those of the authors and should not be attributed in any manner to the European Investment Bank.

References

Adams, K.T., Phillips, P.S., Morris, J.R. 2000. A radical new development for sustainable waste management in the UK: the introduction of local authority Best Value legislation. *Resour. Conserv. Recycl.* 30,221-244.

- ADEME. 2008. Industrial, commercial and household packaging in France - Summary/2008 data. Agence de l'Environnement et de la Maîtrise, France
- ARGUS. 2001. European Packaging Waste Management Systems. Final Report, European Commission, Brussels.
- Bailey, I. 1999. Flexibility, harmonization and the single market in EU environmental policy: The packaging waste Directive. *J. Common. Mark. Std.* 37,549-571.
- BMU. 2011. Evaluierung der Verpackungsverordnung. Umweltforschungsplan des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit, Berlin.
- BMWI. 2009. Ökonomische und ökologische Bewertung der getrennten Sammlung von verwertbaren Abfällen aus privaten Haushalten sowie vergleichbaren Anfallstellen. Bundesministeriums für Wirtschaft und Technologie, Berlin.
- Bundeskartellamt. 2011. Case summary: Coordination of tenders for sales packaging waste collection services by compliance schemes. The Bundeskartellamt, Bonn.
- Chen, C.C. 2010. Spatial inequality in municipal solid waste disposal across regions in developing countries. *Int. J. Environ. Sci. Tech.* 7,447-456.
- Cruz, N.F., Simões, P., Marques, R. 2012. Economic cost recovery in the recycling of packaging waste: the case of Portugal. *J. Clean. Prod.* 37,8-18.
- Cruz, N.F., Simões, P., Marques, R. 2013. The hurdles of local governments with PPP contracts in the waste sector. *Environ. Plan. C.* 31,292-307.
- De Jaeger, S., Eyckmans, J., Rogge, N., Puyenbroeck, T.V. 2011. Wasteful waste-reducing policies? The impact of waste reduction policy instruments on collection and processing costs of municipal solid waste. *Waste. Manag.* 31,1429-1440.
- DSD. 2011. Der Grüne Punkt - Duales System Deutschland GmbH. <http://www.gruener-punkt.de>. Accessed 24-08-2011.
- Eco-Emballages. 2010. La base de données e-coûts: Principaux résultats. Eco-Emballages, Paris.
- Eco-Emballages. 2011. Annual and Sustainable Development Report 2010. Eco-Emballages, Paris.
- Eco-Rom. 2011. Recycle now for a better future. Annual report 2010, Eco-Rom Ambalaje, Bucharest.
- Eichstadt, T., Kahlenborn, W. 2000. Packaging Waste: German Case Study. Final report for TEP project, European Commission Framework Programme IV, Ecologic - Centre for International and European Environmental Research, Berlin.

- EIMPack. 2011. The Economics of Packaging Waste Recycling: The Case of Portugal. EIMPack project, Instituto Superior Técnico, Lisbon.
- EIMPack. 2012a. Framework, Evolution and Economics of Packaging Waste Recycling: The Case of Germany. EIMPack project, Instituto Superior Técnico, Lisbon.
- EIMPack. 2012b. The Economics of Packaging Waste Recycling: The Case of France. EIMPack project, Instituto Superior Técnico, Lisbon.
- EIMPack. 2012c. The Economics of Packaging Waste Recycling: The Case of Romania. EIMPack project, Instituto Superior Técnico, Lisbon.
- European Commission. 2006. Implementation of Directive 94/62/EC on packaging and packaging waste and its impact on the environment, as well as on the functioning of the internal market. Report from the Commission to the Council and the European Parliament, European Commission, Brussels.
- Eurostat. 2012. Eurostat News Release 48/2012: Environment in the EU27. Eurostat Press Office, Luxembourg.
- Ezebilo, E.E., Animasaun, E.D. 2011. Households' perceptions of private sector municipal solid waste management services: A binary choice analysis. *Int. J. Environ. Sci. Tech.* 8,677-686.
- Garcés, C., Lafuente, A., Pedraja, M., Rivera, P. 2002. Urban waste recycling behavior: antecedents of participation in a selective collection program. *Environ. Manage.* 30,378-390.
- Hansen, W., Christopher, M., Verbuecheln, M. 2002. EU Waste Policy and Challenges for Regional and Local Authorities. Ecologic - Centre for International and European Environmental Research, Berlin.
- Koesegi, N. 2011. Development strategies for producer responsibility and recycling. International Solid Waste Association, Vienna.
- Lavee, D. 2007. Is municipal solid waste recycling economically efficient? *Environ. Manage.* 40,926-943.
- OECD. 2001. Extended producer responsibility: A guidance manual for governments. OECD, Paris.
- Okuda, I., Thomson, V.E. 2007. Regionalization of municipal solid waste management in Japan: balancing the proximity principle with economic efficiency. *Environ. Manage.* 40,12-19.
- Pires, J.S. 2011. Avaliação dos custos acrescidos com a recolha selectiva de embalagens. The Water and Waste Services Regulation Authority, Lisbon.
- PRO-Europe. 2010. Producer responsibility in action. Packaging Recovery Organisation Europe, Brussels.

- PRO-Europe. 2011. Uniformity in diversity: Producer responsibility in action. Packaging Recovery Organisation Europe, Brussels.
- Rigamonti, L., Gross, M., Giugliano, M. 2010. Life cycle assessment of sub-units composing a MSW management system. *J. Clean. Prod.* 18,1652-1662.
- SPV. 2010. Activities Report 2009. Sociedade Ponto Verde, Oeiras.
- Walls, M. 2005. How local governments structure contracts with private firms: economic theory and evidence on solid waste and recycling contracts. *Public Works Manag. Pol.* 9,206-222.
- Yau, Y. 2010. Domestic waste recycling, collective action and economic incentive: The case in Hong Kong. *Waste. Manag.* 30,2440-2447.

Table 1 Municipal waste production and treatment in 2010. Source: Eurostat

	Waste generated (10 ³ tons)	Landfilled (10 ³ tons)		Incinerated (10 ³ tons)		Recycled (10 ³ tons)		Composted (10 ³ tons)	
EU-27	253.517	94.284	38,4%	55.156	22,5%	62.027	25,3%	33.892	13,8%
France	34.535	10.745	31,1%	11.730	34,0%	6.143	17,8%	5.917	17,1%
Germany	49.237	206	0,4%	18.256	37,1%	22.476	45,6%	8.298	16,9%
Portugal	5.457	3.381	62,0%	1.058	19,4%	619	11,3%	399	7,3%
Romania	7.830	6.214	98,7%	0	0,0%	79	1,3%	4	0,1%
UK	32.450	15.870	49,3%	3.750	11,6%	8.050	25,0%	4.550	14,1%

Table 2 Packaging waste generated and recycled in 2010. Source: Eurostat

<i>Packaging waste generated</i>	Packaging waste (all materials)			Paper & cardboard	Plastic	Wooden	Metallic	Glass
	(tons)	(kg per capita)	(% municipal waste)	(% packaging waste)	(% packaging waste)	(% packaging waste)	(% packaging waste)	(% packaging waste)
EU-27	78,672,423	156.8	31	39	19	15	6	20
France	12,515,928	192.9	36	37	16	19	5	23
Germany	16,002,600	195.7	33	45	17	16	5	17
Portugal	1,664,296	156.5	30	42	22	6	6	24
Romania	974,940	45.5	12	27	29	22	6	16
UK	10,824,820	173.9	33	35	23	9	7	25

<i>Packaging waste recycled</i>	Packaging waste (all materials)		Paper & cardboard	Plastic	Wooden	Metallic	Glass
	(tons)	(%)	(%)	(%)	(%)	(%)	(%)
EU-27	49,765,018	63.3	83.5	33.3	38.1	71.5	69.2
France	7,645,844	61.1	91.9	23.7	19.1	74.8	69.8
Germany	11,627,900	72.7	90.2	49.4	27.5	92.7	86.1
Portugal	923,991	55.5	67.0	24.5	66.0	72.0	56.6
Romania	422,776	43.4	66.8	28.2	18.1	65.7	56.8
UK	6,568,370	60.7	81.9	24.1	75.4	55.9	60.7

Table 3 Green Dot fees in France for 2010. Source: PRO-Europe (2011).

Fees by packaging material	(€/ton)
Glass	4,5
Plastic	222,2
Paper and cardboard	152,6
Steel	28,2
Aluminum	56,6
Others	152,6

Table 4 FSLA in France for 2010. Source: EIMPack (2012b)

Level	Performance (P) Kg/inh./year	Financial Support (S) in €/ton					
1	$P \leq N_b$	$S = S_b$					
2	$N_b < P \leq N_h$	$S = \frac{(N_b \times S_b) + (P - N_b) \times S_i}{P}$					
3	$N_h < P \leq N_p$	$S = \frac{(N_b \times S_b) + (N_h - N_b) \times S_i + (P - N_h) \times S_p}{P}$					
4	$P > N_p$	$S = \frac{(P - N_p + N_b) \times S_b + (N_h - N_b) \times S_i + (N_p - N_h) \times S_p}{P}$					
	<i>Material</i>	<i>N_b</i>	<i>N_h</i>	<i>N_p</i>	<i>S_b</i>	<i>S_i</i>	<i>S_p</i>
	Steel	1	2	7	45	62,5	80
	Aluminium	0,1	0,2	1	230	280	330
	Paper/Cardboard	4	8	18	120	200	280
	Plastic	1,6	3,2	8	310	575	840
	Glass	15	30	45	3	5	7
	EMR	4	8	18	60	100	140

S_p – plafond support;
 S_i – intermediary support;
 S_b – bottom support;
 N_b – lower level;
 N_h – high level;
 N_p – plafond Level.

Table 5 Take-back prices in France for 2010. Source: EIMPack (2012b)

Material	Option Filières	Option Federations		Option individual	
	Price (€/ton)	Average (€/ton)	Range (€/ton)	Average (€/ton)	Range (€/ton)
Steel from selective collection (packs)	111,6	126,4	79-174	159,3	124-195
Steel from bottom ashes	41,5	49,3	6-93	69,1	47-92
Aluminum from selective collection	451	499,3	348-651	337,9	205-471
Aluminum from bottom ashes	552	635,8	573-698	<i>n.a.</i>	<i>n.a.</i>
Plastics	196,3	189,6	151-229	<i>n.a.</i>	<i>n.a.</i>
Paper/cardboard	72,3	75,6	55-96	51.4	35-68
Glass	22,42	<i>n.a.</i>	<i>n.a.</i>	<i>n.a.</i>	<i>n.a.</i>

Table 6 FSLA in Portugal for 2010. Source: SPV (2011)

Material	Kg/inhabit/year			€/ton		
	X1	X2	X3	P1	P2	P3
Glass	14,3	24,5	40,8	35,0	48,0	60,0
Paper/cardboard	8,0	10,0	15,0	122,0	136,0	149,0
Plastic	2,1	3,6	15,3	732,0	782,0	832,0
Steel	0,4	0,7	4,1	540,0	580,0	619,0
Aluminum	0,02	0,04	0,86	689,0	914,0	1155,0
Composite Packaging	0,3	1,8	3,0	693,0	741,0	788,0

Table 7 Green Dot fees, financial support, and average price of packaging material in Romania for 2010. Source: PRO-Europe (2010), Eco-Rom (2011) and EIMPack (2012c)

Packaging Material	Green Dot Fees (€/ton)	Bonus payment (€/ton)	Average price €/ton
Glass	16,29	23,89	6,9
PET	21,47	32,40	333,5
Plastics	11,68	15,39	253,0
Cardboard paper	13,27	13,67	126,5
Steel	10,27	13,88	218,5
Aluminum	10,27	13,89	977,5
Wood	10,53	10,60	29,9

Table 8 Values used to estimate the “other benefits” of recycling. Source: EIMPack (2011, 2012b and 2012c)

Variable	Portugal	France	Romania
Unit costs of refuse collection	49 €/t	85 €/t	12 €/t
Unit cost of other treatment (landfill, incineration, etc.)	54 €/t	96 €/t	15 €/t
Efficiencies of sorting:			
Glass	95%	99%	90%
Paper/cardboard	93%	95%	45%
Other packaging	63%	76-80%	45%

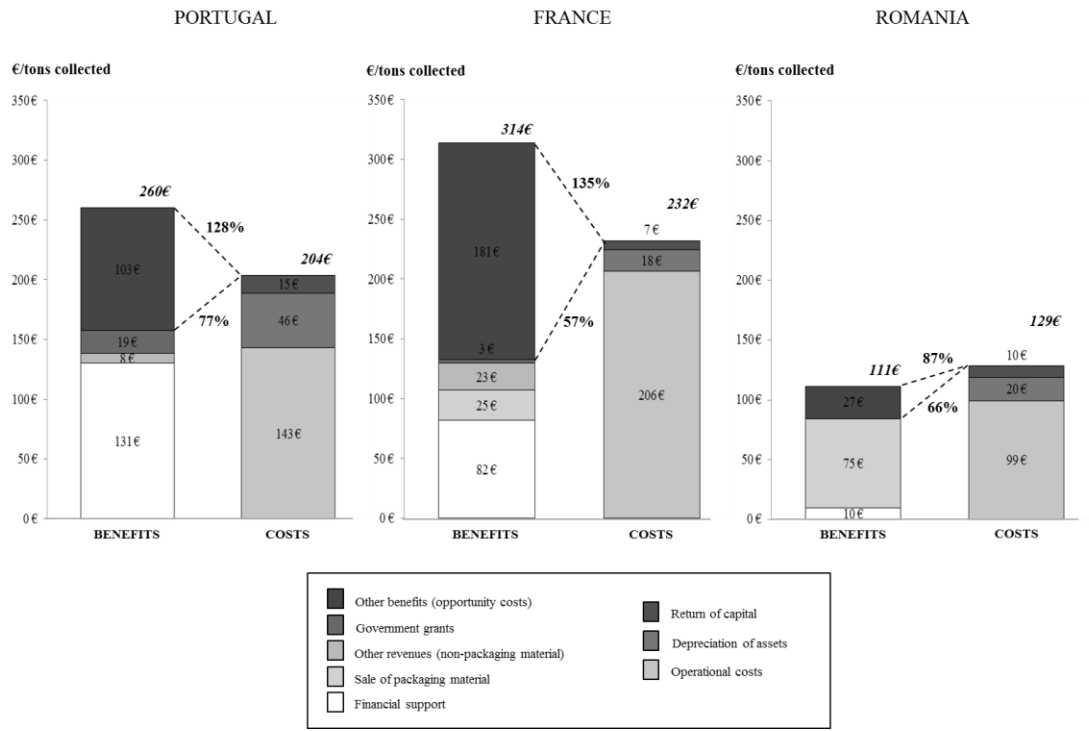


Fig. 1 Cost coverage considering aggregate tons

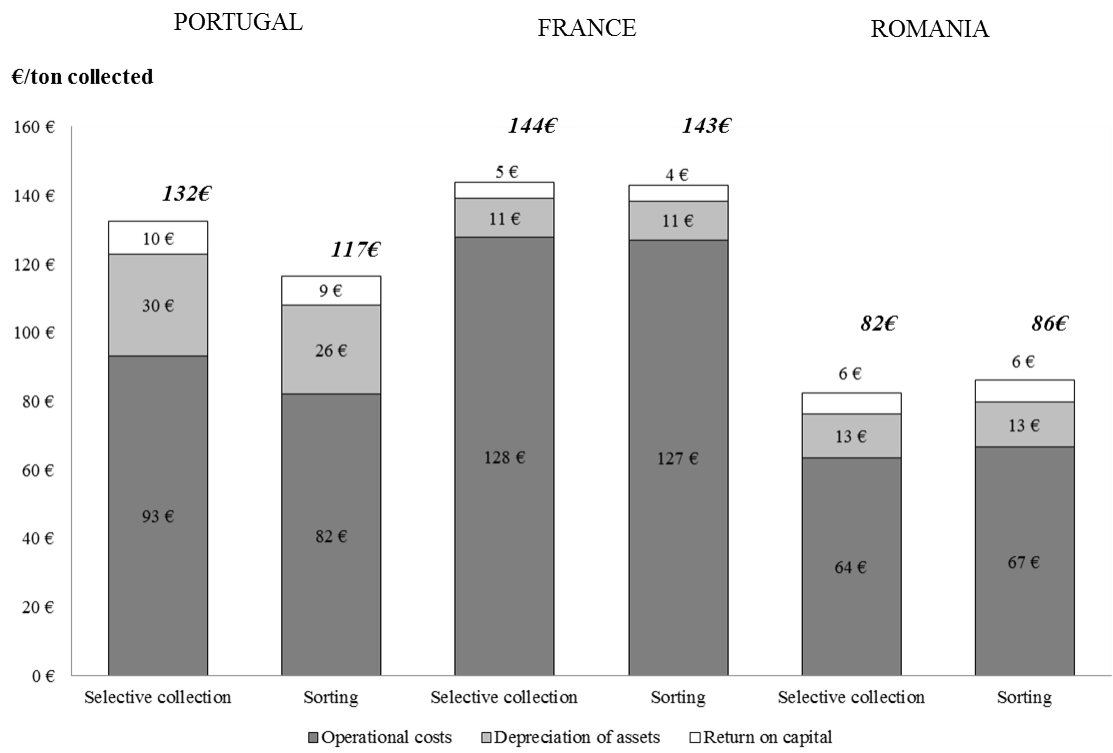


Fig. 2 Unit cost of selective collection and sorting per tons collected

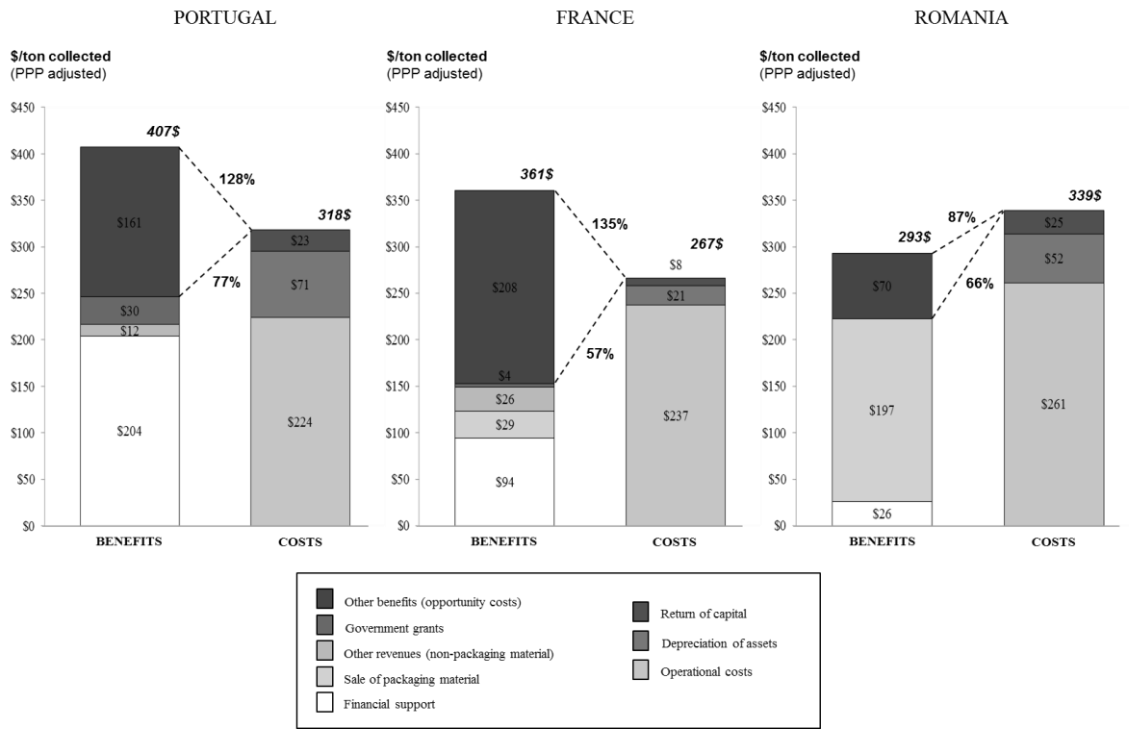


Fig. 3 Cost coverage considering (PPP-adjusted) international dollars per ton