

Bocconi

Monitoring the efficiency and effectiveness of EPR systems in Europe



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le risorse naturali, l'energia,
l'ambiente e le reti

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Objectives

Croci et al. (2021) evaluated 21 EPR systems using KPIs on cost-efficiency and recycling performance. This study:

- Expands the scope to include different **packaging waste management schemes**:
 - EPR based on Producer Responsibility Organizations (PROs)
 - Deposit and Return Systems (DRS)
 - Public waste management with **tax-based** financing.
- Incorporates **updated & new data** on operational performance and EPR fees.
- Introduces a **dynamic KPI framework** for annual, real-time monitoring.
- **Interactive maps** will ensure public access, enhancing transparency and accountability.

Methodology Overview

Based on quantitative **KPIs**:

- **Recycling KPI**: % of material recycled vs. placed on the market.
- **Cost KPI**: cost per ton of recycled material.
 - PROs: based on average fees and actual recycling output.
 - DRS: includes handling and admin costs, adjusted for collection methods.

Detailed EPR System **Classifications**:

- **Market structure**: (e.g. competitive vs. non-competitive schemes; household vs. all waste).
- **Operational responsibility**: public, private, or hybrid collection models.
- **System scale**: based on population served.

Several **Data Sources**:

- Draws from PRO-Europe, EXPRA, Global Deposit Book, national/institutional reports.
- Covers **2014–2023**, across multiple materials and EU countries.
- EPR system changes happened between 2024-2025 fall outside of the scope of the analysis (e.g. enlargement of Spanish and French PROs' ecosystems).

Methodology: KPIs

- Recycling KPI: normalized recycling rate, defined as:

$$\text{norm}\left(\frac{\text{Recycled}_{m,t}}{\text{PoM}_{m,t}}\right)$$

This measures the proportion of placed-on-market (PoM) material that is ultimately recycled.

- Cost KPI: normalized cost per ton of recycled material, defined as:

$$\text{norm}\left[\frac{(\text{Fee}_{m,t} * \text{PoM}_{m,t})}{\text{Recycled}_{m,t}}\right]$$

Adjustments of the DRS cost KPI:

$$\text{norm}\left[\frac{((\text{Hfee} + \text{EPR fee})_{m,t} * \text{UnitsPoM}_{m,t})}{\text{Recycled}_{m,t}}\right]$$

where: m = material type, t = year, Fee = average fee charged by PROs, PoM = placed on market (tons), Recycled = tons of material recycled; *Hfee* = handling fee.

DRS fees do not cover coordination, communication and reporting costs, while PRO fees cover these categories.

Methodology: Evaluation of Public waste management with tax-based financing

Qualitative assessment focusing on four countries—**Lithuania, Latvia, Hungary and Croatia**—where packaging waste taxation is alternative to or integrated with other Extended Producer Responsibility (EPR) schemes, evaluated based on:

- i) the **types of packaging** materials subject to taxation
- ii) the **complementarity with other waste management schemes** for the same material type
- iii) the structure of the **tax rate**
- iv) the **revenues** generated from these taxes

Cost and Performance KPIs could be identified only for Hungary and Croatia due to the limited scope of the public taxation scheme in Lithuania and Latvia.

Assessment across packaging waste management schemes

Method:

Minor adjustments to the KPI framework developed for scheme-specific analysis:

- Time-averaged recycling rate per scheme (all materials included).
- Time-averaged cost per ton of recycled material (all materials included).
- Normalization of KPIs enables cross-scheme comparability despite material and system variations.

Caveats:

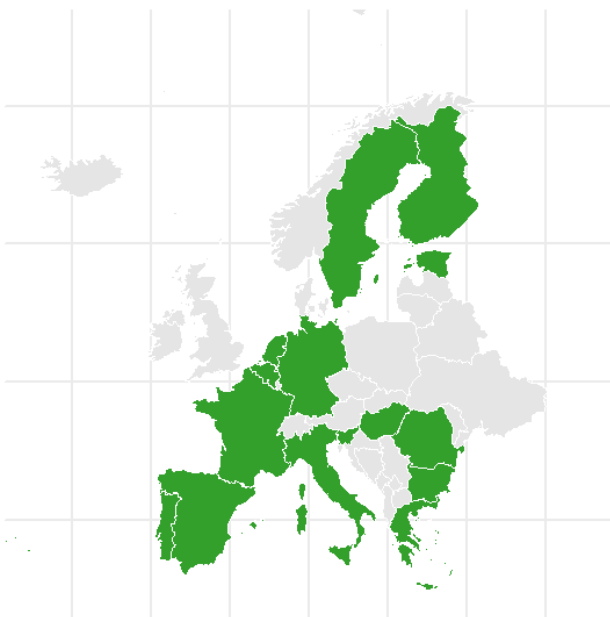
- Normalization across structurally different systems may affect interpretation.

Benefits:

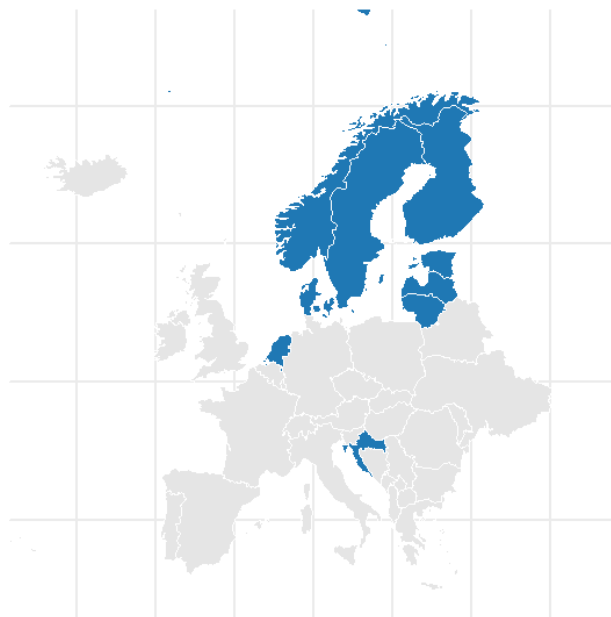
- Enables high-level benchmarking of compliance strategies.

Overall classification of EPR systems

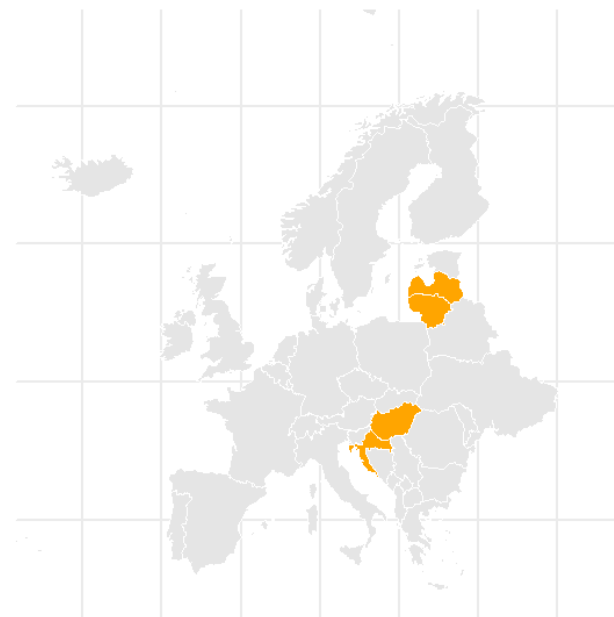
Countries with Evaluated PROs



Countries with Evaluated DRS

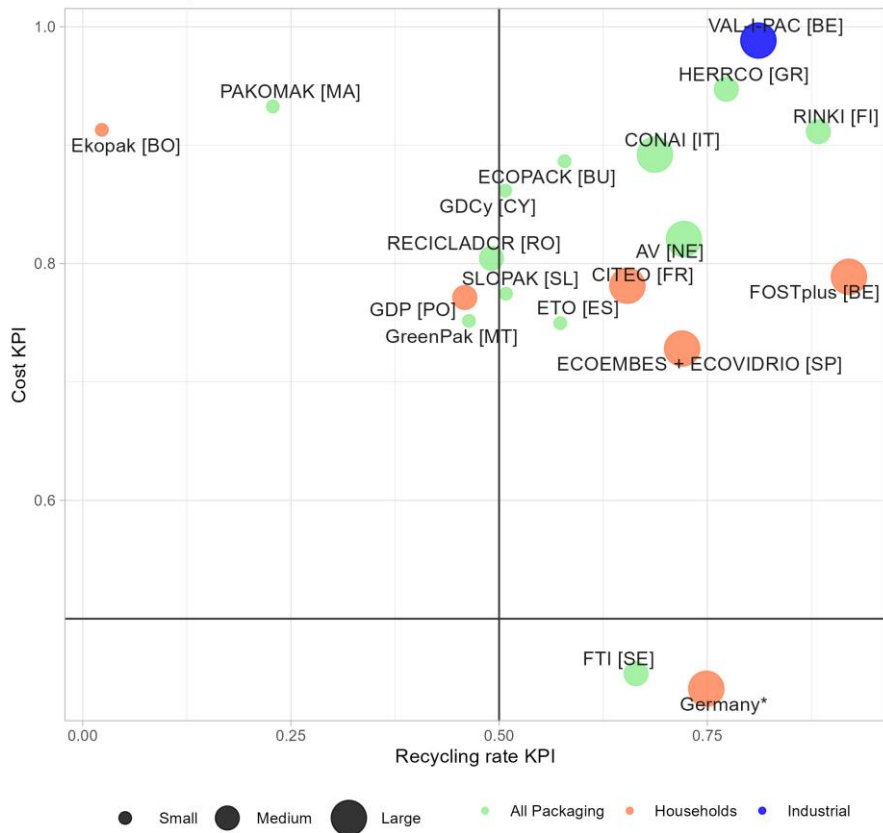


Countries with Evaluated Tax



KPI values by PRO, all materials

Mean KPIs performance

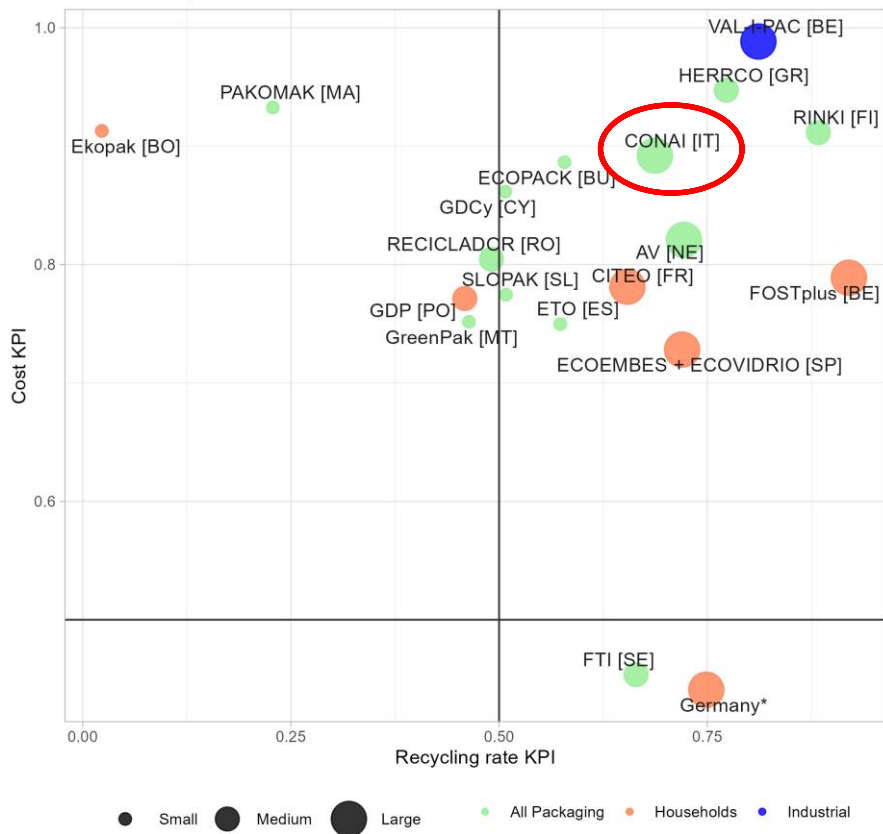


Overall, most PROs demonstrate relatively **strong performance** when considering the **combination of the two KPIs**.

*Germany: average of all PROs – Cost data from PROs license calculators
Period considered: 2014-2023.

KPI values by PRO, all materials

Mean KPIs performance

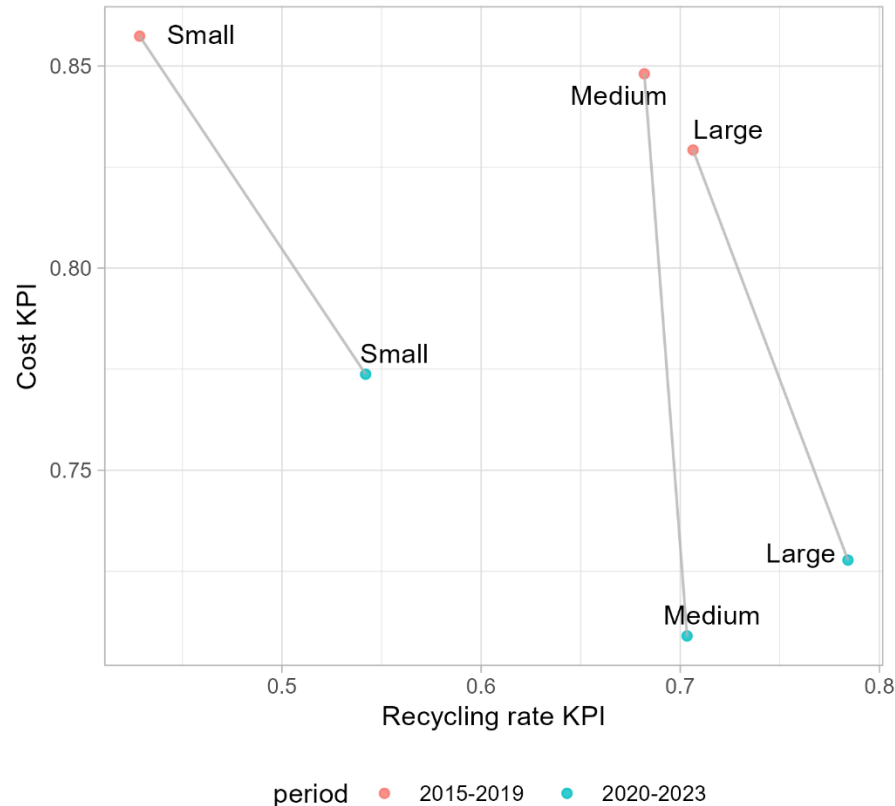


Overall, most PROs demonstrate relatively **strong performance** when considering the **combination of the two KPIs**.

CONAI is among the best PROs with respect to both cost and recycling KPIs.

*Germany: average of all PROs – Cost data from PROs license calculators
Period considered: 2014-2023.

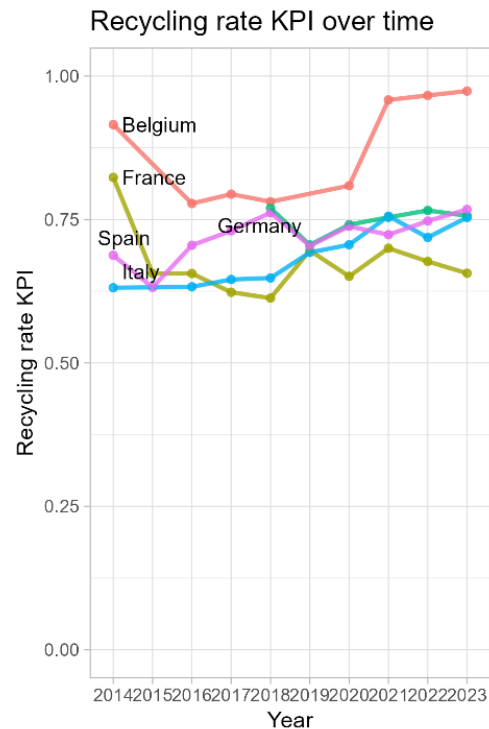
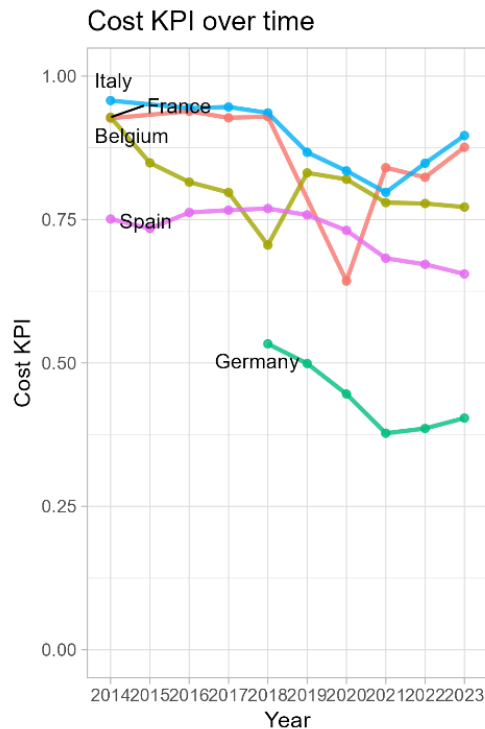
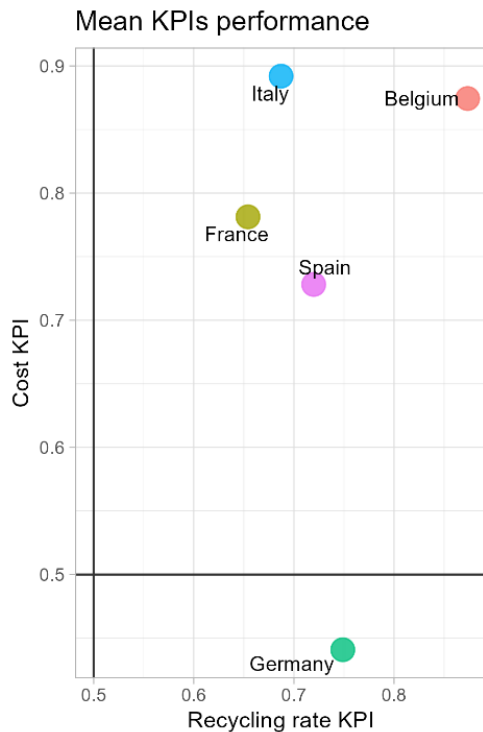
Average KPI values by time period and PRO, all materials



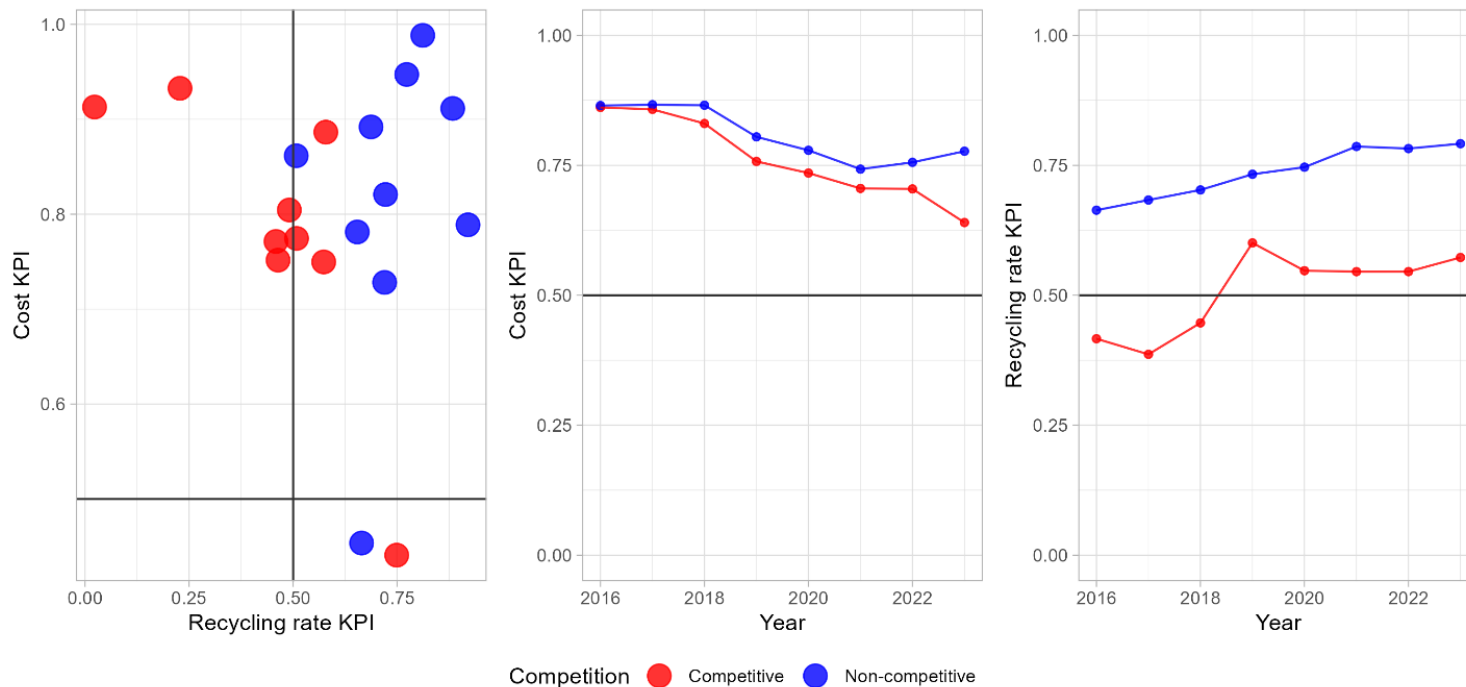
- Cost KPI has declined across all groups, indicating that costs have increased over time
- Recycling KPI has increased in the Large and Small group, indicating that recycling performance has increased over time.

Average and time-specific KPI values by large countries, all materials

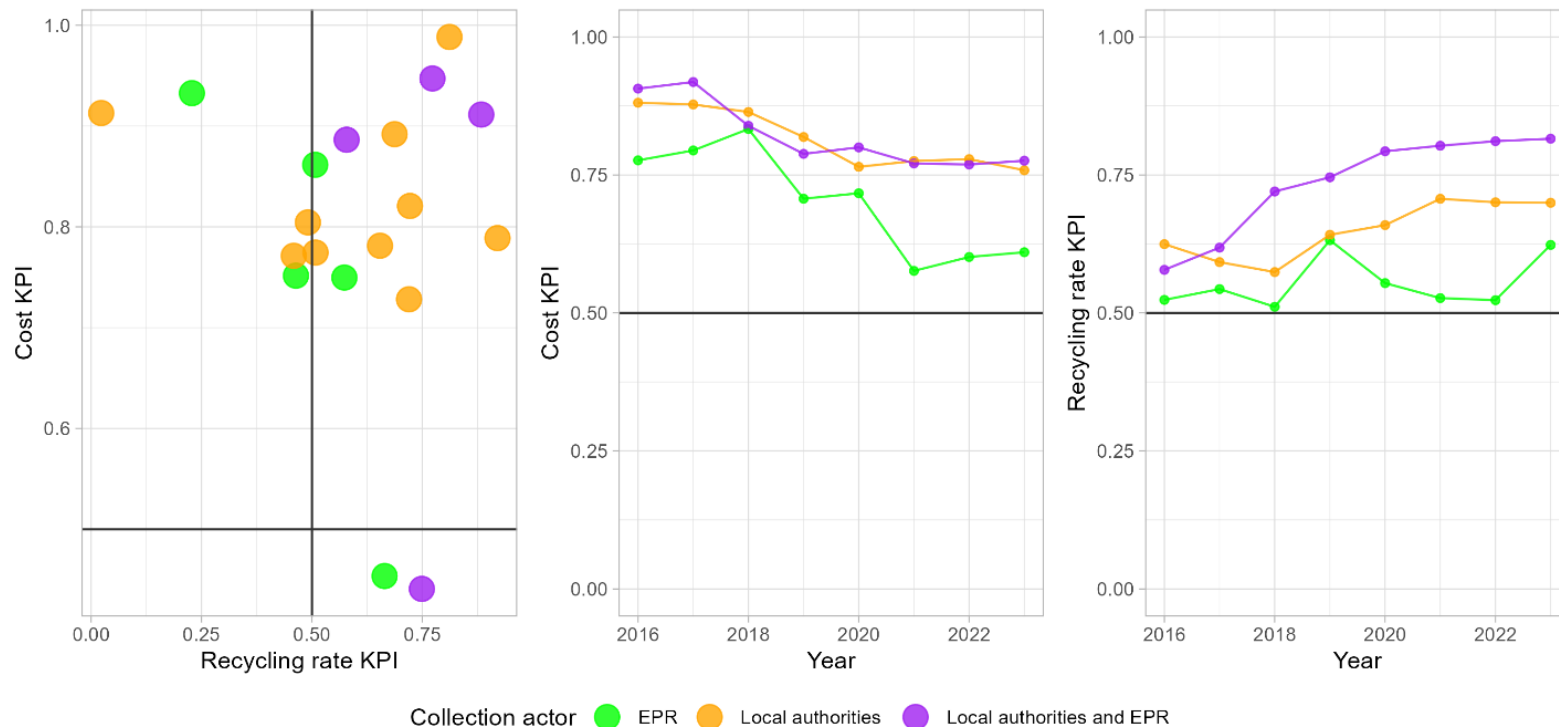
- Germany has the lowest score of the cost KPI, while has recycling rates in line with most comparable countries.
- Belgium has the highest recycling rate KPI and among the highest cost KPI, together with Italy.



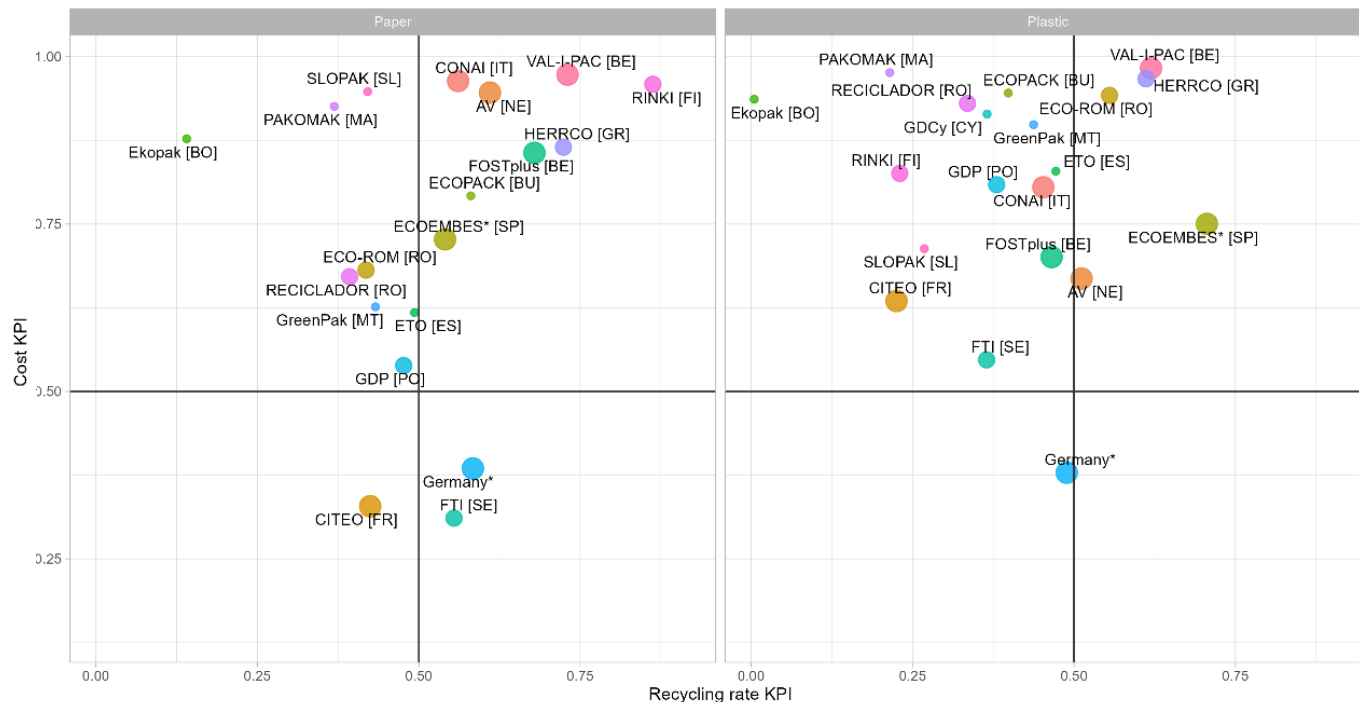
Average and time-specific KPI values by EPR group, all materials



Average and time-specific KPI values by collection group, all materials

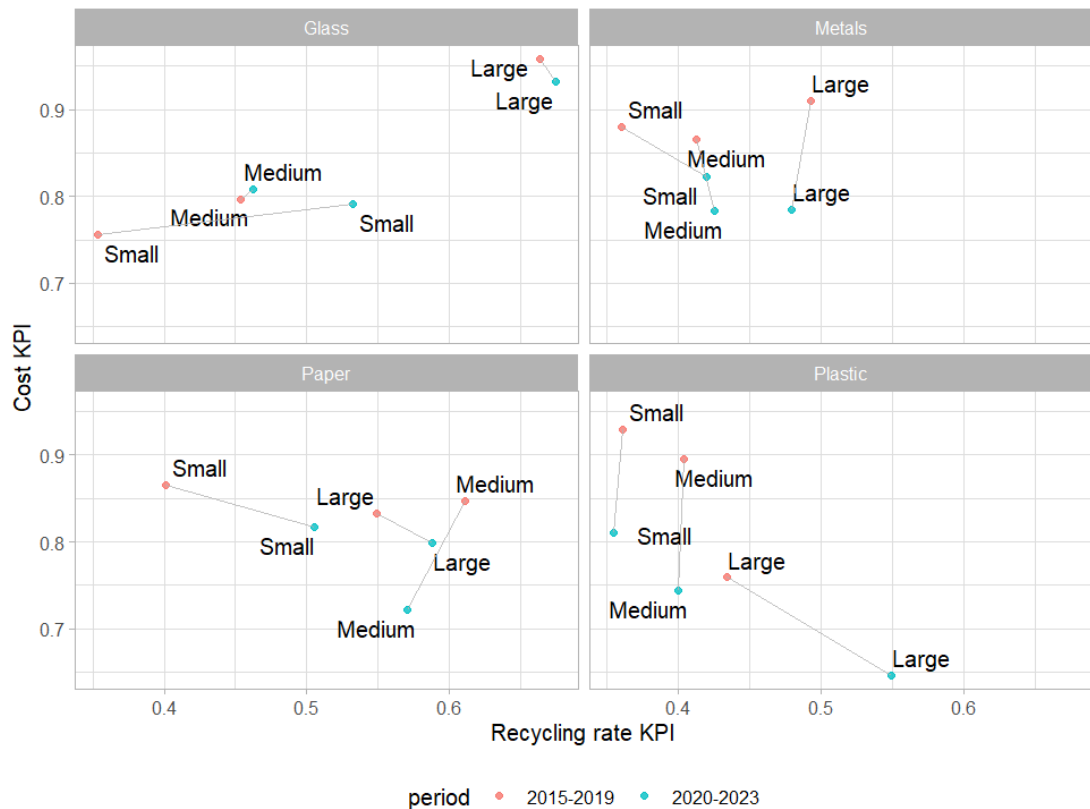


Average KPI values by material between all PROs



- Paper: Recycling KPI is generally high, while cost KPI is more heterogeneous
- Plastic: Recycling KPI is generally low, very few PROs score well in both KPIs

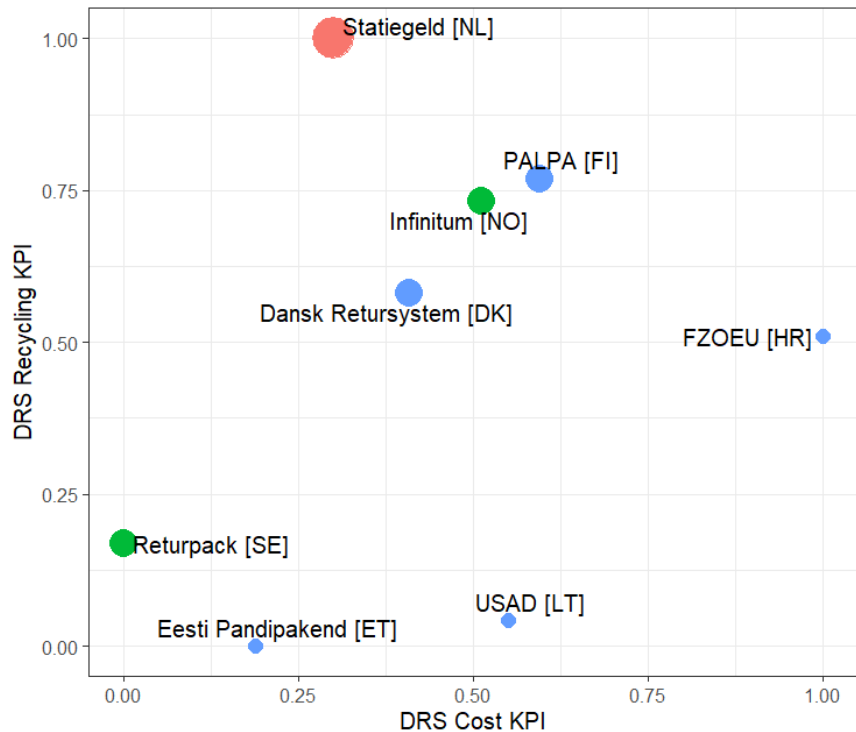
Average KPI values by material over time



The decline in the cost KPI in the more recent period is primarily driven by the plastic stream.

Only large PROs have achieved both a reduction in costs and an improvement in recycling plastics.

Performance of DRS



The KPIs for the DRS paint an heterogenous picture:

- the DRS in the Netherlands has the highest scope in the recycling KPI
- the DRS in Croatia has the highest score in the cost KPI.

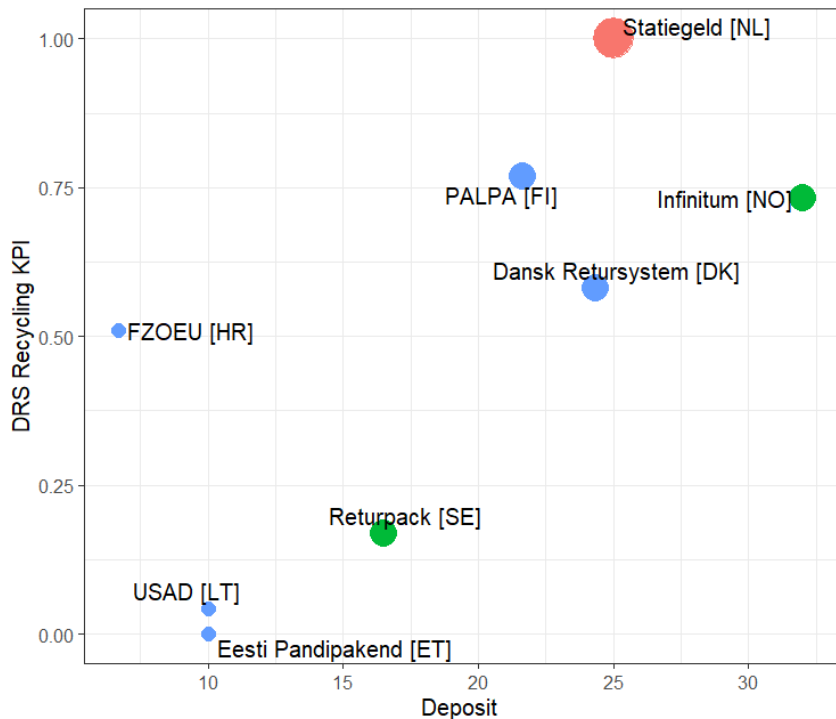
Systems in Denmark, Norway and Finland show very similar performance with average KPI values.

Period considered: 2016-2022

Material group • PET • PET, Metal • PET, Metal, Glass

● Small (<5 mln pop) ● Medium (5-10 mln pop) ● Large (>10 mln pop)

Performance of DRS in relation to the Deposit value



The score in the recycling KPI is highly correlated with the average value of the deposit.

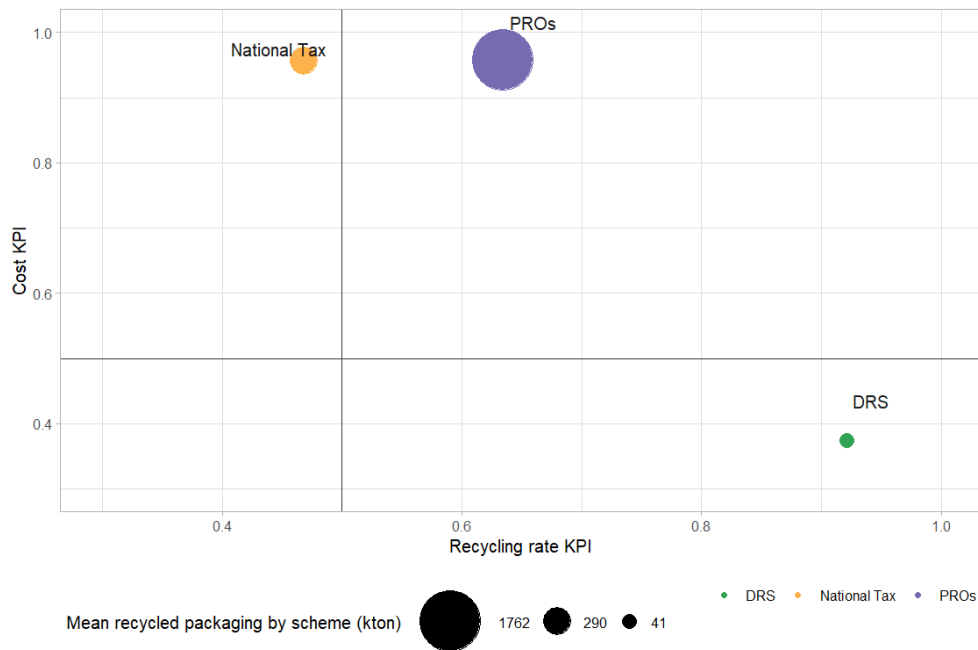
Values of the deposit above 20 cent per unit are associated with KPI scores >0.60.

Analysis of Packaging Waste Taxation Schemes

Table 1: Main features of the packaging waste taxation schemes in selected EU countries

Country	Name	Role in waste management system	Tax Basis	Tax Rate structure	Taxation revenues
Lithuania	Tax on pollution	Complementary to PROs	Glass, Paper and Plastic (only non-recyclable)	Glass: 0.395 €/kg, Paper: 0.188 €/kg Plastic: 0.875 €/kg	NA
Latvia	Natural resource tax	Complementary to PROs	Bioplastic, composite cardboard, polystyrene Foam, Plastic bag, Plastic recyclable not recycled or recovered. Plastic non-recyclable not recovered.	Bioplastic: 0.24 €/kg; Composite cardboard: 1.25 €/kg; Polystyrene: 2.2 €/kg; Foam: 24.4 €/kg; Plastic bag: 1.5/4.8 €/kg; Plastic recyclable but not recycled / recovered: 0.8 €/kg Plastic non-recyclable not recovered: 1.25€/kg.	NA
Hungary (until 2022)	Environmental Protection Product Charges	Alternative to other schemes (PRO, DRS)	All packaging	Varying depending on packaging.	~100 mln
Hungary (2023)	Environmental Protection Product Charges	Complementary to PRO	Plastic carrier bags (biodegradable and non)	4.21 €/kg (0.7 €/kg is biodegradable)	NA
Croatia	Environmental Protection and Energy Efficiency Fund	Alternative to PRO. Complementary to DRS.	All packaging	Varying depending on packaging.	~12 mln

KPI assessment across waste management schemes



DRS schemes are **effective in the collection** of targeted materials (beverage packaging), but at a relatively **high cost**:

- higher relative recycling performance.
- lower relative cost efficiency.

PROs achieve **high recycling rates**, while maintaining **high cost-efficiency**, offering a **more balanced result**.

Public tax-based systems have similar costs than PROs but **lower recycling effectiveness**. Its performance relies on fiscal incentives alone, which limits effectiveness.

PROs manage on average **much higher quantities** than alternatives schemes:

- **6 times higher** than public-tax schemes
- **43 times higher** than DRS.

Conclusions

This study provides a comprehensive benchmarking of EPR, DRS, and taxation-based packaging waste systems across Europe, using updated KPIs to assess cost-efficiency and recycling performance.

PRO-specific results:

- Recent years saw a general **reduction in the cost performance**, matched by an **increase in recycling performance**.
- **Large PROs** outperform smaller ones in **recycling effectiveness**.
- **Non-competitive PROs** tend to achieve **higher recycling rates**, suggesting advantages in centralized coordination.

The comparative analysis underscores that no single compliance scheme optimally balances recycling performance and cost-efficiency:

- **DRS systems** are the **most effective strategy** for specific high-value, homogenous materials but remain expensive.
- **PROs** offer broader coverage and **better cost-efficiency** but face challenges in meeting the highest recycling targets, especially for complex materials like plastics.
- **Taxation**, while valuable as a **policy lever**, is insufficient on its own to drive circular outcomes.

Dashboard examples

Interactive KPIs Performance Plot

Select Role of PRO:

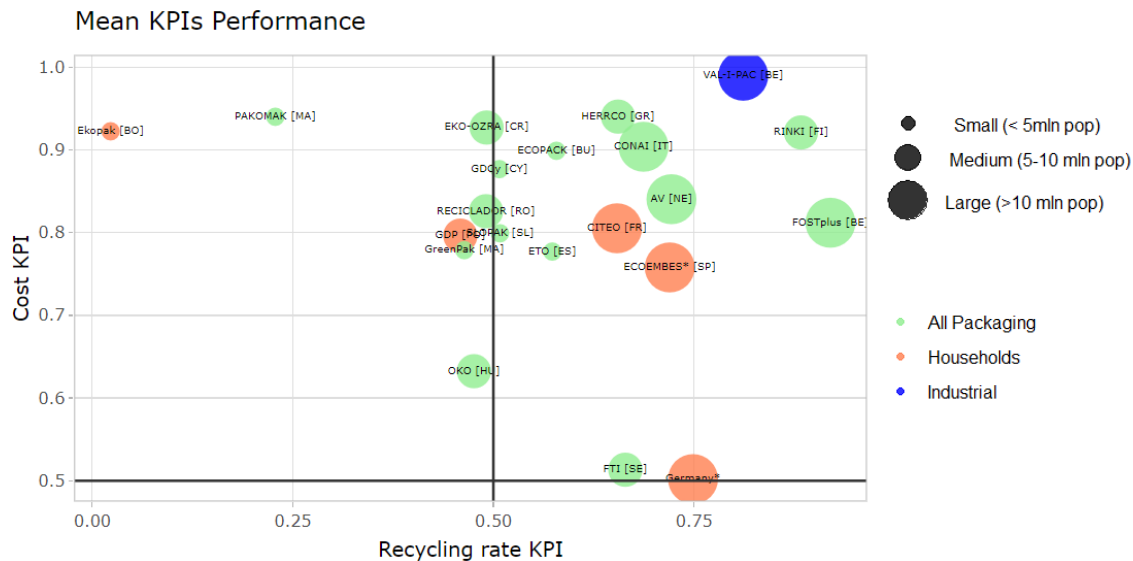
All

Select PRO:

All

Select Dimensional Group:

All



Additional Results

Analysis of Hungarian Waste Taxation Scheme

In 2023 the Hungarian waste management scheme changed: a single state-commissioned PRO (MOHU MOL) is responsible for EPR (for profit), while the tax scheme remained in place only for plastic bags.

