8th International Conference on
Sustainable Solid Waste Management
Thessaloniki, Greece, 23 - 26 JUNE 2021

Municipal Waste in the EU: A DEA and convergence analysis at regional level

Authors: Elisa Chioatto
Alberto Fedele
Paolo Sospiro

Presenting author: Alberto Fedele

June 23rd, 2021

SUMMARY

Research on the impact and effectiveness of EU Directives concerning waste at NUTS-2 regional level assessed with DEA models and analysed through convergence analysis

1 **INTRODUCTION**
Presentation of the problem

2 **CONTEXT ANALYSIS**
Analysis of the context elements affecting the problem

3 **LEGAL FRAMEWORK**
Identify the influent legal framework

4 **DATA**
Data determination and manipolation

5 **METHODOLOGY**
Methodology applied for the study

6 **RESULTS**
Discussion of the results and conclusions

INTRODUCTION

In 2015, 92.8 billion tonnes of resources entered the global economy , and material resource use is expected to double by 2050, reaching 186 billion tonnes (UN)

Since 2000 the extraction of raw materials increases yearly at the rate 3.2% (OECD)

« Our Common Future, sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” ».
(UN)

Guiding towards a green EU, to be resource-efficient based on a competitive low carbon economy (7th EAP)

Since the beginning of the XX century waste started to be a significant global issue threating the environment and the human health.
It start to attract much more attention, not just by citizens but also by the public institutions and policy makers

CONTEXT ANALYSIS

'waste' means any substance or object which the holder discards or intends or is required to discard

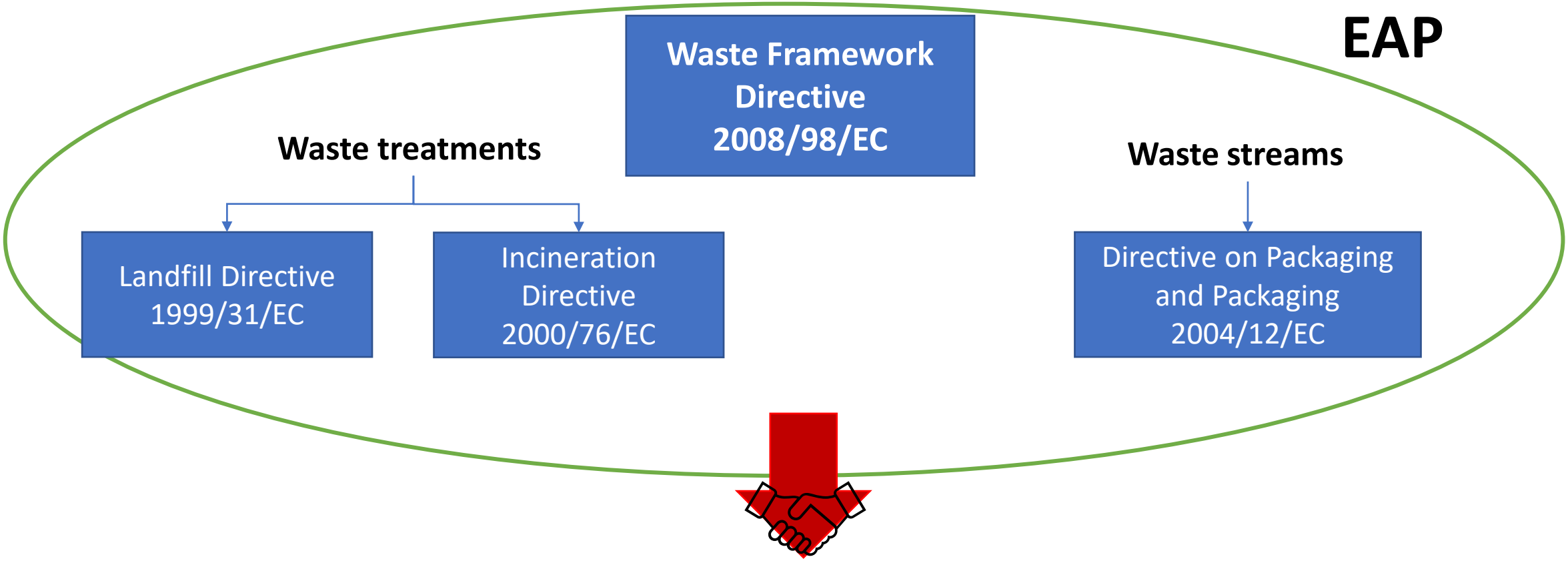
Def. in 2008/98/EC reviewed Waste Framework Directive

Mai
clas

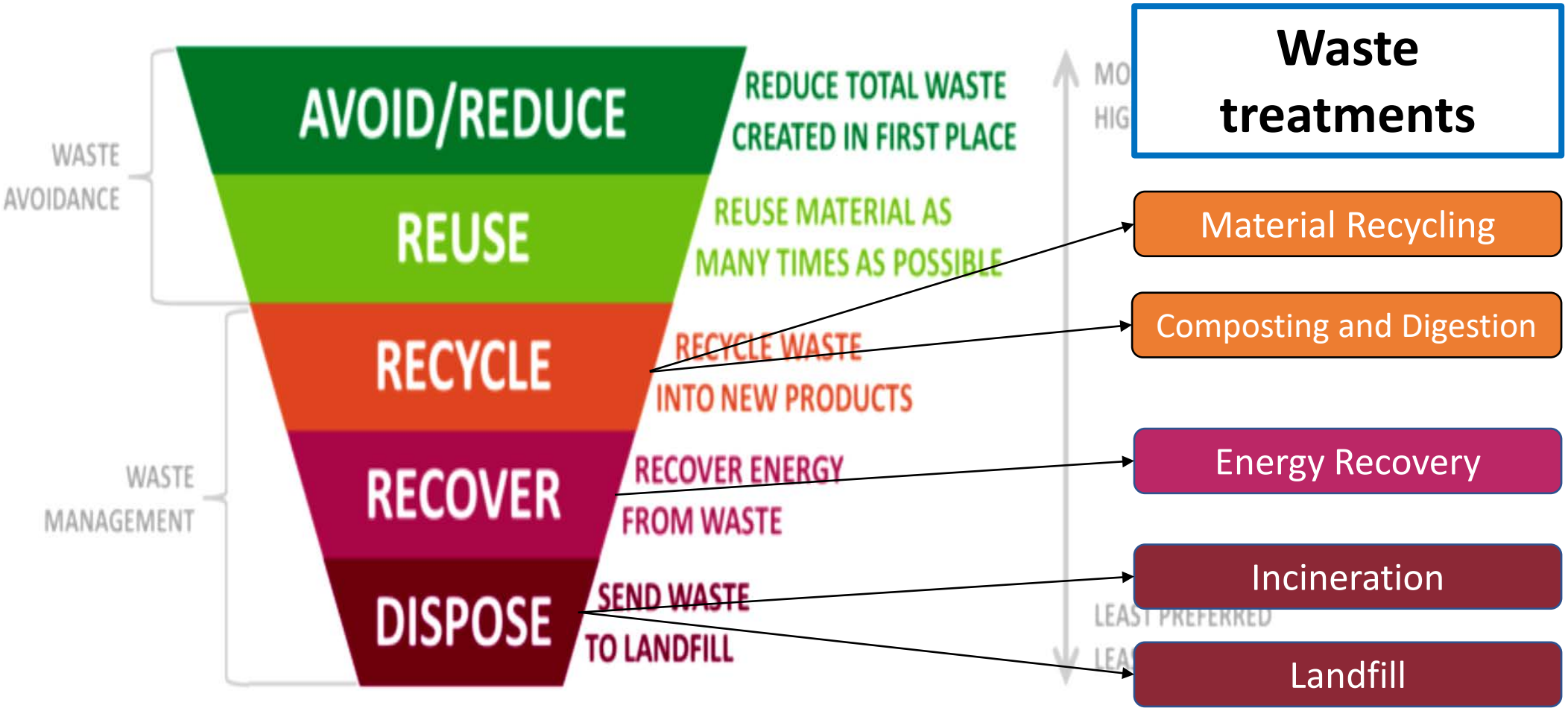
Waste produced mainly by households but includes similar waste from other sources (commerce, offices, public institutions).
The amount of municipal waste generated consists of waste collected by or on behalf of municipal authorities and disposed of through the waste management system.

MSW Municipal Solid Waste

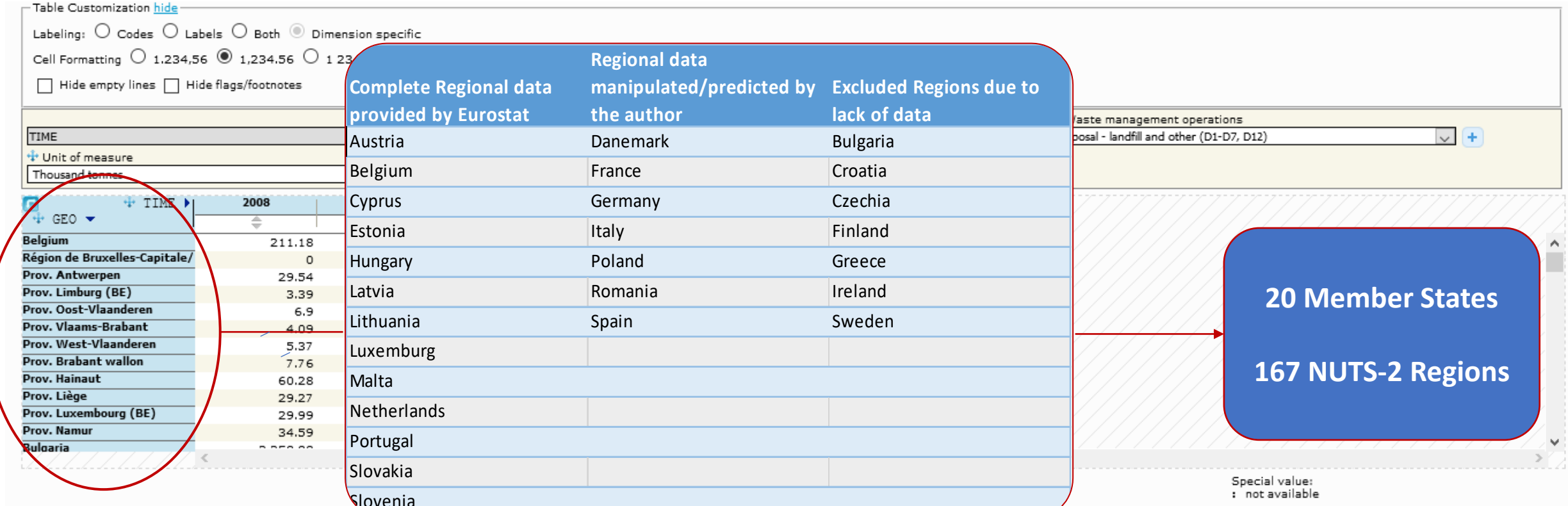
LEGAL FRAMEWORK



LEGAL FRAMEWORK



DATA

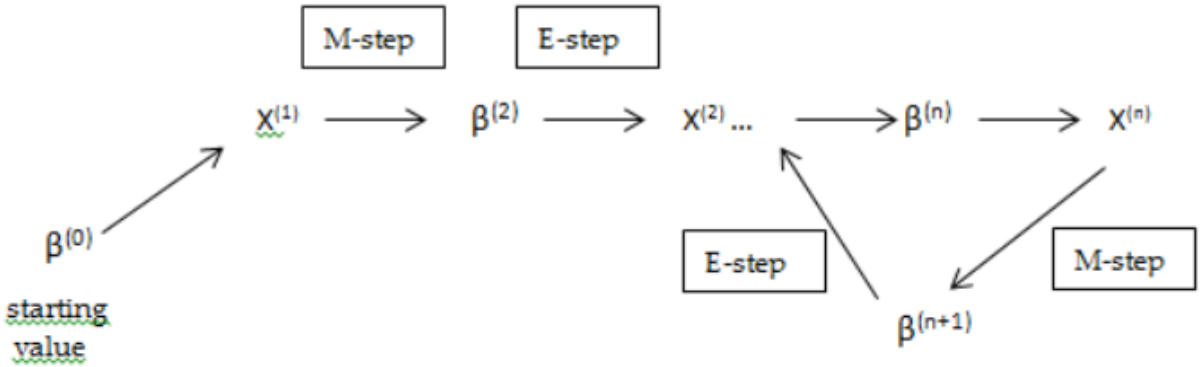


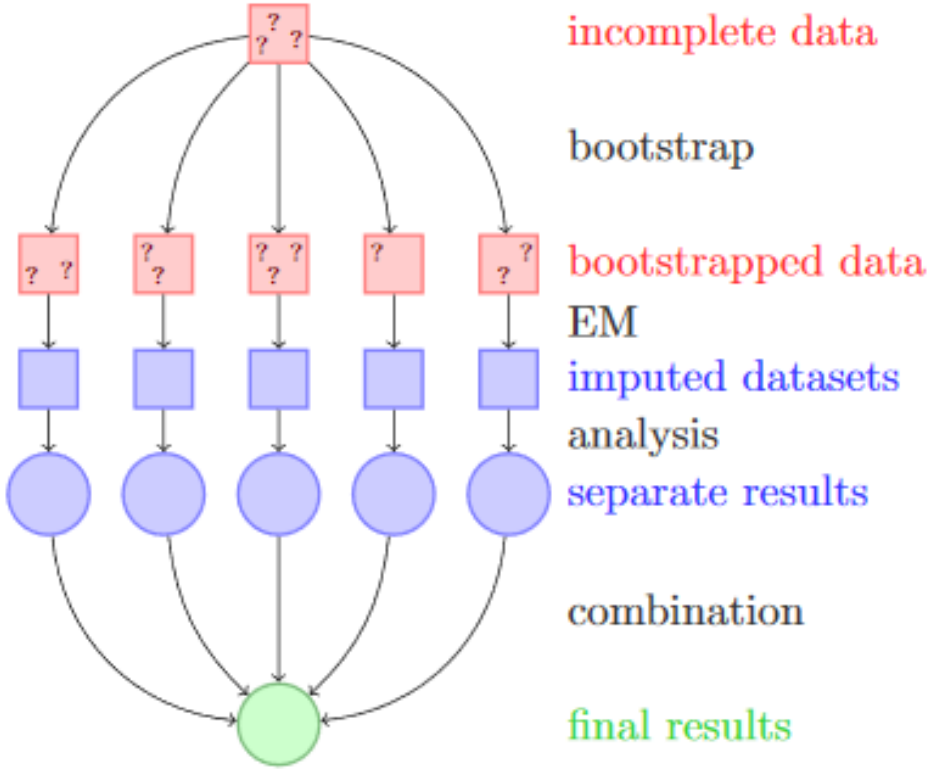
Complete Regional data provided by Eurostat	Regional data manipulated/predicted by the author	Excluded Regions due to lack of data
Austria	Danemark	Bulgaria
Belgium	France	Croatia
Cyprus	Germany	Czechia
Estonia	Italy	Finland
Hungary	Poland	Greece
Latvia	Romania	Ireland
Lithuania	Spain	Sweden
Luxemburg		
Malta		
Netherlands		
Portugal		
Slovakia		
Slovenia		

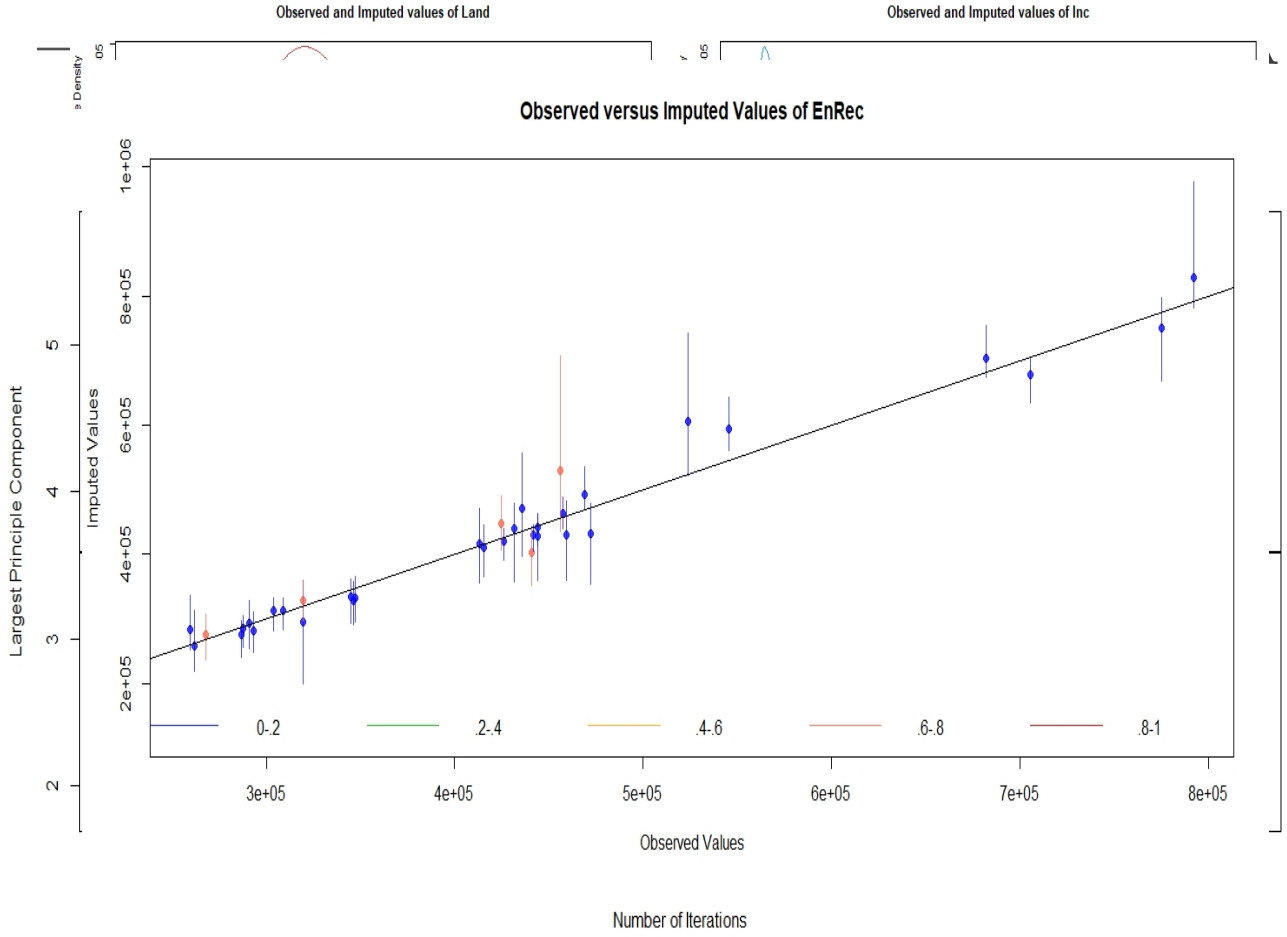
DATA

HP:

- Multi-variate Normal Distribution (MVN)
- Missing at random (MAR)







Diagnostic Tools:

- Comparing distribution densities
- Overimputation
- Overdispersion

DATA

Integrated by National Statistical Institutes data
- Reclassification under Eurostat Criteria
- Dataset imputed 2008-2019

- Missing periods: 2009, 2012, 2013
- Double application; periods 2008-11 and 2008-13

Integrated by National Statistical Institutes data
- Reclassification under Eurostat Criteria
- Extraction of missing treatments rates
- Gap fulfilled on the weighted average rate

- Integrated by ISPRA data
- Obtained the recycling rates
- Insert in the periods where is known compost

- Missing the variabile of energy recovery in the periods 2008-11

- Standard configuration statistically unreliable
- New setting: Increase the priors of 5%, shrink the bounds, consider a polynomial relation with the time

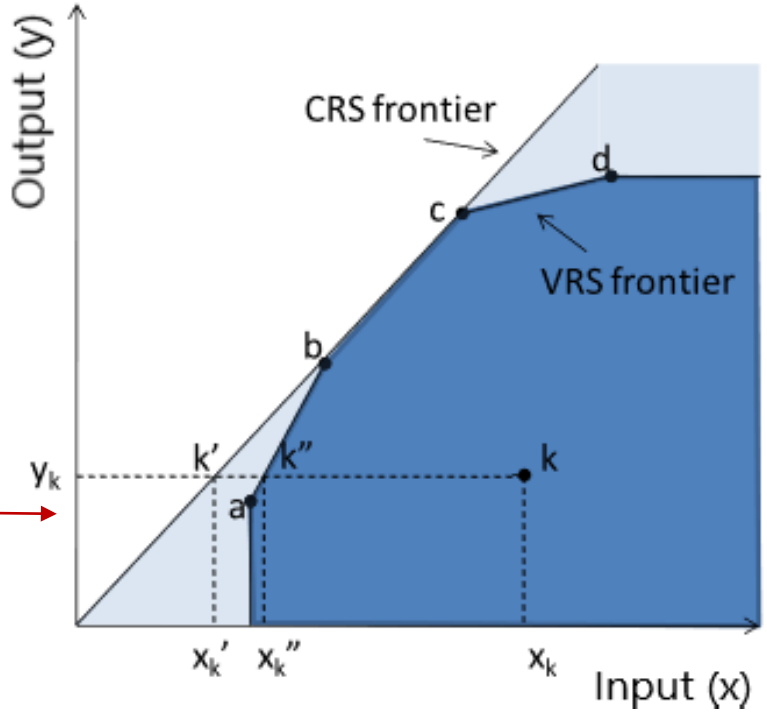
Integrated by National Statistical Institutes data
- Reclassification under Eurostat Criteria
- Dataset imputed 2008-2017
- Gap fulfilled through rates wheighted on CV

METHODOLOGY

Data Envelopment Analysis (DEA)

- Econometric linear programming approach that measures the efficiency of
- Non-parametric method, doesn't require any a priori assumption
- Consider simultaneously multiple inputs and multiple outputs
- Applicable when is unknown the variables relation
- Endogenous measurement, identify the relative efficiency

- Build the efficiency frontier considering every input and output
- The distance from the frontier constitute the efficiency measurement



- It's not considered the influence of exogenous factors
- Output oriented, considered under control the waste treatments
- Variables normalized on the waste generated, considered the rates
- Efficiency measurement represented by a CI which aggregate the simple indicators

METHODOLOGY

Benefit-of-Doubt (BoD)

- Pure DEA output setting
- Output oriented DEA, sub indicators as outputs and a “dummy inputs” equal to 1
- Able to consider the multidimensional complexity through the CI
- The five waste treatments rates considered as simple indicators
- Evaluate the specific DMU in the best possible light in relation to the others
- Definition of the regional optimal weighting to obtain the higher performance evaluation possible
- Consider as CRS
- It’s computed the optimization linear program for each region
- Application of 4 different models

METHODOLOGY

BoD- Directional model. .

$$CI_k = max_{w_{k,i};v_{k,s}} \frac{1}{1+(\sum_{i=1}^{r} w_{k,i} y_{k,i}^{+} - \sum_{s=1}^{l} v_{k,s} y_{k,s}^{-})}$$

s.t.

$$\sum_{i=1}^{r} w_{k,i}\ y_{k,i} - \sum_{s=1}^{l} v_{k,s} y_{k,s}^{-} \leq 1 \qquad j = 1; \ldots; k; \ldots; N$$

$$\sum_{i=1}^{r} w_{k,i}\ g_i^{+} + \sum_{s=1}^{l} v_{k,s} g_s^{-} = 1 \qquad j = 1; \ldots; k; \ldots; N$$

$$\frac{w_{k,i} g_i^{+}}{\sum_{i=1}^{r} w_{k,i}\ g_i^{+} + \sum_{s=1}^{l} v_{k,s} g_s^{-}} \geq 0.05 \qquad i = 1; \ldots\ldots; r$$

$$\frac{v_{k,s} g_s^{-}}{\sum_{i=1}^{r} w_{k,i}\ g_i^{+} + \sum_{s=1}^{l} v_{k,s} g_s^{-}} \geq 0.05 \qquad s = 1; \ldots\ldots; l$$

$$w_{k,i} \geq 0 \qquad i = 1; \ldots\ldots; r$$

$$v_{k,s} \geq 0 \qquad s = 1; \ldots\ldots; l$$

METHODOLOGY

β-convergence

$$\frac{1}{T}\sum_{t=1}^{T}\ln\left(\frac{Y_{k,t+1}}{Y_{k,t}}\right) = \ln\beta_0 + \beta_1 \ln X_{k,t_0} + \ln U_{k,t_0}$$

- Linear model
- Identifies the reduction of disparities
- OLS estimation
- Non-linear in terms of variables

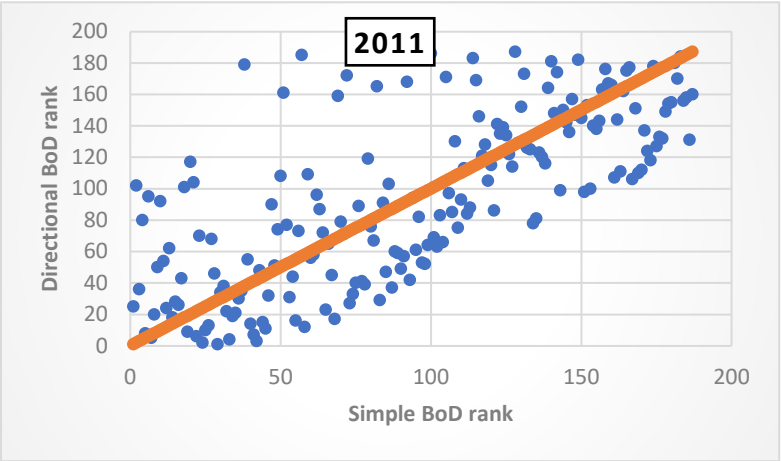
σ-convergence

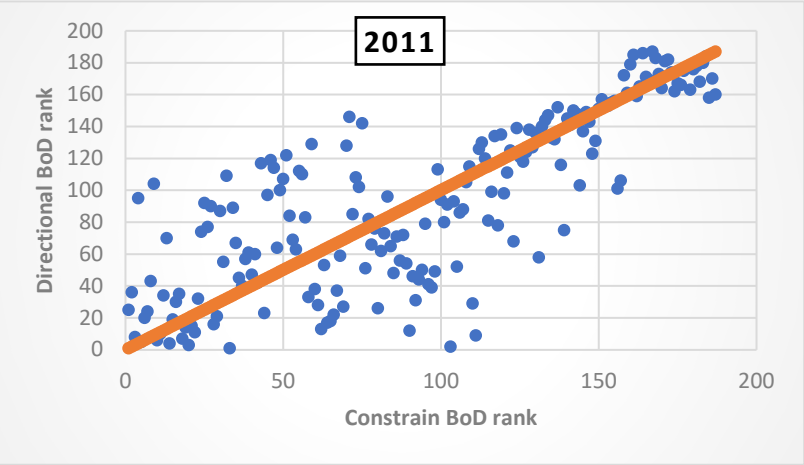
$$cv = \alpha_0 + \alpha_1 t + U_t$$

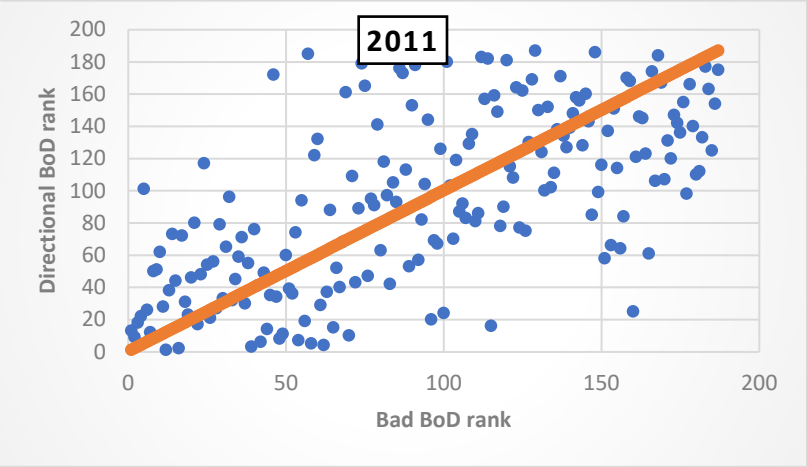
- β-convergence necessary but not sufficient
- Detects the evolution of dispersion
- CV as reference measurement

RESULTS

- Different results
- Detect a linear relation between the models



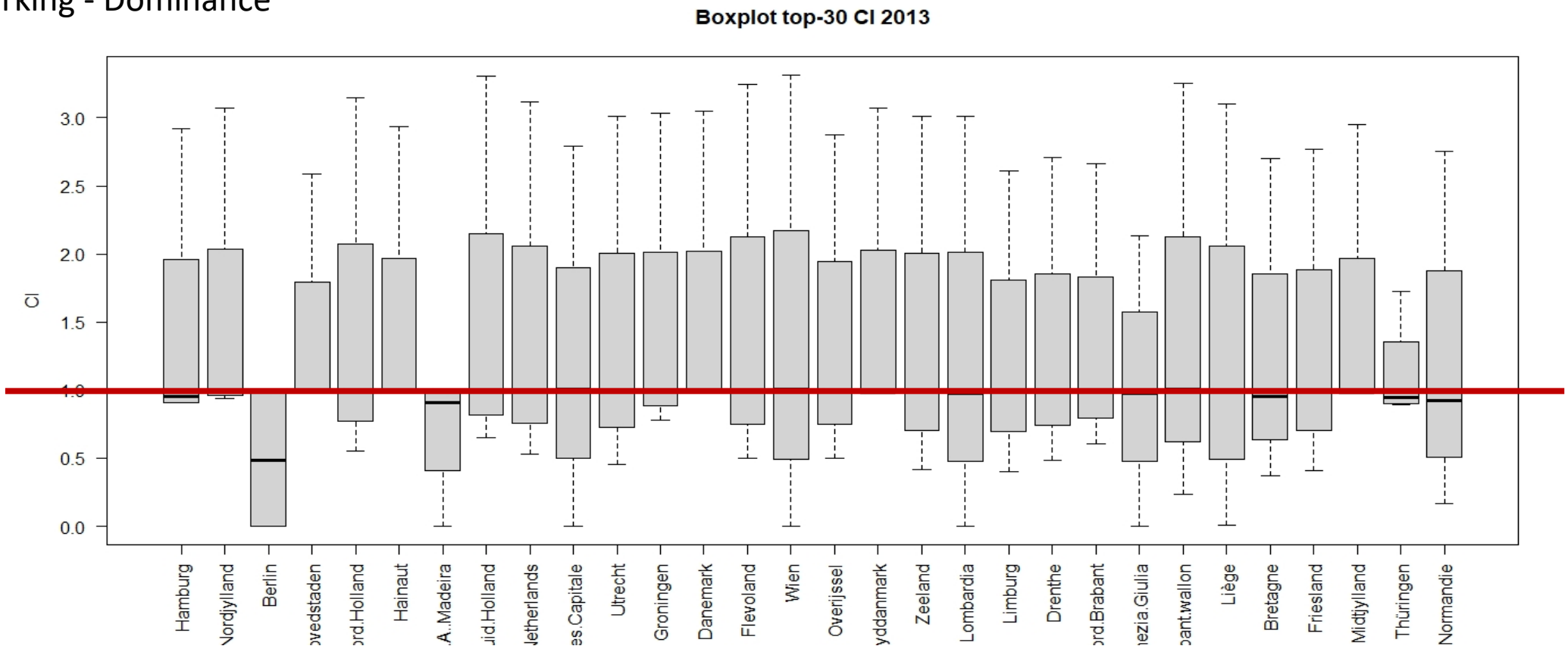




Directional BoD	Simple BoD	Constrain BoD	Bad BoD
2008	0.772433651	0.856969305	0.583603405
2009	0.740449022	0.803175891	0.539629816
2010	0.724732896	0.793258802	0.5311423
2011	0.724044719	0.792801853	0.648057139
2012	0.749797217	0.771662892	0.556612188
2013	0.673451785	0.711163882	0.478585769

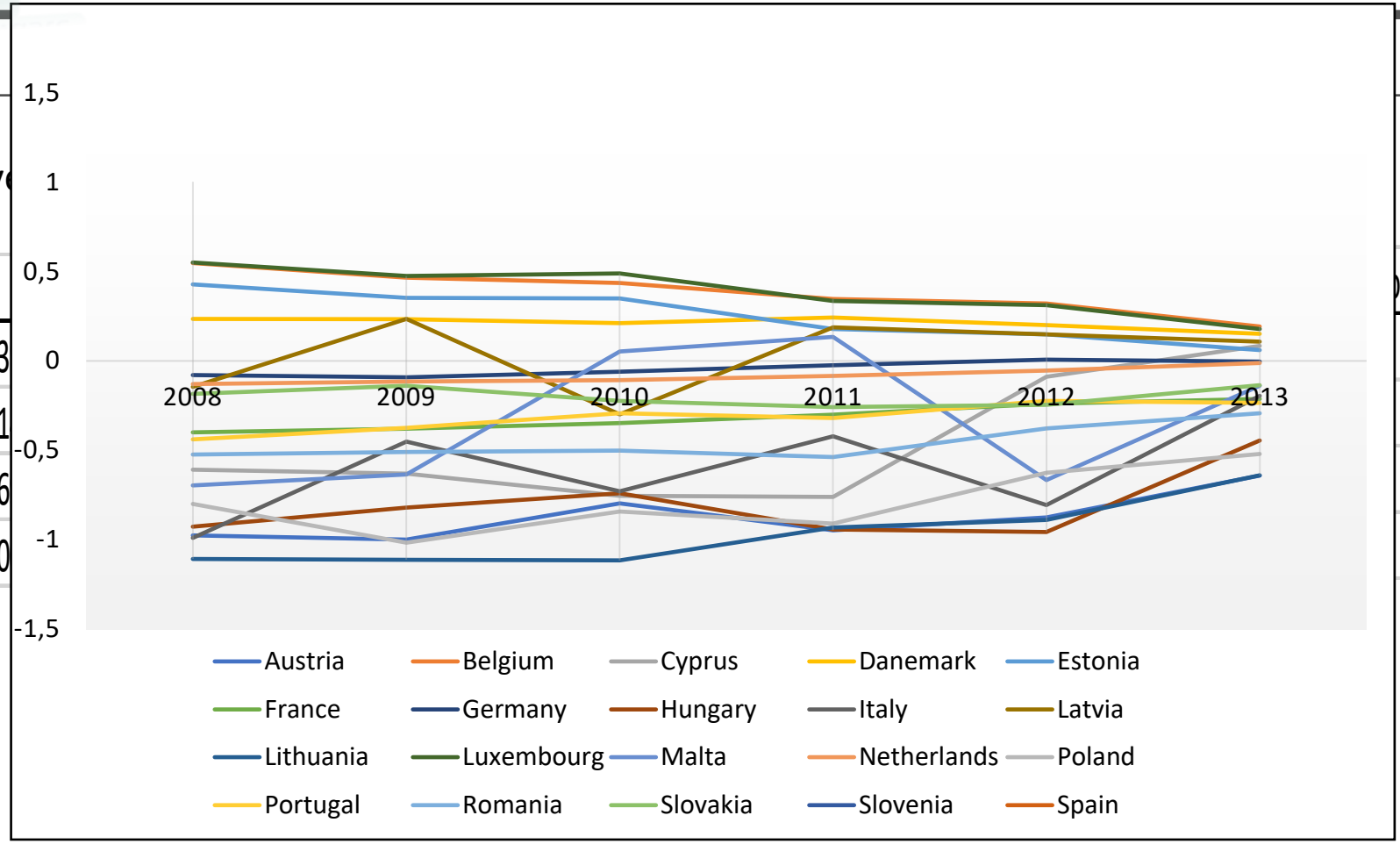
RESULTS

Benchmarking - Dominance



Elements on conv

2008	Simple BoD
Average	0.583
St. Dev.	0.321
Min	0.046
Max	1.000



oD	Directional BoD
0.9962	1.3749
0.0085	1.1776
0.9735	0.0000
1.0221	3.3153

RESULTS

Convergence of best treatments

```
Regional Beta and Sigma Convergence

Absolute Beta Convergence
Model coefficients (Estimation method: OLS)
            Estimate  Std. Error   t value     Pr (>|t|)
Alpha    -0.18540509 0.014616506 -12.68464 6.191356e-27
Beta     -0.12188092 0.005890469 -20.69121 5.126150e-50
Lambda    0.02599461          NA        NA           NA
Halflife 26.66503223          NA        NA           NA
Model summary
          Estimate F value df 1 df 2     Pr (>F)
R-Squared 0.6982676 428.126    1  185 5.12615e-50

Sigma convergence (Trend regression)
             Estimate   Std. Error   t value    Pr(>|t|)
Intercept 72.41000826 14.603626035  4.958358 0.007715122
Time      -0.03581374  0.007263676 -4.930525 0.007869886
Model summary
          Estimate  F value df 1 df 2     Pr (>F)
R-Squared 0.8587076 24.31008    1    4 0.007869886
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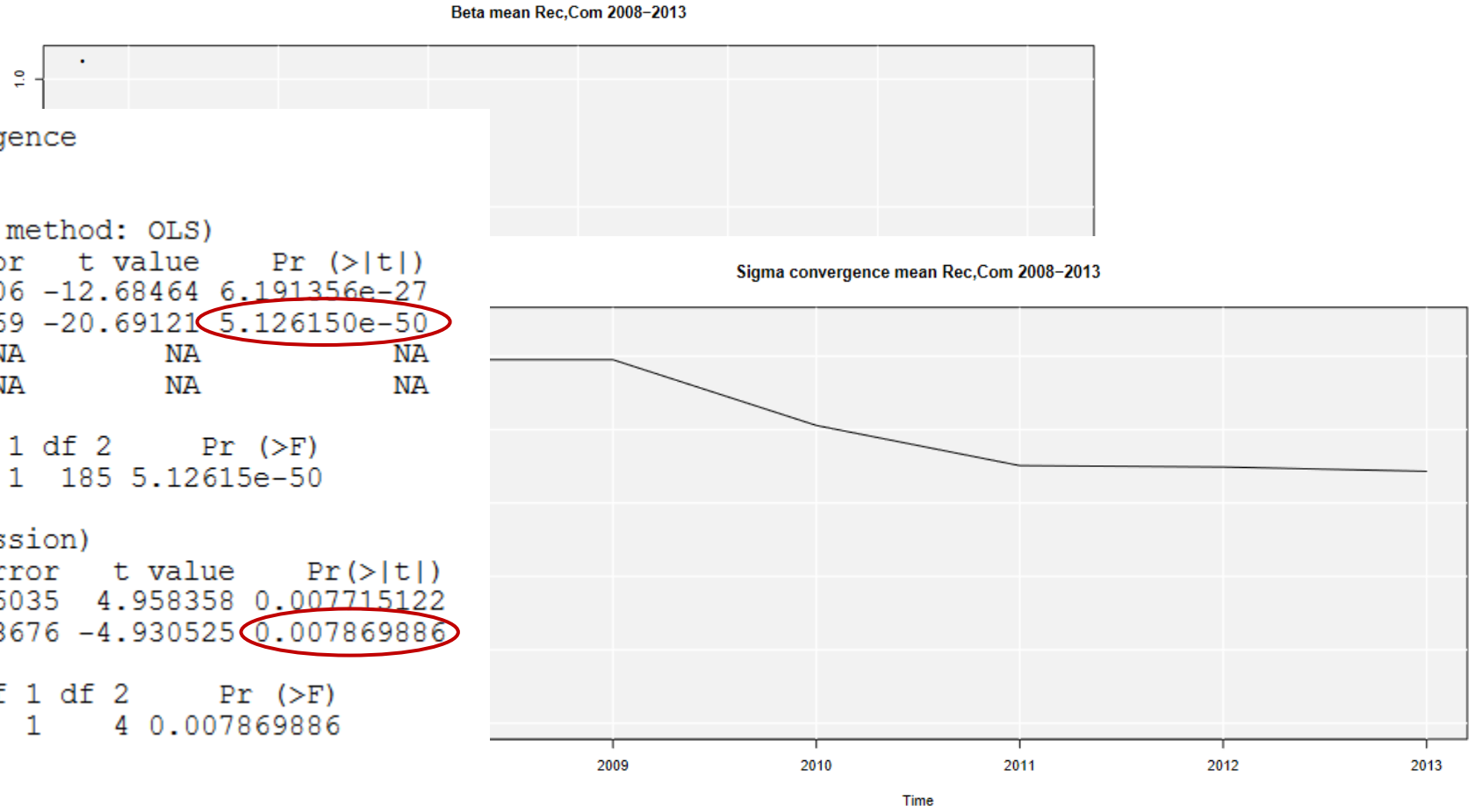
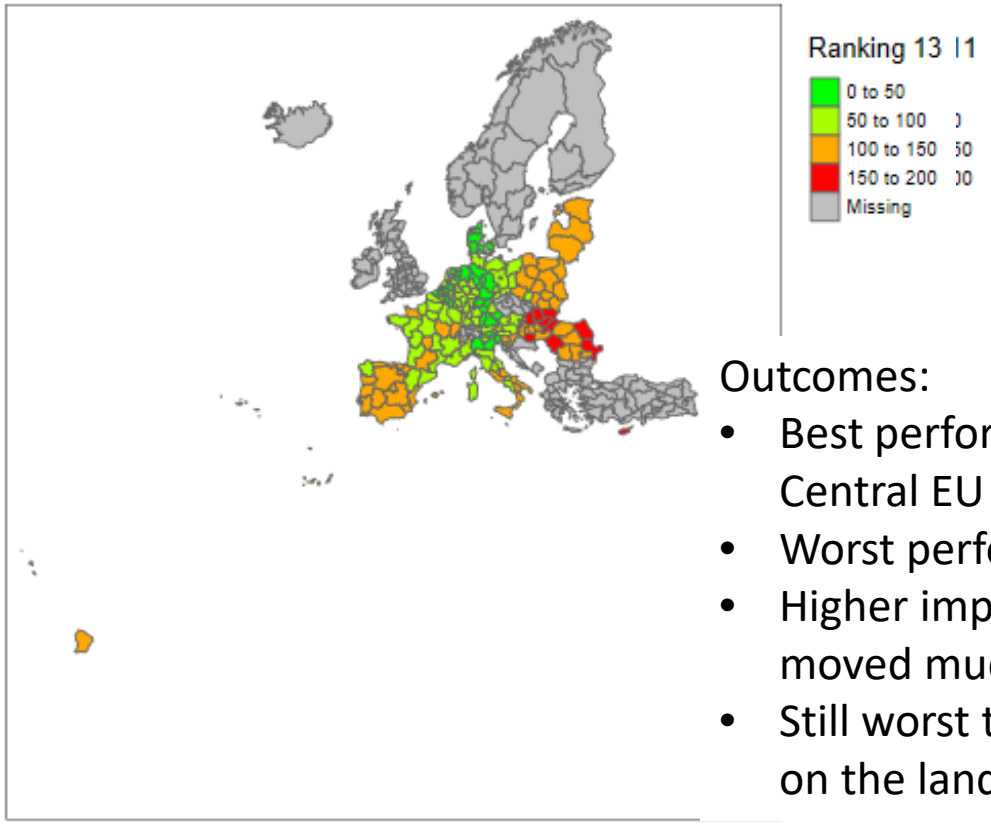


RESULTS

Elements of influence:

- Year of the national waste management pollicies introduction
- Entrance period in the EU



Outcomes:

- Best performers in Northern and Central EU
- Worst performers in Eastern EU
- Higher improvement in the regions moved much more away by landfill
- Still worst the regions that rely more on the landfill treatment

RESULTS

Conclusions achieved:

- Linear relation between the models
- Growing trend of the average performance
- Bigger improvement room for the regions in the first periods
- Detect the benchmark through the dominance
- Decrease of the CI dispersion at national level
- β-convergence and σ-convergence on the best waste treatments
- Improvement of the performances at NUTS-2 regional level
- Remain differences on efficiency performance between regions, even in the same country
- Performance incremental insufficient to achieve the targets set at EU level

Next steps:

- Demonstrate the best fitting model
- Apply a BoD-Conditional model

THANK YOU FOR THE KIND ATTENTION

June 23rd, 2021

Alberto Fedele