Supplementary information

CIRCULAR ECONOMY AND INNOVATIVE ENTREPRENEURSHIP, PREREQUISITES FOR SOCIAL PROGRESS

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EUROSTAT Circular Economy (CE) indicators

Producttion and consumption
- EU self-sufficiency for raw materials (excluded)
- Generation of municipal waste per capita
- Generation of waste excluding major mineral wastes per GDP unit
- Generation of waste excluding major mineral wastes per domestic material consumption

Waste management
- Recycling rate of municipal waste
- Recycling rate of all waste excluding major mineral waste
- Recycling rate of packaging waste by type of packaging
- Recycling rate of e-waste
- Recycling of biowaste
- Recovery rate of construction and demolition waste

Secondary raw materials
- Contribution of recycled materials to raw materials demand - end-of-life recycling input rates (EOL-RIR)
- Circular material use rate
- Trade in recyclable raw materials

Competitiveness and innovation
- Private investments, jobs and gross value added related to circular economy sectors
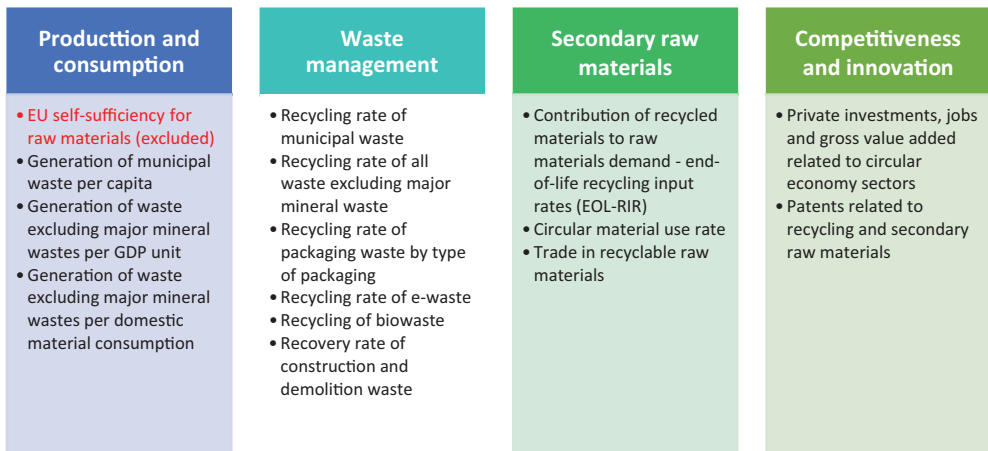- Patents related to recycling and secondary raw materials

Figure 1. Circular Economy indicators (source: Eurostat, source: created by the authors)

To be able to use the set of indicators in the construction of the composite index, it was necessary to impute the data for certain countries using cluster analysis. Simultaneously, with the help of this method of multidimensional data analysis, a grouping of EU states was identified based on the similarities of the indicators included in the analysis (Figure 2).

Consumption patterns, the way waste is collected and managed, and the level of economic development generate significant differences between EU countries. The results of studies conducted for the period 2005–2016, although showing a decrease in municipal waste per capita at EU level, show different trends in the Member States.
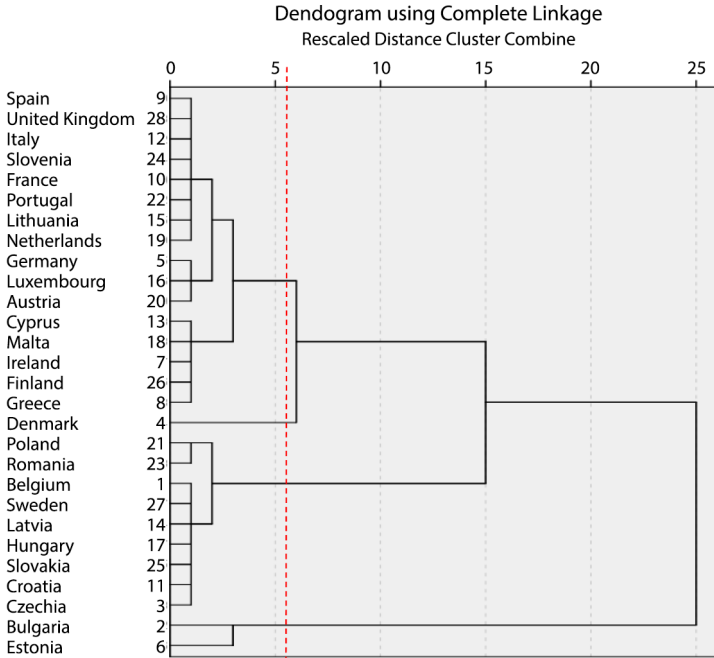
Figure 2. Clusters of EU states based on CE indicators (source: Eurostat, created by the authors)

Table 1. Total variance explained (source: created by the authors)

Com-ponent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumu-lative %	Total	% of Variance	Cumu-lative %	Total	% of Variance	Cumu-lative %
1	4.099	29.282	29.282	4.099	29.282	29.282	3.406	24.328	24.328
2	2.542	18.154	47.436	2.542	18.154	47.436	1.982	14.157	38.486
3	1.784	12.739	60.176	1.784	12.739	60.176	1.977	14.122	52.608
4	1.299	9.279	69.455	1.299	9.279	69.455	1.884	13.458	66.066
5	1.180	8.430	77.885	1.180	8.430	77.885	1.655	11.819	77.885
6	.842	6.013	83.898						
7	.616	4.398	88.296						
8	.488	3.488	91.784						
9	.319	2.279	94.064						
10	.297	2.122	96.186						
11	.250	1.783	97.969						
12	.116	.826	98.795						
13	.104	.745	99.540						
14	.064	.460	100.000						

Note: Extraction Method: Principal Component Analysis.

Table 2. Descriptive statistics (source: created by the authors)

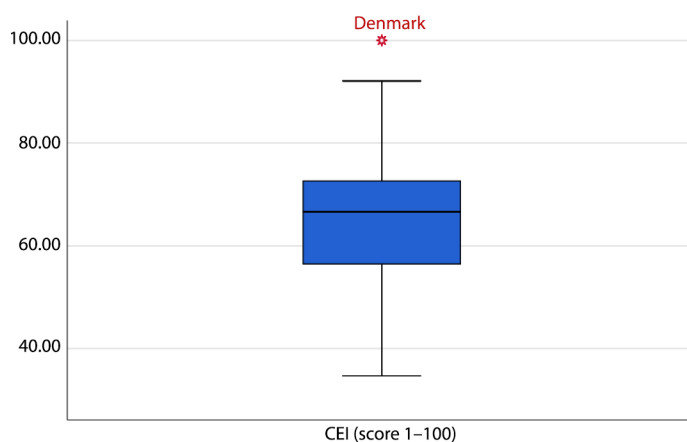|	N	Mean	Std. Deviation
CEI	27	66.5544	14.23616
GEI	27	54.2000	14.24562
GII	27	49.1211	7.91088
SPI	27	87.0167	3.86703
Valid N (listwise)	27		

Figure 3. Diagrama Box-Plot pentru CEI (source: created by the authors)

The analysis of the data related to the considered indices shows their approximately normal distribution (Table 3).

Table 3. Tests of normality (source: created by the authors)

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CEI	.105	27	.200[*]	.979	27	.846
GEI	.177	27	.029	.942	27	.138
GII	.096	27	.200[*]	.955	27	.288
SPI	.148	27	.134	.919	27	.036

Notes: *. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

The correlation analysis highlights the existence of direct and statistically significant links between the composite indices considered (Table 4).

Table 4. Correlations (source: created by the authors)

		SPI	CEI	GEI	GII
Pearson Correlation	SPI	1.000	.761	.803	.809
	CEI	.761	1.000	.658	.599
	GEI	.803	.658	1.000	.913
	GII	.809	.599	.913	1.000
Sig. (1-tailed)	SPI	.	.000	.000	.000
	CEI	.000	.	.000	.000
	GEI	.000	.000	.	.000
	GII	.000	.000	.000	.

The constructed multifactorial regression model (Model I) has as factorial variables CEI, GII and GEI, the effect variable being SPI. The results obtained highlight a valid model, which identifies a direct and significant dependence between SPI and CEI (Table 5).

Table 5. Multiple regression output, Modelul I (source: created by the authors)

ANOVAᵃ						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	301.560	3	100.520	26.500	.000ᵇ
	Residual	87.243	23	3.793		
	Total	388.803	26			
a. Dependent Variable: SPI						
b. Predictors: (Constant), GII, CEI, GEI						

Coefficientsᵃ										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	66.855	3.170		21.092	.000	60.298	73.412		
	CEI	.112	.036	.411	3.134	.005	.038	.185	.567	1.764
	GEI	.030	.070	.110	.428	.673	−.115	.174	.147	6.782
	GII	.226	.118	.463	1.913	.068	−.018	.471	.167	5.995
a. Dependent Variable: SPI										

As the results of the analysis signal the presence, to a certain extent, of the multicollinearity phenomenon (VIF_GEI = 6.782, a value lower than 10), we resorted to estimate another regression model (Model II). This model is estimated for 26 EU countries, Denmark being removed from the analysis (records an outlier value for the CEI variable), the factorial variables being the CEI and GII (the GHG variable was removed).

The results obtained (Table 6) show that Regression Model II is valid, the coefficients of the predictive variables CEI and GII are statistically significant. The hypotheses of the regression model regarding the residual variable are also verified.

Table 6. Multiple Regression output, Modelul II (source: created by the authors)

Model Summary[b]										
Mo-del	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.874[a]	.764	.744	1.92768	.764	37.233	2	23	.000	2.226
a. Predictors: (Constant), GII, CEI										
b. Dependent Variable: SPI										

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	276.713	2	138.356	37.233	.000[b]
	Residual	85.467	23	3.716		
	Total	362.179	25			
a. Dependent Variable:						
b. Predictors: (Constant), GII, CEI						

Coefficients[a]											
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Par-tial	Part	Tole-rance	VIF
1	(Constant)	65.376	2.534		25.799	.000					
	CEI	.129	.037	.436	3.540	.002	.749	.594	.359	.676	1.479
	GII	.266	.060	.549	4.456	.000	.797	.681	.451	.676	1.479
a. Dependent Variable: SPI											

Notations

Abbreviations

CEI – The Circular Ecomony Index;
GII – The Global Innovation Index;
GEI – The Global Entrepreneurship Index;
SPI – The Social Progress Index.