Supplementary Annex:
DEA/BoD weights and robustness checks

This annex reports the numerical tables used to support the additional paragraph added to Section 4.2 of the manuscript. Contribution shares are normalised within each country and therefore sum to 100% across the five DEA/BoD indicators. The values should be interpreted as model-implied contribution shares and robustness diagnostics, not as causal effects.

Table A1. Summary of normalised contribution shares for DEA/BoD indicators in 2021

Indicator	EGD dimension	Mean contribution share	Median contribution share	Countries with positive contribution	Dominant contribution count
E1_4	Climate and energy transition	6.47%	0.00%	24.00%	1
E1_9	Sustainable mobility	12.04%	0.12%	52.00%	2
E2_7	Environmental health	28.73%	1.32%	64.00%	10
E2_8	Circular economy / waste pressure	35.97%	18.93%	76.00%	8
E3_8	Emissions intensity of production	16.79%	0.00%	44.00%	4

Source: own calculations based on DEA/BoD outputs and Eurostat data.

Table A2. Country-level normalised contribution shares in 2021

Country	DEA score	Rank	E1_4	E1_9	E2_7	E2_8	E3_8	Dominant contributor
Austria	0.943	18	1.69%	16.44%	51.61%	18.93%	11.33%	E2_7
Belgium	0.877	23	0.00%	12.23%	49.43%	31.88%	6.46%	E2_7
Bulgaria	0.786	25	0.00%	63.80%	0.00%	0.00%	36.20%	E1_9
Croatia	1.026	8	0.00%	2.84%	0.00%	11.65%	85.51%	E3_8
Czechia	0.898	22	0.00%	0.00%	0.92%	99.08%	0.00%	E2_8
Denmark	0.979	13	6.66%	0.00%	75.19%	18.15%	0.00%	E2_7
Estonia	1.069	5	0.52%	26.29%	73.19%	0.00%	0.00%	E2_7
Finland	1.019	9	0.00%	0.00%	100.00%	0.00%	0.00%	E2_7
France	0.969	14	0.00%	0.00%	1.34%	8.40%	90.26%	E3_8
Germany	0.931	20	0.00%	12.10%	48.89%	39.02%	0.00%	E2_7
Greece	0.943	17	0.00%	0.00%	0.31%	99.69%	0.00%	E2_8
Hungary	0.987	11	0.00%	0.12%	0.00%	99.88%	0.00%	E2_8
Ireland	1.053	6	0.00%	0.00%	87.14%	12.86%	0.00%	E2_7
Italy	0.931	21	0.00%	0.00%	0.77%	97.67%	1.56%	E2_8
Latvia	1.171	2	42.46%	8.73%	0.00%	48.82%	0.00%	E2_8
Lithuania	1.170	3	0.00%	100.00%	0.00%	0.00%	0.00%	E1_9
Luxembourg	0.958	16	0.00%	0.00%	98.39%	1.61%	0.00%	E2_7
Netherlands	1.028	7	0.00%	21.95%	52.09%	25.96%	0.00%	E2_7
Poland	0.854	24	0.00%	0.00%	0.00%	100.00%	0.00%	E2_8
Portugal	1.109	4	15.56%	0.00%	35.79%	42.00%	6.65%	E2_8
Romania	0.999	10	0.00%	19.72%	0.00%	0.00%	80.28%	E3_8
Slovakia	0.959	15	0.00%	0.14%	0.00%	99.86%	0.00%	E2_8
Slovenia	0.932	19	0.00%	16.68%	41.96%	34.34%	7.02%	E2_7
Spain	0.986	12	0.00%	0.00%	1.32%	9.37%	89.31%	E3_8
Sweden	1.461	1	94.81%	0.00%	0.00%	0.00%	5.19%	E1_4

Note: rows are normalised contribution shares calculated as the product of the transformed output and its optimal DEA/BoD shadow weight divided by the country-specific score. Source: own calculations.

Table A3. Robustness check based on the alternative transformation

Year	Variant	Spearman's rho	Kendall's tau	Mean absolute rank change	Max absolute rank change	Same top 3	Same bottom 3	Interpretive note
2013	Alternative transformation: min-max normalization/reversed destimulants	1.000	1.000	0.00	0	Yes	Yes	Ranking unchanged; scores differ only in scale/translation.
2019	Alternative transformation: min-max normalization/reversed destimulants	1.000	1.000	0.00	0	Yes	Yes	Ranking unchanged; scores differ only in scale/translation.
2021	Alternative transformation: min-max normalization/reversed destimulants	1.000	1.000	0.00	0	Yes	Yes	Ranking unchanged; scores differ only in scale/translation.

Source: own calculations.

Table A4. Leave-one-indicator-out robustness check in 2021

Excluded indicator	Spearman's rho	Kendall's tau	Mean absolute rank change	Max absolute rank change	Same top 3	Same bottom 3	Interpretive note
E1_4	0.998	0.987	0.16	1	Yes	Yes	Stable/moderately stable variant
E1_9	0.824	0.713	3.12	13	No	Yes	Stable/moderately stable variant
E2_7	0.552	0.480	5.20	16	Yes	No	Influential indicator
E2_8	0.912	0.753	2.32	7	Yes	No	Stable/moderately stable variant
E3_8	0.893	0.827	1.76	14	Yes	No	Stable/moderately stable variant

Source: own calculations.

Table A5. Frontier-outlier stress tests in 2021

Stress-test variant	Spearman's rho	Kendall's tau	Mean absolute rank change	Max absolute rank change	Same top 3	Same bottom 3	Interpretive note
remove Sweden	0.982	0.920	0.75	4	Yes	Yes	Computed on common country set; lower-efficiency group remains stable.
remove Sweden, Latvia	0.946	0.850	1.39	7	No	Yes	Computed on common country set; lower-efficiency group remains stable.
remove Sweden, Latvia, Lithuania	0.880	0.723	2.36	7	No	Yes	Computed on common country set; lower-efficiency group remains stable.

Source: own calculations.

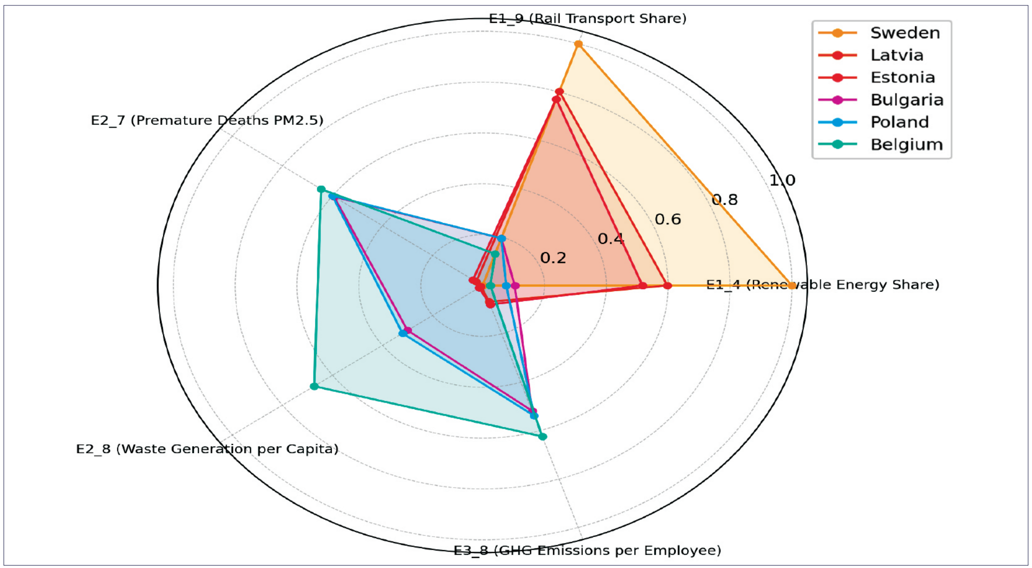
Table A6. VRS/BCC check with one homogeneous technical input

Year	Normal VRS min score	Normal VRS max score	Distinct rounded scores	Implication
2013	1.000	1.000	1	VRS with one homogeneous unit input is degenerate/non-discriminatory; CRS/BoD is the meaningful baseline.
2019	1.000	1.000	1	VRS with one homogeneous unit input is degenerate/non-discriminatory; CRS/BoD is the meaningful baseline.
2021	1.000	1.000	1	VRS with one homogeneous unit input is degenerate/non-discriminatory; CRS/BoD is the meaningful baseline.

Source: own calculations.

Interpretation. The tables show that the baseline DEA/BoD results are stable under an alternative transformation and under frontier-outlier stress tests. The leave-one-indicator-out results indicate that E2_7 is the most influential indicator for the estimated frontier in 2021. The VRS/BCC check is non-discriminatory with the homogeneous technical input, which supports retaining CRS/BoD as the interpretable baseline.

Chart 1. DEA indicators for leading and lagging countries in 2021



Source: own calculations based on Eurostat (2023).