

A Novel Approach to Sustainable Development Assessment Using Temporal Multi-Criteria Methods

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1 The Dataset

Table 1. Decision matrix for 2020 including performance values for SDG 11 criteria assessment.

Country	Symbol	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
Belgium	BE	2.3	14.5	583.5	4.3	605	52	83.58	13.5	10.8
Bulgaria	BG	8.6	8.8	623.4	6.7	1606	34.6	65.05	10.4	19.1
Czechia	CZ	2	13.3	634.4	4.8	892	45.4	83.4	18.3	6.1
Denmark	DK	2.8	18.2	1053.8	2.7	530	45	97.7	12.7	7.3
Germany	DE	1.2	21.6	586.7	3.3	676	68.3	95.97	11.2	8.2
Estonia	EE	2.1	8	1484.4	4.4	423	28.9	83	11.6	5.5
Ireland	IE	1.4	10.3	972.7	2.9	322	40.4	61.86	13.6	11.3
Greece	EL	5.8	20.1	710.2	5.5	1001	21	94.2	12.9	18.1
Spain	ES	3.4	21.9	577.5	2.9	561	36.4	86.62	10	14.1
France	FR	3.8	20.7	845.1	3.7	544	42.3	79.85	13	17.7
Croatia	HR	5.1	8.1	722.5	5.9	1064	29.5	36.9	11.1	2.4
Italy	IT	6.1	14.3	484.3	4	843	51.4	59.6	14.1	8.4
Cyprus	CY	1.6	14	939	5.4	595	16.4	82.65	12.4	10.4
Latvia	LV	11.5	12.5	1276.1	7.3	924	39.6	80.41	12.3	5.3
Lithuania	LT	5.4	14.7	1090.5	6.2	998	45.1	77	5.8	3.3
Luxembourg	LU	1.6	19.7	565.2	4.1	346	52.8	98.3	13.4	11
Hungary	HU	7.6	9.3	811.5	4.7	1205	32	80.91	21.2	5.3
Malta	MT	1	30.8	201.4	2.3	641	10.5	6.54	13.8	11.4
Netherlands	NL	1.5	25.5	456.9	3	551	56.9	99.52	9.9	15.7
Austria	AT	3	16.8	740.1	3.9	606	61.8	99.1	19.4	5.7
Poland	PL	7.9	12.6	633.7	6.6	1291	38.7	74.78	12.4	4.4
Portugal	PT	3.9	25.1	689.1	5.2	523	26.5	84.64	6.8	6.6
Romania	RO	14.3	16.1	528.4	8.5	1261	13.7	51.8	18.1	8.8
Slovenia	SI	3.1	15	625.1	3.8	744	59.3	69.32	8.7	7.3
Slovakia	SK	3.2	9.9	631.8	4.5	934	42.2	68.8	18.8	4.3
Finland	FI	1	14.1	2447.6	4	288	41.6	85	13	7
Sweden	SE	2.5	17.3	2223	2	258	38.3	96	16	13.8

2 Results

Table 2. Annual TOPSIS and VIKOR preference values.

Country	TOPSIS						VIKOR					
	2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020
BE	0.7266	0.7152	0.7074	0.6926	0.6731	0.6592	0.2613	0.2859	0.2908	0.2948	0.3371	0.3408
BG	0.3781	0.3689	0.3453	0.3454	0.3508	0.3519	0.6438	0.6589	0.6844	0.6906	0.6982	0.6935
CZ	0.6743	0.6785	0.6894	0.6726	0.6757	0.6809	0.3076	0.3218	0.3073	0.3125	0.3322	0.3115
DK	0.7618	0.7724	0.7548	0.7323	0.7223	0.7133	0.1678	0.1849	0.1973	0.1970	0.2335	0.2314
DE	0.7189	0.7076	0.7045	0.6757	0.6627	0.6904	0.2559	0.2860	0.2923	0.3053	0.3399	0.2981
EE	0.7751	0.7717	0.7756	0.7595	0.7640	0.7682	0.1299	0.1472	0.1317	0.1391	0.1494	0.1347
IE	0.7707	0.7682	0.7790	0.7591	0.7477	0.7106	0.1673	0.1876	0.1757	0.1766	0.2086	0.2365
EL	0.5687	0.5756	0.5256	0.5478	0.4981	0.4769	0.3845	0.4079	0.4533	0.4073	0.4769	0.5278
ES	0.7197	0.7128	0.7255	0.7020	0.6828	0.5985	0.2570	0.2843	0.2721	0.2867	0.3266	0.4113
FR	0.7297	0.7139	0.7267	0.6869	0.6733	0.5847	0.2404	0.2758	0.2649	0.2840	0.3190	0.4139
HR	0.5554	0.5597	0.5513	0.5598	0.5545	0.5922	0.3954	0.3972	0.4048	0.3841	0.4047	0.3897
IT	0.4806	0.5517	0.5965	0.6075	0.5829	0.5446	0.4920	0.4120	0.3826	0.3643	0.4079	0.4353
CY	0.7385	0.7364	0.7371	0.7005	0.6866	0.6736	0.2229	0.2363	0.2477	0.2691	0.3042	0.3083
LV	0.3210	0.3606	0.3017	0.2971	0.3501	0.4048	0.7093	0.6654	0.7763	0.8202	0.7631	0.6937
LT	0.5411	0.5697	0.5451	0.5901	0.5212	0.6135	0.4237	0.3873	0.4273	0.3590	0.4723	0.3296
LU	0.7143	0.7072	0.7050	0.6972	0.6849	0.6738	0.2737	0.2937	0.2945	0.2873	0.3136	0.3192
HU	0.2843	0.2580	0.2257	0.5266	0.4895	0.5104	0.7246	0.7804	0.8434	0.4142	0.4889	0.4590
MT	0.6588	0.6472	0.6597	0.6248	0.6006	0.6014	0.3779	0.4227	0.4042	0.4436	0.5014	0.5012
NL	0.7183	0.7036	0.7126	0.6727	0.6512	0.6263	0.2667	0.3013	0.2926	0.3247	0.3700	0.3908
AT	0.6875	0.6882	0.6720	0.6977	0.6841	0.6954	0.2613	0.2776	0.2865	0.2558	0.2924	0.2605
PL	0.4767	0.4896	0.4180	0.4628	0.4624	0.4778	0.4883	0.4794	0.5648	0.5166	0.5363	0.5261
PT	0.6509	0.6493	0.6578	0.6460	0.6201	0.6185	0.3230	0.3389	0.3404	0.3335	0.3821	0.3928
RO	0.1326	0.1403	0.1399	0.1732	0.1996	0.2384	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SI	0.6355	0.6627	0.6515	0.6385	0.6429	0.6582	0.3157	0.3228	0.3222	0.3167	0.3481	0.3398
SK	0.6383	0.6408	0.6006	0.6532	0.6450	0.6603	0.3402	0.3518	0.3688	0.3088	0.3401	0.3229
FI	0.8894	0.9012	0.9024	0.8798	0.8852	0.8537	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SE	0.8668	0.8570	0.8571	0.7937	0.7954	0.7480	0.0130	0.0350	0.0394	0.1015	0.1137	0.1743

Table 3. Annual TOPSIS and VIKOR rankings.

Country	TOPSIS						VIKOR					
	2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020
BE	8	7	10	10	12	12	10	10	10	11	12	14
BG	24	24	24	25	25	26	24	24	24	25	25	25
CZ	14	14	13	14	10	8	14	14	14	14	11	9
DK	5	3	5	5	5	4	5	4	5	5	5	4
DE	10	10	12	12	13	7	8	11	11	12	13	7
EE	3	4	4	3	3	2	3	3	3	3	3	2
IE	4	5	3	4	4	5	4	5	4	4	4	5
EL	19	19	22	22	22	24	19	20	22	21	21	24
ES	9	9	8	6	9	18	9	9	8	9	10	18
FR	7	8	7	11	11	20	7	7	7	8	9	19
HR	20	21	20	21	20	19	20	19	20	20	18	15
IT	22	22	19	19	19	21	23	21	18	19	19	20
CY	6	6	6	7	6	10	6	6	6	7	7	8
LV	25	25	25	26	26	25	25	25	25	26	26	26
LT	21	20	21	20	21	16	21	18	21	18	20	12
LU	12	11	11	9	7	9	13	12	13	10	8	10
HU	26	26	26	23	23	22	26	26	26	22	22	21
MT	15	17	15	18	18	17	18	22	19	23	23	22
NL	11	12	9	13	14	14	12	13	12	16	16	16
AT	13	13	14	8	8	6	11	8	9	6	6	6
PL	23	23	23	24	24	23	22	23	23	24	24	23
PT	16	16	16	16	17	15	16	16	16	17	17	17
RO	27	27	27	27	27	27	27	27	27	27	27	27
SI	18	15	17	17	16	13	15	15	15	15	15	13
SK	17	18	18	15	15	11	17	17	17	13	14	11
FI	1	1	1	1	1	1	1	1	1	1	1	1
SE	2	2	2	2	2	3	2	2	2	2	2	3

Table 4. Final preference values obtained with compared MCDA approaches.

Country	2020 TOPSIS	2020 VIKOR	AVG TOPSIS	AVG VIKOR	DARIA-TOPSIS	DARIA-VIKOR
BE	0.6592	0.3408	0.7004	0.3023	0.6401	0.3919
BG	0.3519	0.6935	0.3597	0.6719	0.3336	0.7092
CZ	0.6809	0.3115	0.6783	0.3209	0.6853	0.3263
DK	0.7133	0.2314	0.7463	0.2041	0.6970	0.2959
DE	0.6904	0.2981	0.6959	0.2991	0.6747	0.3435
EE	0.7682	0.1347	0.7723	0.1430	0.7640	0.1645
IE	0.7106	0.2365	0.7607	0.1929	0.6951	0.3024
EL	0.4769	0.5278	0.5443	0.4325	0.4390	0.5886
ES	0.5985	0.4113	0.6997	0.3024	0.5681	0.4963
FR	0.5847	0.4139	0.6990	0.2897	0.5477	0.5101
HR	0.5922	0.3897	0.5579	0.3972	0.6032	0.3791
IT	0.5446	0.4353	0.5570	0.4114	0.5853	0.3818
CY	0.6736	0.3083	0.7203	0.2622	0.6536	0.3768
LV	0.4048	0.6937	0.3262	0.7361	0.4658	0.6532
LT	0.6135	0.3296	0.5600	0.4037	0.6447	0.2634
LU	0.6738	0.3192	0.7002	0.2992	0.6627	0.3479
HU	0.5104	0.4590	0.3608	0.6408	0.6895	0.3088
MT	0.6014	0.5012	0.6375	0.4388	0.5799	0.5596
NL	0.6263	0.3908	0.6894	0.3204	0.5988	0.4658
AT	0.6954	0.2605	0.6861	0.2793	0.7020	0.2322
PL	0.4778	0.5261	0.4587	0.5188	0.5028	0.5572
PT	0.6185	0.3928	0.6414	0.3540	0.6059	0.4320
RO	0.2384	1.0000	0.1565	1.0000	0.3591	1.0000
SI	0.6582	0.3398	0.6480	0.3318	0.6670	0.3595
SK	0.6603	0.3229	0.6381	0.3456	0.6754	0.2911
FI	0.8537	0.0000	0.8930	0.0000	0.8439	0.0000
SE	0.7480	0.1743	0.8380	0.0504	0.7193	0.5605