

A DEA Approach to Evaluate the Electric Mobility Deployment in European Countries

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Introduction

The European green deal embodies an ambitious plan to fight the climate change, aiming to achieve carbon neutrality, by 2050. Transportation is the remaining sector where emissions are still above the 1990 emissions level, being the road transportation the biggest emitter and the main share of transport energy demand.

Main elements of the strategy plan are the **increasing efficiency of the transport system** and the use of **low-emission energy sources** for transport, which can be accomplished by the deployment of the battery electric vehicles and plug-in hybrid electric vehicles (PEV).

This work aims to assess the performance of European countries (27 EU and United Kingdom) on the deployment of low-emission alternative energies and vehicles in road transportation. A Benefit-of-the-doubt (BoD) model based on Data Envelopment Analysis is used to calculate a composite indicator (CI) for several European countries, aggregating several sub-indicators built from a dataset for the 2019 year.

Methodology and Results

Data and Model

Set $M=8$ the selected sub-indicators i , being $m=5$ isotonic and $M-m=3$ reverse, to assess the road sustainability performance of EU countries:

	Renewable energy	Railway length	Public transport	PEV market share	Industrial Prod. Index (IPI)	GHG Emissions	Energy Intensity	New car emissions
Mean	0.088	0.053	17.757	0.029	1.105	2.101	159.350	122.521
St.dev.	0.053	0.032	4.277	0.034	0.079	1.606	73.459	9.474
Max	0.303	0.121	28.400	0.149	1.310	10.031	396.430	137.600
Min	0.033	0.013	9.400	0.004	0.973	0.935	50.930	98.400

using the BoD model proposed by [1] with proportional virtual weight restrictions [2] for a constant $k \in]0, 1[$ to assess the CI for each country j_0 :

$$CI_{j_0} = \max \sum_{i=1}^m w_i y_{ij_0} - \sum_{i=m+1}^M w_i y_{ij_0}$$

$$s.t. \quad \sum_{i=1}^m w_i y_{ij} - \sum_{i=m+1}^M w_i y_{ij} \leq 1 \quad \forall j = 1, \dots, s$$

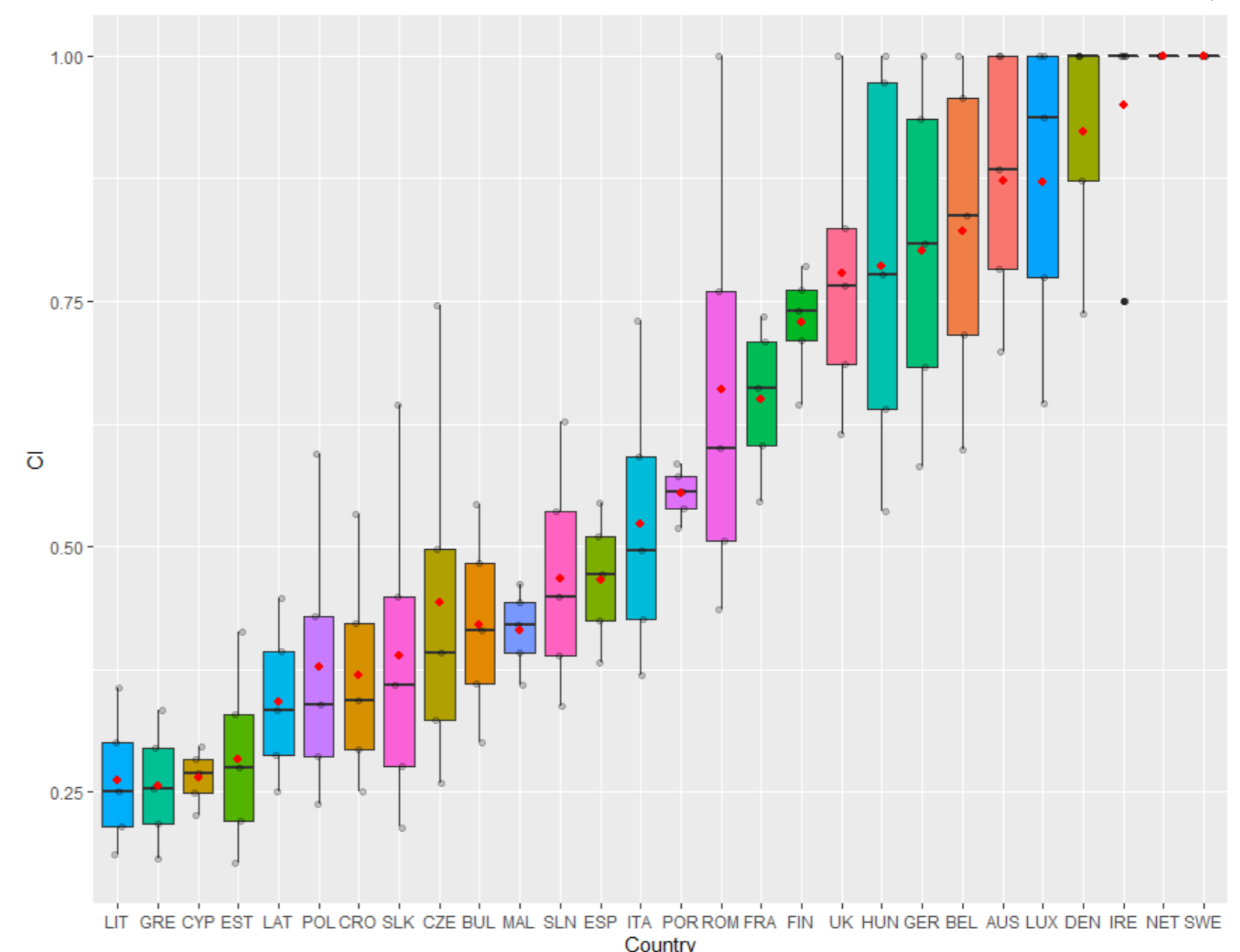
$$\frac{1}{M}(1-k) \leq \frac{w_i y_{ij_0}}{\sum_{i=1}^M w_i y_{ij_0}} \leq \frac{1}{M}(1+k) \quad \forall i = 1, \dots, M$$

$$w_i \geq 0 \quad \forall i = 1, \dots, M$$

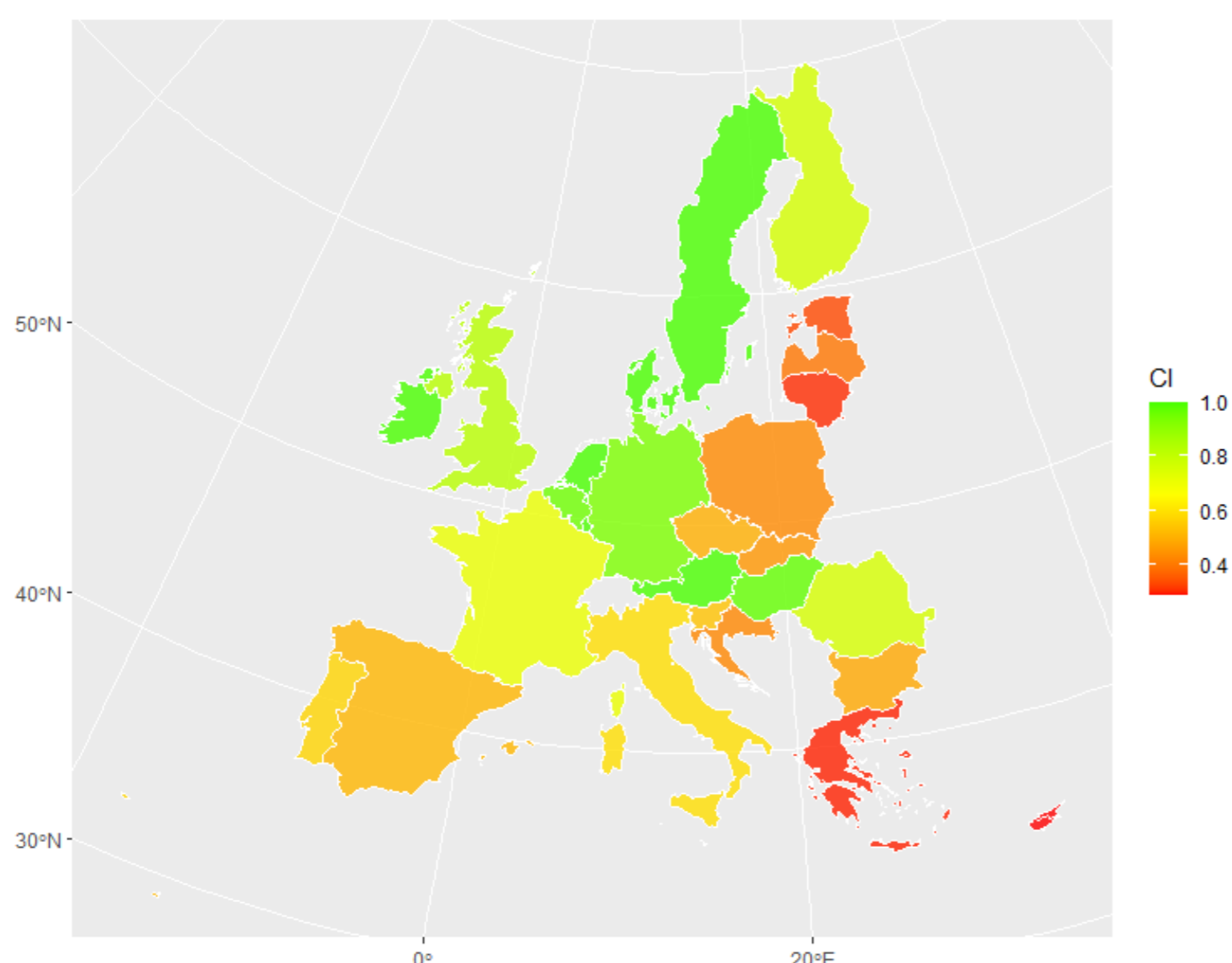
If no reverse sub-indicators, this model is equivalent to the BoD model [3]

Results

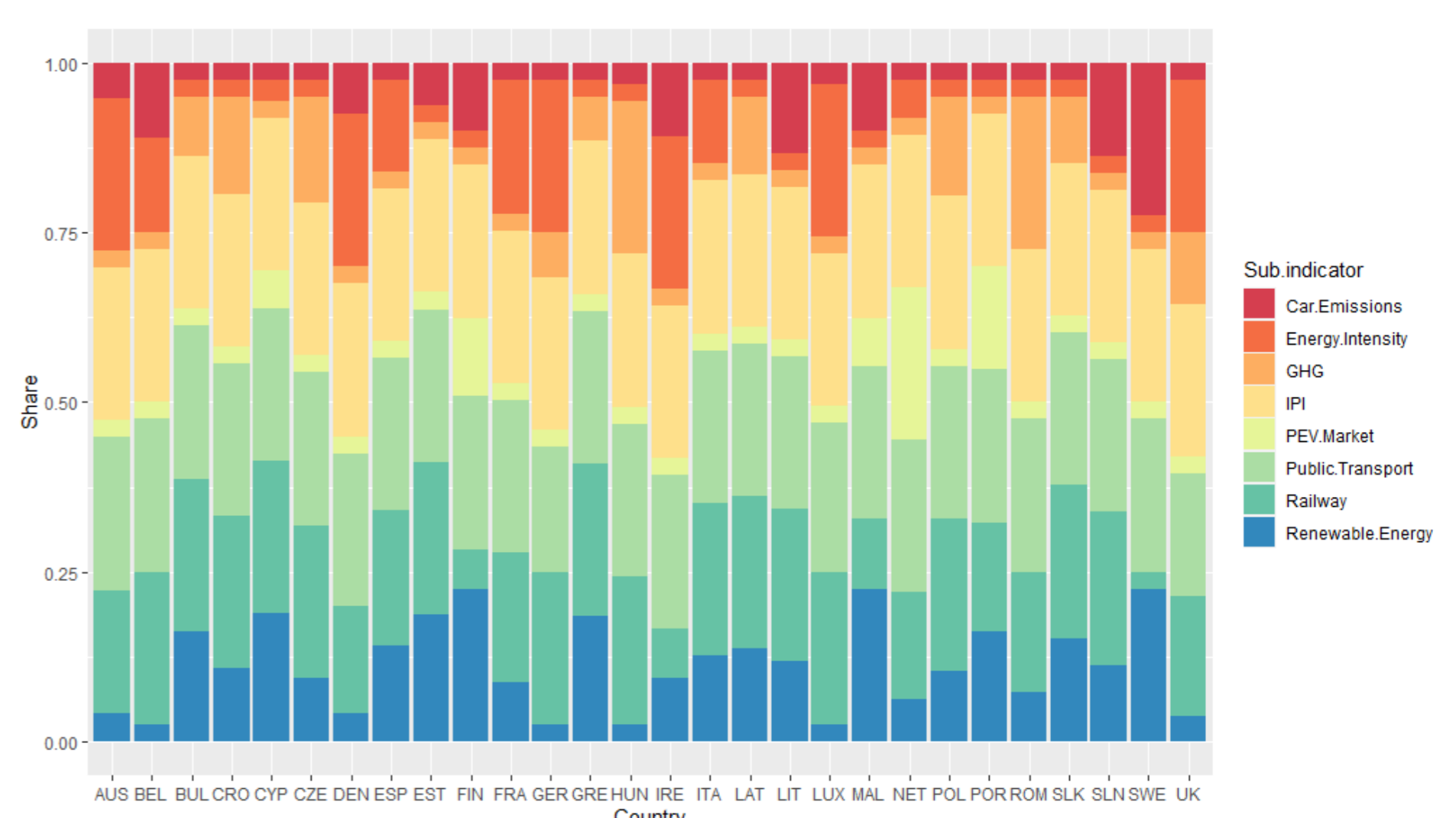
1 Analysis of the CI achieved in 5 scenarios with BoD model for each country using $k=0.5, 0.6, 0.7, 0.8$ and 0.9 (mean)



2 Performance assessment of EU countries in the selected scenario with $k=0.8$



3 Optimal weight structures for each country using $k=0.8$



Conclusions

- CI results are robust for variations of k , except with $k=0.9$, where higher variations were observed. Scenario with $k=0.8$ is adopted as a trade-off between robustness and flexibility.
- 6 benchmarks are identified (AUS, DEN, IRE, LUX, NET, SWE), the mean of CI is 0.66 and St.dev. is 0.27. Most countries have potential to improve road transport sustainability following the best practices adopted mainly by NET and SWE.
- The model allocates more weight to the isotonic sub-indicators (average share=79%) than to the reverse ones (average share=21%) in which the lowest average share is attributed to the electric mobility (4%).
- The performance assessment for each country tends to attribute high proportion to the sub-indicators with higher relative performance and a low proportion to the sub-indicators with poor relative performance, being relevant to identify its strengths and weaknesses.

Main References

- [1] Färe, R., Karagiannis, G., Hasannasab, M., Margaritis, D.: A Benefit-of-the-doubt Model with Reverse Indicators. EJOR 278(2), 394-400 (2019)
- [2] Wong, Y.H., Beasley, J.: Restricting Weight Flexibility in Data Envelopment Analysis. JORS 41(9), 829-835 (1990).
- [3] Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T.: An Introduction to 'Benefit of the Doubt' Composite Indicators. Social Indicators Research 82(1), 111-145 (2007)