Measurement problems on transition performance

Amaia Palencia-Esteban[a], Pedro Salas-Rojo[a], Paolo Brunori[ab] and Luca Lodi[b]

[a]LSE [b]UniFI

31/01/2024

SPES Sustainability performances, evidence & scenarios

Funded by European Union's Horizon Europe Programme under Grant Agreement No. 101094551

The composite indicators

D3.1 Report on mapping indicators and composite indices relevant to measure transition performances:

- Comprehensive set of 44 composite indicators and dashboards
- 15 short-listed indicator systems
- 5 final indicators:

1. Planetary Pressure Adjusted Human Development Index (PHDI) - *UNDP*
2. Transition Performance Index (TPI) - *European Commission*
3. Better Life Index (BLI) - *OECD*
4. Green Growth Index (GGI) - *Global Green Growth Institute*
5. Sustainable Development Goals (SDG) - *SDG Transformation Center*

Sensitivity Analysis

SPES Sustainability performances, evidence & scenarios

- Freudenberg (2003) critical approach to developing a composite indicator.
- Saisana et al. (2005) proposed uncertainity and sensitivity analysis to assess their validity.
- Papadimitriou et al. (2019): JRC audit of the SDG.
- Commission et al. (2022): JRC audit of the TPI.
- Acosta et al. (2019, 2022) & Flore et al. (2019): robustness GGI.

Method I: Composite indicators

SPES Sustainability performances, evidence & scenarios

Constructed following two consecutive steps:

1. Normalization to deal with different units of measurement. Details
2. Aggregation: geometric or arithmetic mean and weights optional. PHDI GGI BLI TPI SDG

Overall Summary

Method II: Sensitivity analysis

SPES Sustainability performances, evidence & scenarios

For indicator I, with components $I(x_1, x_2, .., x_n)$, where $x_1(x_{1c1}, x_{1c2}, ..., x_{1cn})$.

For each $x_i \in I$

1. Define $p=0.02$.
2. Define (max x_i, min x_i) or theoretical thresholds.
3. Take a country, change its value: $(x'_{ic1} = x_{ic1} * 1.02)$.
4. Normalize x'_i using 2.
5. Estimate I' and calculate the elasticity:

$$\epsilon_{I,x_i} = \frac{\triangle I}{\triangle x_i} \times \frac{x_i}{I} \tag{1}$$

6. Repeat 3-5 for each country.

Partial analysis: for each indicator we derive 27 elasticities.

Method III: Data

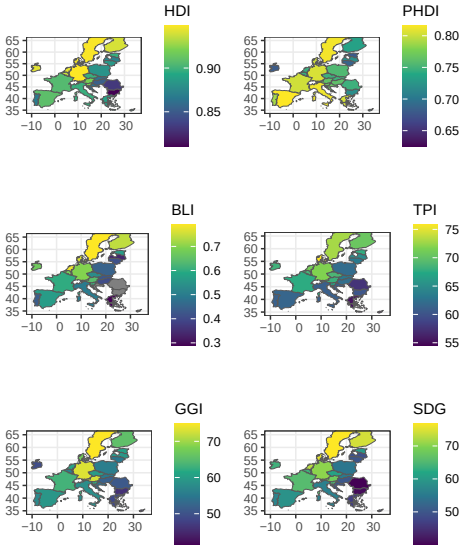
SPES Sustainability performances, evidence & scenarios

We focus on EU-27 & 2019. More generally:

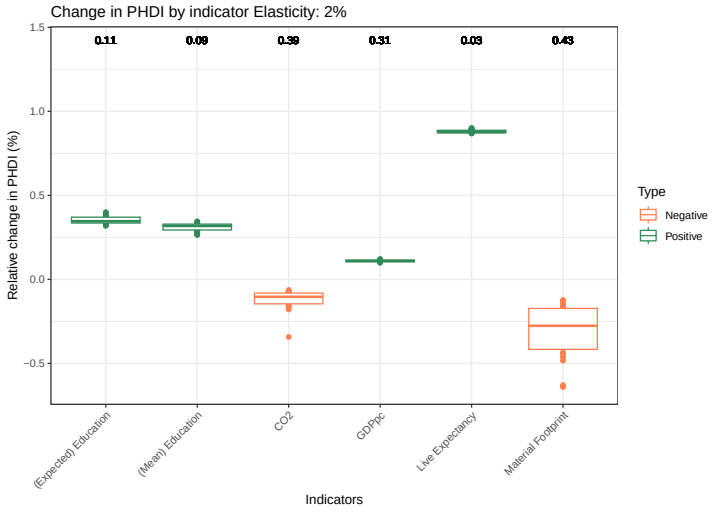
- PHDI: complete (1990-2021).
- TPI: complete (2011-2021) but "Energy productivity" (IEA) not available.
- BLI: not comparable across editions (download tricky), 5 countries out, some missing values despite imputations.
- GGI: few components change across editions and recurring missing values despite imputation (2000-2020). Capping corrections not provided.
- SDG: rather incomplete (2000-2023), no imputations and some components have varied over the years.

Results I: Baseline analysis

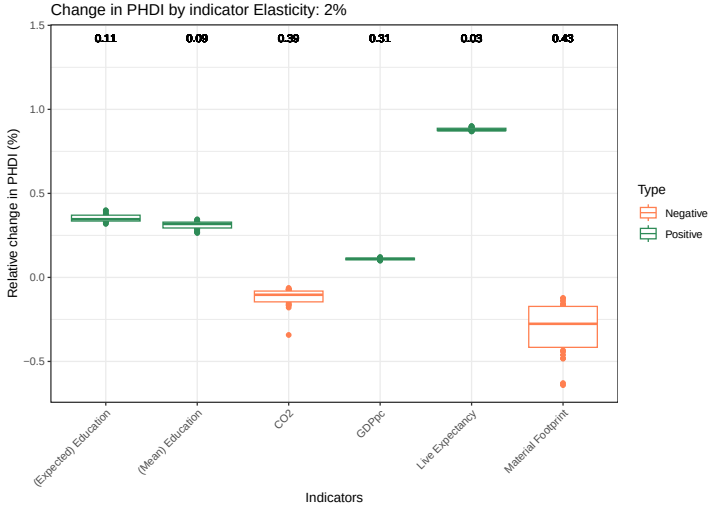
PHDI | BLI | TPI | GGI | SDG



Results II: PHID



Results II: PHID



Life Expectancy: [75.06, 83.55] and GNIpc [22732, 76019]

Results: CV example

Two components $\{x, y\}$ and 5 countries $\{A, B, C, D, E\}$.

$x = \{1, 2, 3, 4, 5\}$ and $y = \{1001, 1002, 1003, 1004, 1005\}$

Variable	Mean	Sd	CV
X	3	1.58	0.53
Y	1003	1.58	0.002

Results: CV example

Two components $\{x, y\}$ and 5 countries $\{A, B, C, D, E\}$.

$x = \{1, 2, 3, 4, 5\}$ and $y = \{1001, 1002, 1003, 1004, 1005\}$

Variable	Mean	Sd	CV
X	3	1.58	0.53
Y	1003	1.58	0.002

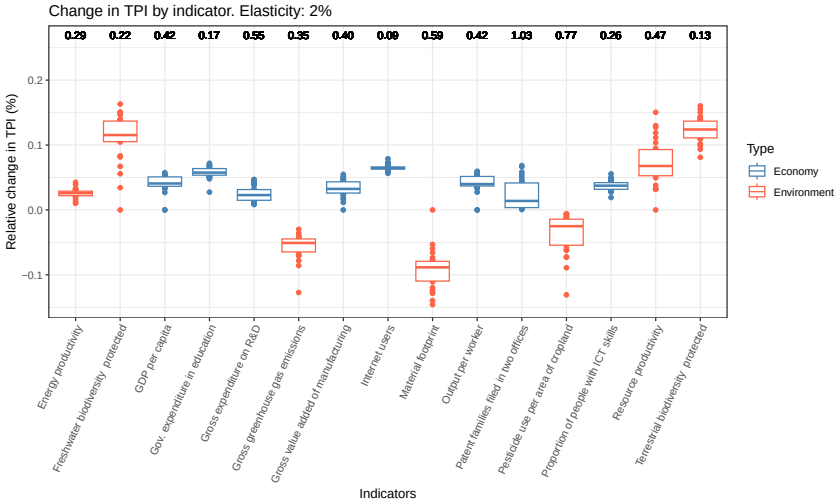
If country A raises its value by 2%:

$x' = \{1.02, 2, 3, 4, 5\}$ and $y' = \{1021, 1002, 1003, 1004, 1005\}$

Ranking altered in y'. After normalization, the indicator will show a higher sensitivity.

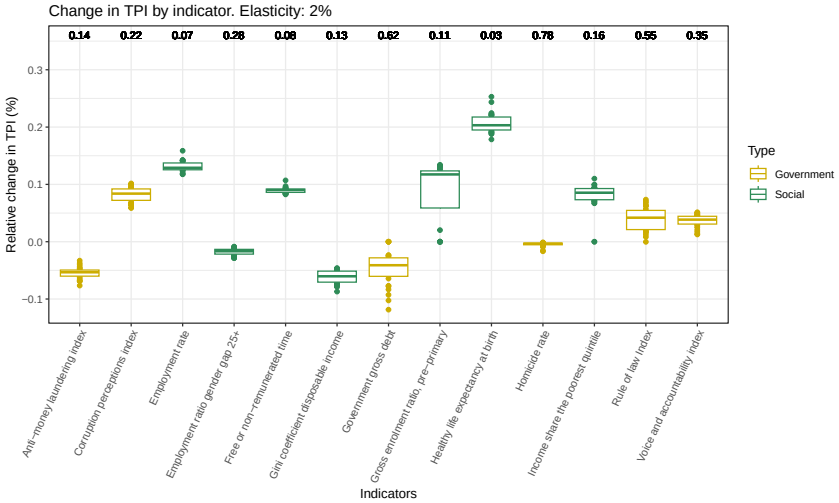
Results III: TPI

Figure: Transition Performance Index (Economic and Environment)



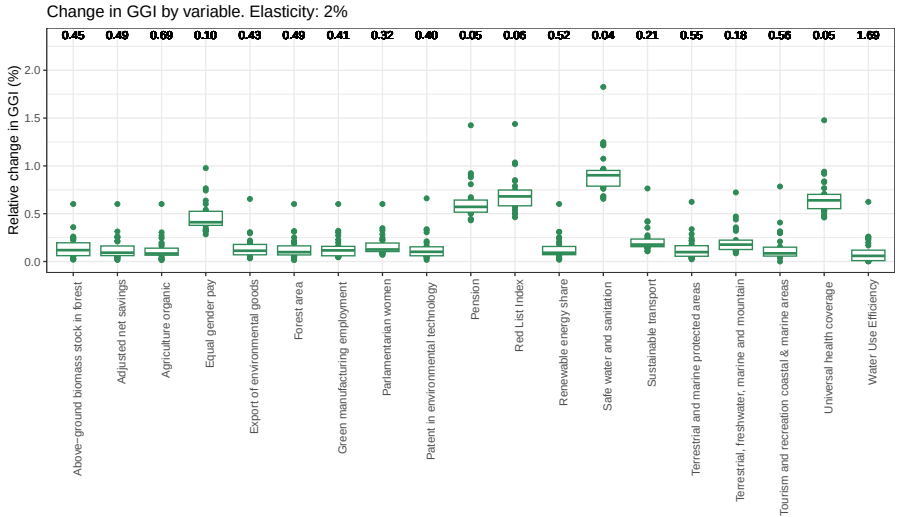
Results III: TPI

Figure: Transition Performance Index (Government and Social))



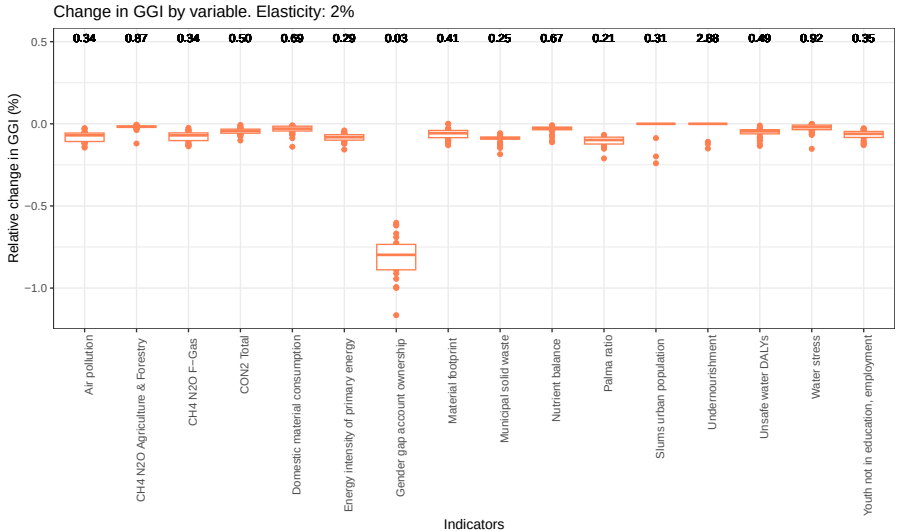
Results IV: GGI

Figure: Green Growth Index (Positive)



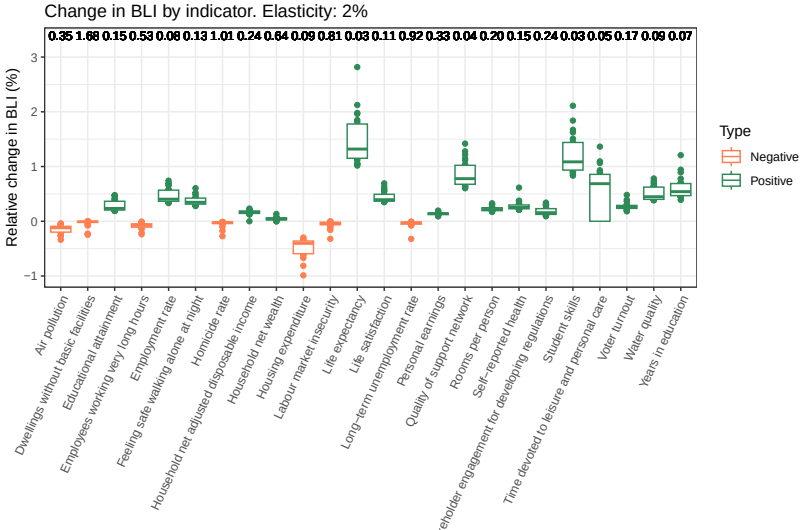
Results IV: GGI

Figure: Green Growth Index (Negative)



Results V: BLI

Figure: Better Life Index



Results V: BLI

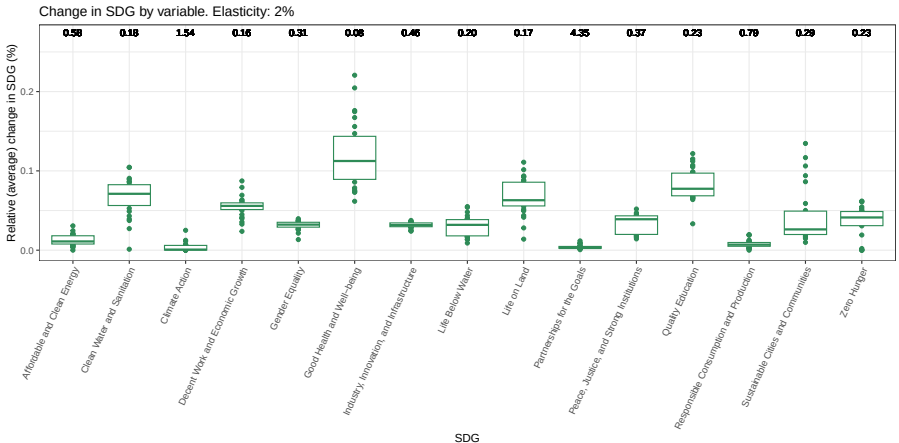
The highest elasticity (2.8) registered for BLI's "Life Expectancy" in Greece.

	Life Expectancy	BLI
Baseline	81.5	0.29
2pp change	83.1	0.3

Substantial variations in individual components have a limited impact.

Results VI: SDG

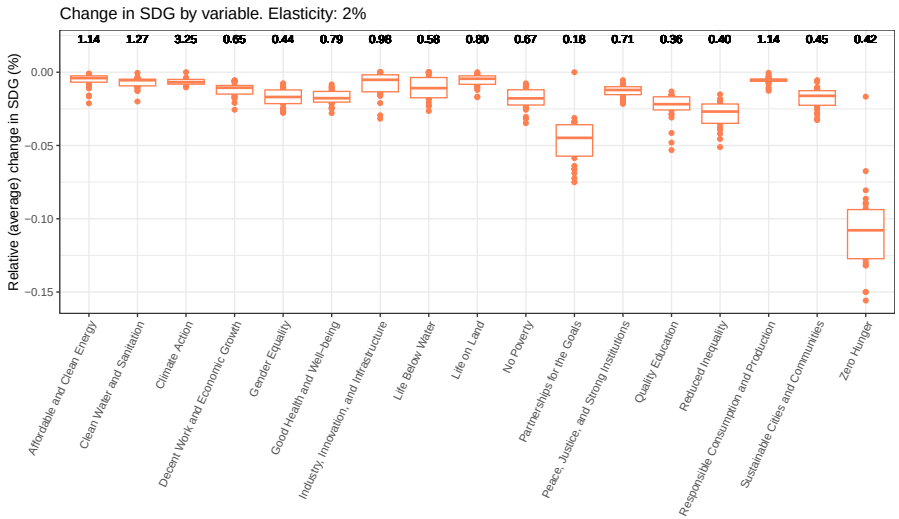
Figure: Sustainable Development Growth (Positive) [1]



[1] Elasticities averaged into the 17 dimensions.

Results VI: SDG

Figure: Sustainable Development Growth (Negative)



Elasticities overview by indicators

Indicator	Range Elasticity	Mean Elasticity (sd)	Pearson Correlation (p-values)
PHDI	Positive: (0.1 ; 0.9) Negative: (-0.64 ; -0.06)	Positive: 0.41 (0.29) Negative: -0.21 (0.14)	-0.92 (0.01)
TPI	Positive: (0 ; 0.25) Negative: (-0.15 ; 0)	Positive: 0.07 (0.05) Negative: -0.05 (0.03)	-0.49 (0.01)
BLI	Positive: (0 ; 2.8) Negative: (-0.99 ; 0)	Positive: 0.48 (0.43) Negative: -0.10 (0.19)	-0.21 (0.23)
GGI	Positive: (0 ; 1.8) Negative: (-1.16 ; 0)	Positive: 0.29 (0.29) Negative: -0.13 (0.18)	-0.50 (0.01)
SDG	Positive: (-0.01 ; 0.43) Negative: (-0.50 ; 0)	Positive: 0.05 (0.06) Negative: -0.02 (0.04)	-0.06 (0.52)

Robustness

We deal with the choice of p and statistical significance. For each component and country:

- Draw 200 random p values from $U(0, 0.1)$.
- Estimate the change in the indicator for all options.
- Averaging "elasticities" across all repetitions: get mean elasticity and 95% CI.

Results: PHDI | TPI1 | TPI2 | GGI1 | GGI2 | BLI | SDG1 | SDG2

Conclusions

SPES Sustainability performances, evidence & scenarios

- Baseline pattern: North, Central-West, West-South and East.
- Baseline HDI vs. PHDI: different ranking, climatic variables important.
- The indicators are rather insensitive to changing its components' values.
- Association between the dispersion of the non-normalized values of the components and elasticity of the indicator.
- The index's sensitivity is not driven by the theoretical or wellbeing relevance of its components, but rather by the measurement unit before normalizing.
- Robust to setting $p \neq 2$ and bootstrappimg.

Is this desirable?

Thanks for your attention

contact: a.palencia-esteban@lse.ac.uk

SPES Sustainability performances, evidence & scenarios

www.sustainabilityperformances.eu

Thanks for your attention

contact: a.palencia-esteban@lse.ac.uk

SPES Sustainability performances, evidence & scenarios

www.sustainabilityperformances.eu

Re-scaling method

Min-max transformation, depends on the direction of the variable.

If positive:

$$x_{normalized} = \frac{x - min(x)}{max(x) - min(x)}$$

If negative:

$$x_{normalized} = \frac{max(x) - x}{max(x) - min(x)}$$

The max-min can be defined by the values in the sample or be fixed based on some theoretical values.

Back

Formulas I

$$PHDI = (LEI * EI * II)^{1/3} * \frac{C + MF}{2} = HDI * Adjustment \quad (2)$$

Min-max transformation, values fixed. Components:

- LEI: Life expectancy index (life expectancy at birth)
- EI: Education index (expected and mean years of schooling)
- II: GNI idex (GNI per capita)
- C: CO2 emisions per capita
- MF: Material footprint per capita

It adjusts the HDI (geometric mean) for planetary pressure (arithmetic mean)

Back

Formulas II

$$GGI = \frac{1}{N}\sum_{i=1}^{N} x_i \tag{3}$$

Min-max transformation: sample values.

36 components aggregated into 16 pillars (arithmetic), then aggregated into 4 dimensions (geometric), then aggregated to get indicator (geometric).

Framework

$$BLI = \frac{1}{N}\sum_{i=1}^{N} x_i \tag{4}$$

Min-max transformation: sample values.

24 components aggregated into 11 dimensions (arithmetic).

Back

Formulas III

$$TPI = \frac{1}{N} \sum_{i=1}^{N} w * x_i \tag{5}$$

Min-max transformation: values fixed.
28 components aggregated into 4 dimensions (arithmetic).
Weights=(0.2 for economic and social, 0.25 governance, 0.35 environmental)

$$SDG = \frac{1}{N} \sum_{i=1}^{N} x_i \tag{6}$$

Min-max transformation: fixed values.
114 components aggregated into 17 SDGs (arithmetic).

Back

GGI Framework

SPES Sustainability performances, evidence & scenarios

Dimensions [Goals]	Indicator categories [Pillars]	Indicators [metrics]
Efficient and sustainable resource use 	Efficient and sustainable energy	EE1 Ratio of total primary energy supply to GDP (MJ per $2011 PPP GDP)
		EE2 Share of renewable to total final energy consumption (Percent)
	Efficient and sustainable water use	EW1 Water use efficiency (USD per m^3)
		EW2 Share of freshwater withdrawal to available freshwater resources (Percent)
	Sustainable land use	SL1 Soil nutrient budget (Nitrogen kilogram per hectare)
		SL2 Share of organic agriculture to total agricultural land area (Percent)
	Material use efficiency	ME1 Total domestic material consumption (DMC) per unit of GDP (Kilogram per GDP)
		ME2 Total material footprint (MF) per capita (Tons per capita)
Natural capital protection 	Environmental quality	EQ1 PM2.5 air pollution, mean annual population-weighted exposure (Micrograms per m^3)
		EQ2 DALY rate due to unsafe water sources (DALY lost per 100,000 persons)
		EQ3 Municipal solid waste (MSW) generation per capita (Tons per year per capita)
	Greenhouse gas emissions reductions	GE1 Ratio of CO_2 emissions to population, including AFOLU (Tons per capita)
		GE2 Ratio of non-CO_2 emissions to population, excluding AFOLU (CO_2e per capita)
		GE3 Ratio of non-CO_2 emissions in agriculture to population (CO_2eq tons per capita)
	Biodiversity and ecosystem protection	BE1 Average proportion of key biodiversity areas covered by protected areas (Percent)
		BE2 Share of forest area to total land area (Percent)
		BE3 Above-ground biomass stock in forest (Tons per hectare)
	Cultural and social value	CV1 Red list index (Index)
		CV2 Tourism and recreation in coastal and marine areas (Score)
		CV3 Share of terrestrial and marine protected areas to total territorial areas (Percent)

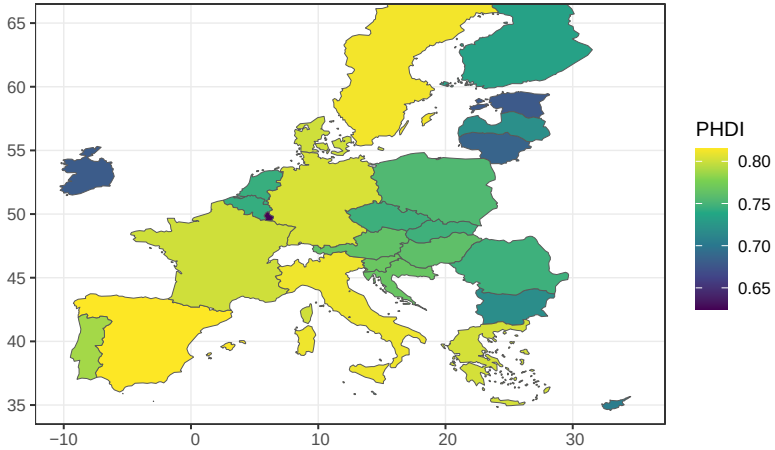
Summary: Indicators and Aggregation Methods

SPES Sustainability performances, evidence & scenarios

Indicator	Areas-Components	Normalization	Aggregation
PHDI	HDI: 4 components aggregated into 3 dimensions. PP: 2 indicators	Min-max transformation, values fixed.	HDI geometric mean adjusted (multiplied) by the PP geometric mean.
TPI	28 components aggregated into 4 dimensions	Min-max transformation, values fixed	Different weights by dimension + arithmetic averaging of the pillars
BLI	24 components aggregated into 11 topics	Min-max transformation, base on sample values	Equal weights + arithmetic aggregation
GGI	36 components aggregated into 16 indicator categories (pillars), aggregated into 4 dimensions (goals)	Min-max transformation, based on sample values	Equal weights + arithmetic aggregation of normalized components + geometric aggregation of indicator categories + geometric aggregation of dimensions
SDG	114 components (85 global and 29 specifically for OECD countries) aggregated into 17 SDGs	Min-max transformation, upper bound defined based on a specific decision tree	Equal weights + arithmetic mean of components for each goal + average scores across all 17 goals

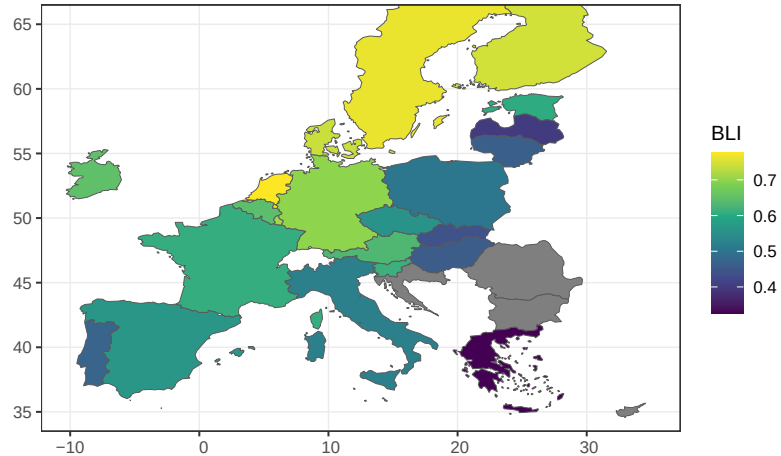
Back

Baseline: PHDI



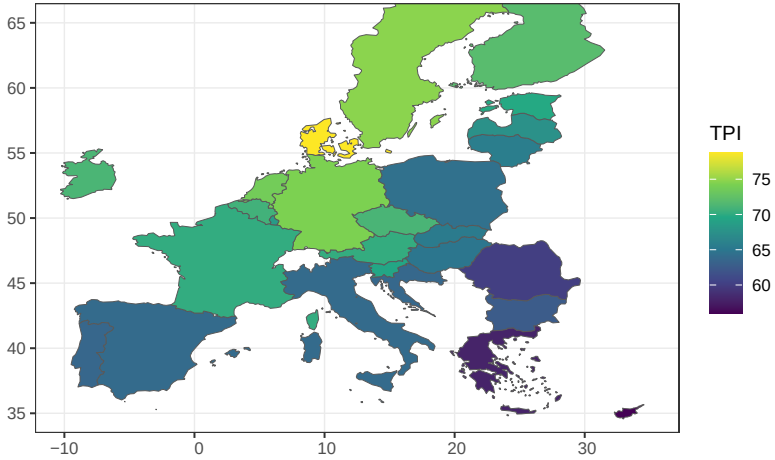
Back

Baseline: BLI



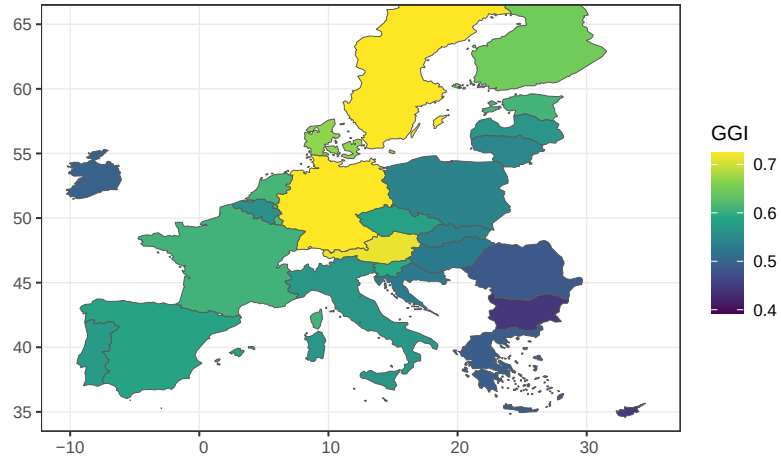
Back

Baseline: TPI

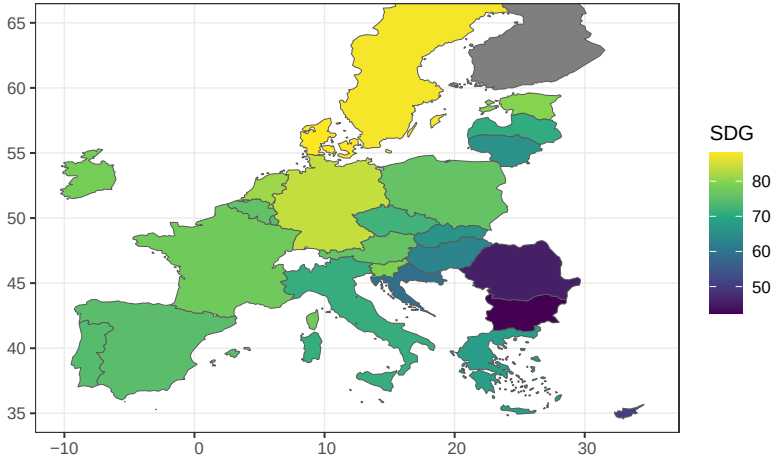


Back

Baseline: GGI



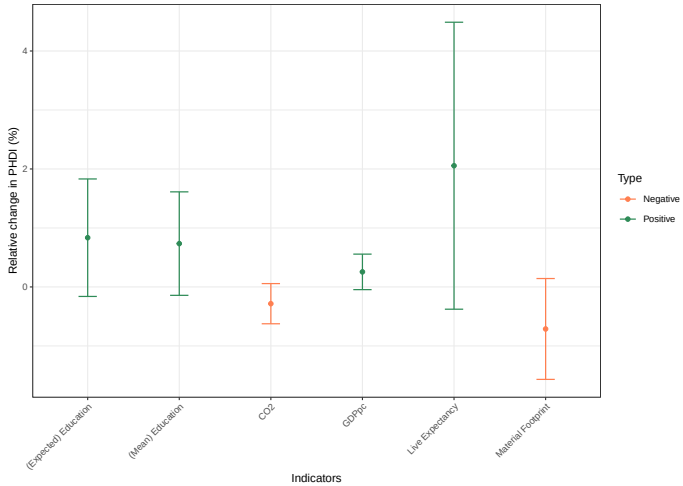
Baseline: SDG



Back

Robustness: PHDI

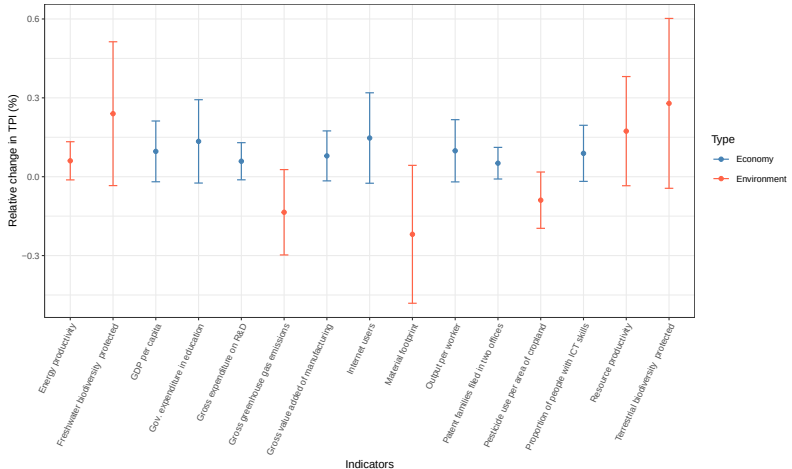
Figure: Planetary pressures-adjusted Human Development Index (Random Elasticity)



Back

Robustness: TPI

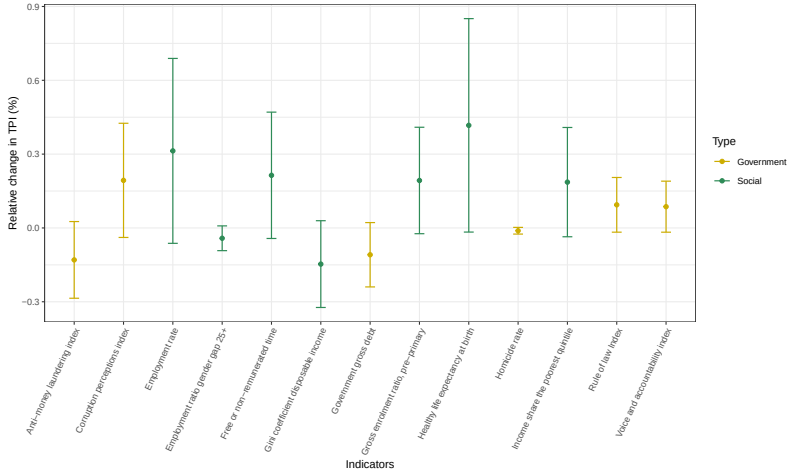
Figure: Transition Performance Index (Economic and Environment, Random Elasticity)



Back

Robustness: TPI

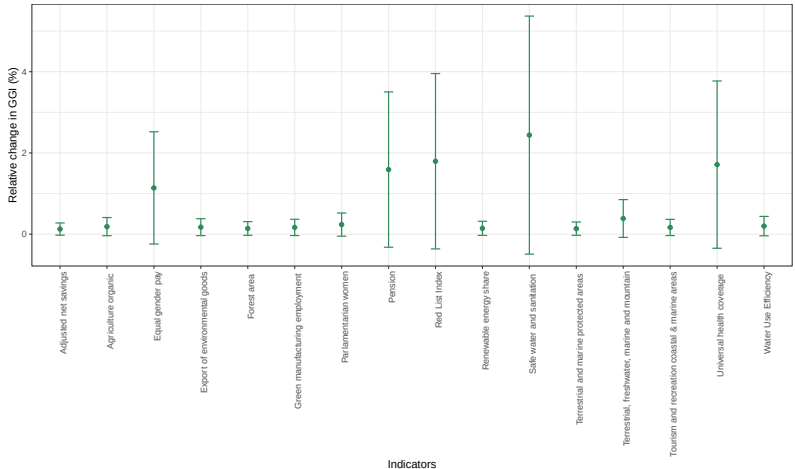
Figure: Transition Performance Index (Government and Social, Random Elasticity)



Back

Robustness: GGI

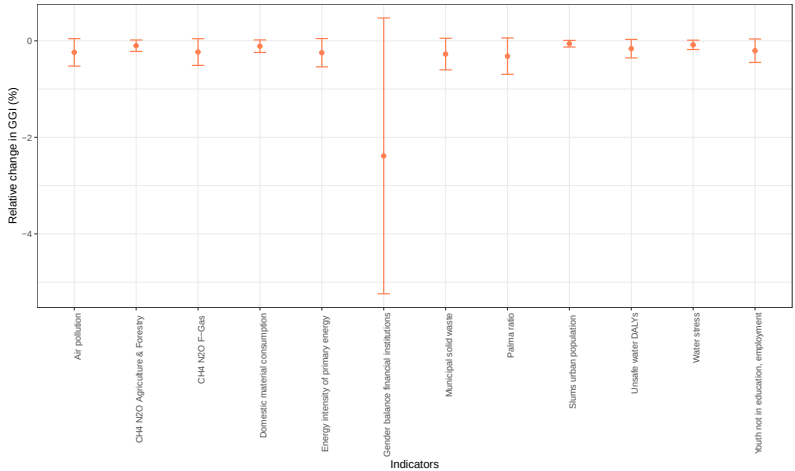
Figure: Green Growth Index (Positive, Random Elasticity)



Back

Robustness: GGI

Figure: Green Growth Index (Negative, Random Elasticity)

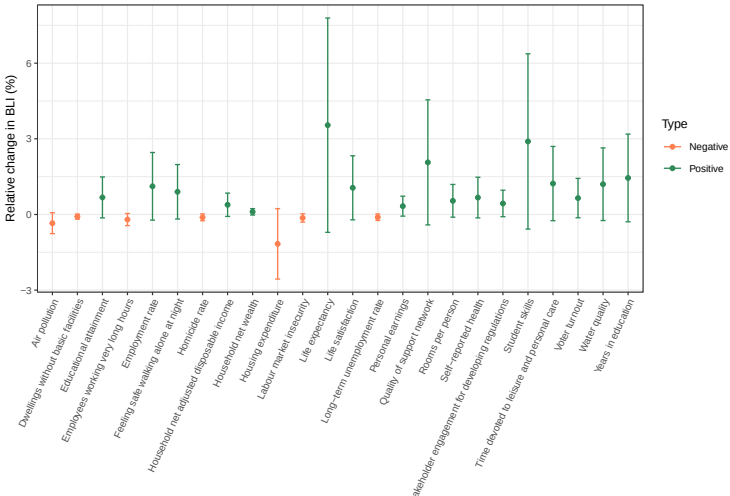


Back

Robustness: BLI

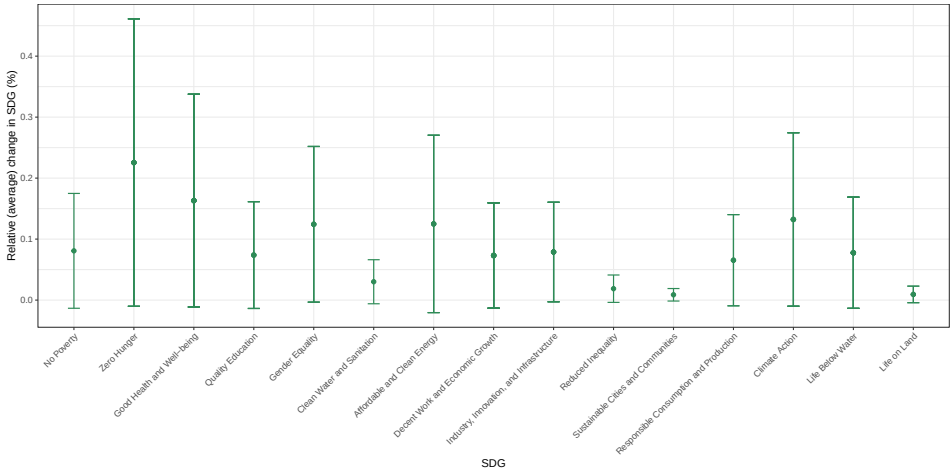
Back

Figure: Better Life Index (Random Elasticity)



Robustness: SDG

Figure: Sustainable Development Growth (Positive, Random Elasticity)



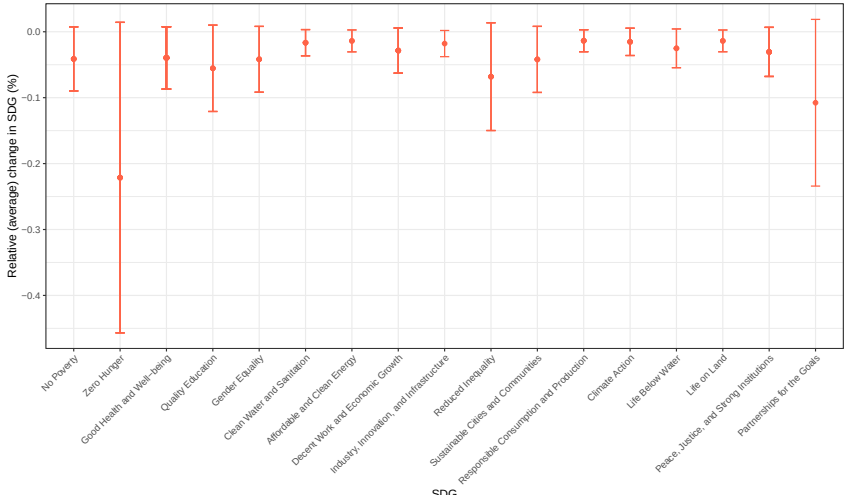
Back

Robustness: SDG

Back

SPES Sustainability performances, evidence & scenarios

Figure: Sustainable Development Growth (Negative, Random Elasticity)



PARTNERS

SPES Sustainability performances, evidence & scenarios

UNIVERSITÀ DEGLI STUDI FIRENZE

Lead partner

OSLOMET

OSLO METROPOLITAN UNIVERSITY
STORBYUNIVERSITETET

UNIVERSITY OF AMSTERDAM

université de BORDEAUX

UNIVERSITY OF BELGRADE
Faculty of Economics

European University Institute

International Institute for Applied Systems Analysis
IIASA

TÁRKI Social Research Institute
TÁRSADALOMKUTATÁSI INTÉZET ZRT.

social platform

pep partnership for economic policy

LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Associated partner

ASVIS Alleanza Italiana per lo Sviluppo Sostenibile

Affiliated partner