Absolute Environment Sustainability Assessment (AESA) of Global Economy

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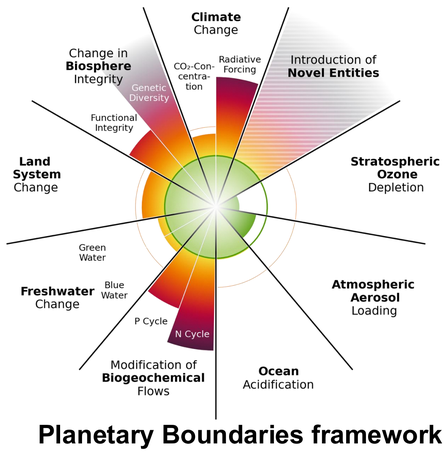
1 Background

- ✓ Industrialisation and rising consumption have pushed **7 of 9 Earth system processes** (e.g., climate, freshwater, biodiversity) beyond safe limits.
- ✓ **AESA** determines whether the economy operates within ecological limits (i.e., **absolute environmental sustainability**), moving beyond relative metrics (doing less harm).
- ✓ The **Planetary Boundaries (PBs) framework** is increasingly driving regulation and corporate strategy (EU Green Deal, L'Oréal etc.)



Planetary Boundaries framework

2 Objectives

Benchmark the absolute environmental sustainability of major economies.

Trace environmental pressures embodied within global trade and supply chains.

Uncover and quantify the key economic and structural factors driving environmental change.

3 Methodology

Allocating global limits into sub-global levels

Global limits

PBs framework
- 7 Earth system processes
- 9 environmental indicators

Individual share

Downscaling
- Equal per capita

Country share

Upscaling to country level
- Grandfathering
- Ability to pay
- Responsibility

$$SOS_{sub\text{-}global} = SOS_{global} * AF$$

SOS: safe operating space
AF: allocation factors

Calculating environmental impacts across global economies

✓ **Model & Scope**
Model: Environmental extended multi-regional input-output (EE-MRIO) analysis
Data: Exiobase v3.9.6 covering the period 1995-2020, consumption footprint
Scope: 38 High-Income and 11 Middle/Low-Income economies
Tool: Python (Pymrio package)

✓ **Impact Assessment**: Environmental impact (E) quantified using our new **Planetary Boundary Impact Assessment (PB-IA) method**

$$E = BLY * CF$$

B: footprint intensity; ***L*** (Leontief Inverse): direct+indirect requirements; ***Y***: final demand; ***CF***: characterisation factors

✓ **Environmental Decoupling**

$\frac{\Delta E}{\Delta GDP}$
- >1 Coupling
- <1 Weak decoupling
- <0 Strong decoupling

✓ **PBs transgression**

$\frac{E}{SOS_{sub\text{-}global}}$
- >1 Not Absolute sustainable
- ≤1 Absolute sustainable

Structural decomposition analysis

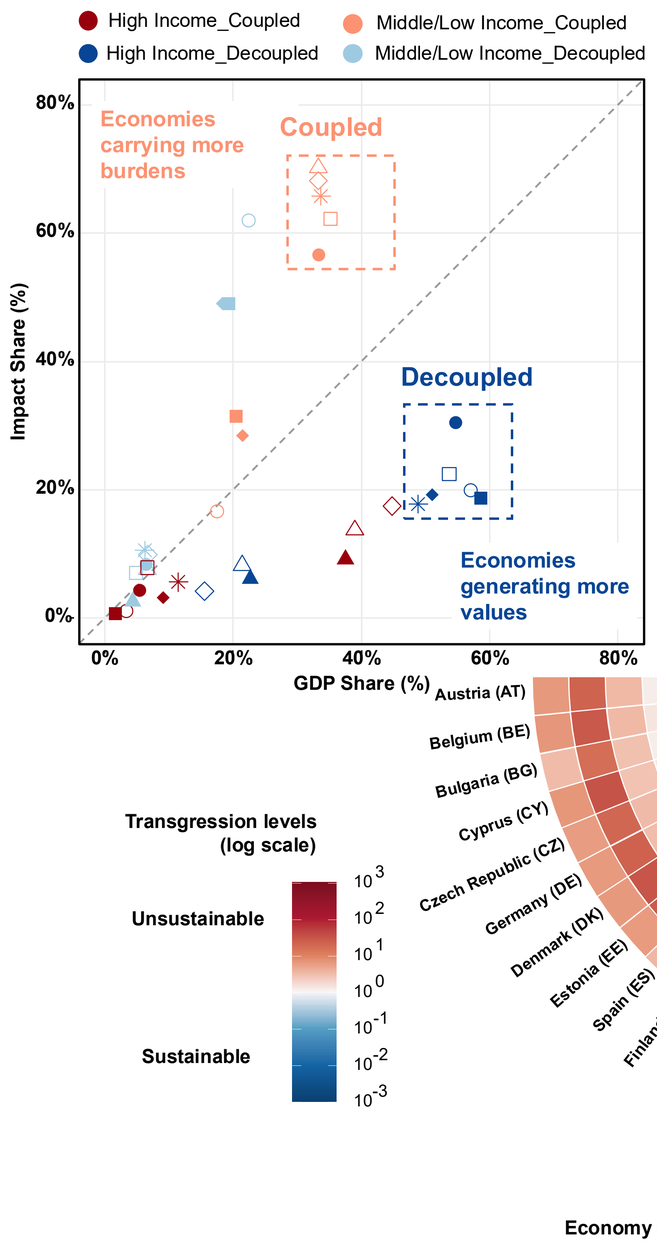
To trace the drivers of environmental change (ΔE) between time 0 and 1, we employ **structural decomposition analysis (SDA)**, which breaks down the change into **8 key driving factors**.

$$\Delta E_i^r = E_{i1}^r - E_{i0}^r = f_{i1} L_1 Y_1^r - f_{i0} L_0 Y_0^r$$

ΔE can be decomposed into: domestic/foreign impact intensity ($\Delta f^d, \Delta f^f$), production structure ($\Delta L^d, \Delta L^f$), consumption structure (ΔY_{str}^d, ΔY_{str}^f), and consumption level (ΔY_{lev}^d, ΔY_{lev}^f).

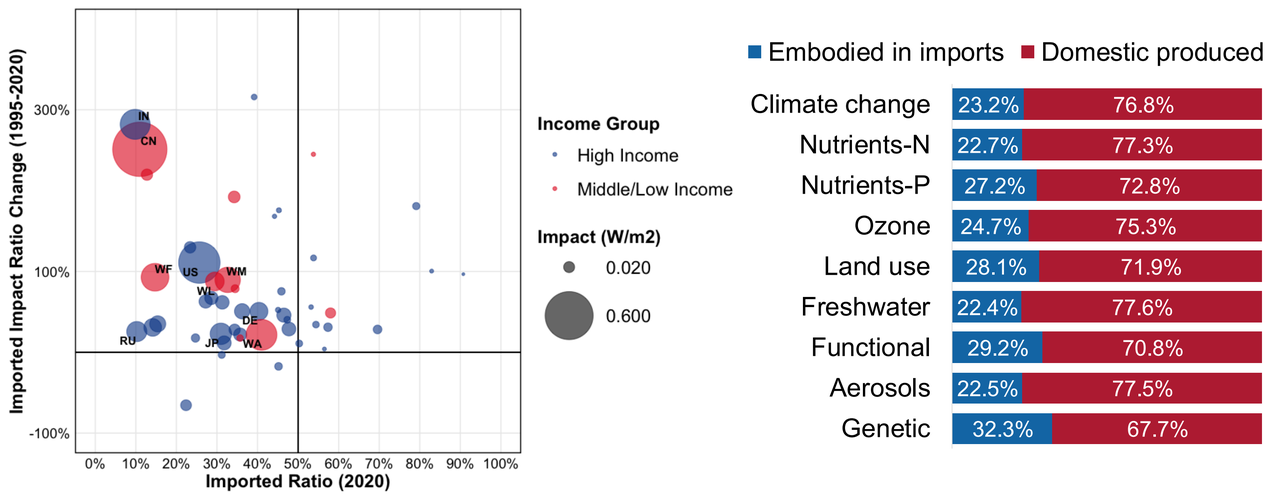
4 Results

✓ **Decoupling is uneven and insufficient, no economy achieves absolute environmental sustainability**
1. Over half of global GDP is decoupling from **climate, land-use, and biodiversity pressures,** yet no economy is absolute environmentally sustainable.
2. Decoupling is mainly in high-income economies, which account for only **~20–35%** of global impacts.
3. Middle/low-income economies generate **~65–80%** of impacts and remain strongly coupled.

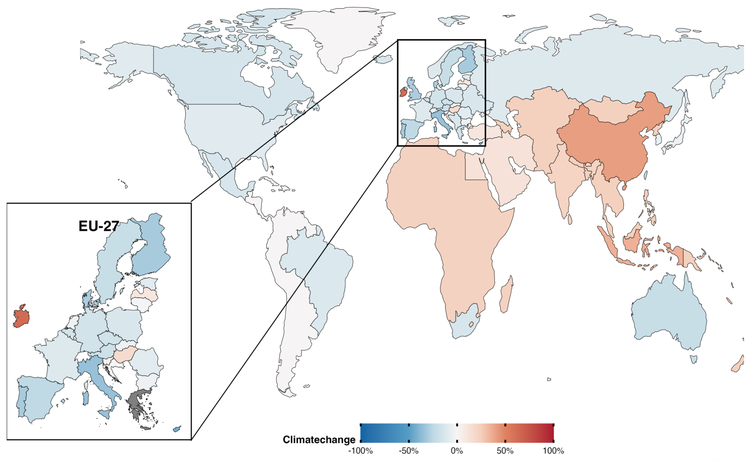


Economy decoupling and transgression levels (equal per capita) for 2020

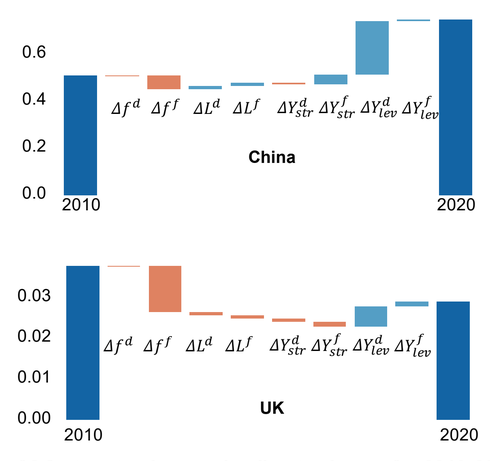
✓ **Impacts embodied in imports are increasing, but domestic production still dominates (~68%~78%)**



✓ **SDA identifies drivers behind changes over time for different economies (e.g. climate change)**
1. UK's climate change impact reduction benefits from impact intensity improvement (cleaner imports).
2. Demand growth is the primarily driver for impact increase in China



Changes in climate change for 2010-2020



Contributions of 8 factors to changes in climate change for 2010-2020

5 Conclusion

- ✓ Decoupling is uneven and insufficient across economies and PBs, no economy is absolute environmentally sustainable.
- ✓ Efficiency improvement is not enough, industries must explore circular business models.
- ✓ Not only "Carbon Neutrality", but also absolute environmental sustainability.

6 Future works

- ✓ Apply the PB-IA method at the **sectoral and product** level.

References

1. Sakschewski and Caesar et al. 2025. *Planetary Health Check.*
2. Stadler et al. (2018). *Journal of Industrial Ecology,* 22(3).
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