Can an island grow and stay clean?

Under every GDP line sits a **smoke line** → it falls only while **smoke per dollar** falls faster than GDP grows (**decoupling**) · three reasons it can turn: **technique**, **composition**, **scale** · count it twice: where it is **made** and where it is **bought** · the hump is a **hypothesis**, not a law. The lesson picks no side on growth.

1 Two lines, one ratio

Macro 10

- Macro 10: **rule of 70** (doubles every `70 ÷ r` years) · $10,000 at 3% → 3 doublings in 70 years → ≈ **$80,000**
- `smoke = GDP × smoke per dollar` · Coralia, index 2006 = 100: GDP 100 → 150 → **200**, chimney smoke 100 → 120 → **60** · per $ million `1.0 → 0.8 → 0.3` (`60 ÷ 200`)
- **Decoupling** = GDP ↑ while smoke ↓: the lines part company · a **race**: GDP 400 at 0.3 → `400 × 0.3 = 120` = the 2016 peak again ⇒ GDP doubles → smoke per dollar must **halve** just to stand still
- Practice · Kelua: GDP 100 → 200, smoke 100 → 80 → `80 ÷ 200 = 0.4` · GDP 300 → `300 × 0.4 = 120` · GDP 400, smoke kept at 80 → `80 ÷ 400 = 0.2`

2 Why the line turns

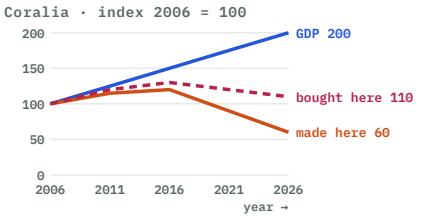
Grossman & Krueger 1991

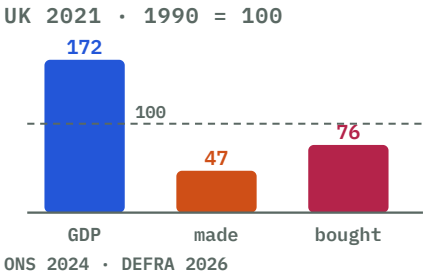
- **Gene Grossman** and **Alan Krueger** (American economists, 1991): three channels · **technique** = same goods, less smoke per unit (Lessons 1-6: tax, price, ban, sun) · **composition** = a different mix (software, tourism, less steel) · **scale** = more of everything ↑ ⇒ line turns when technique + composition beat scale
- Hidden 4th inside composition: steel no longer made at home, still used → made on Palmera, shipped in ⇒ **carbon leakage** = smoke moved to another country's chimneys: off one book, still in the sky
- Practice · technique: gas plant, bus filters | composition: software, closed cement works | scale: tourists, more people · cement → leakage · chain: tax at home → costlier at home → made abroad, shipped in → chimney count ↓, bought count not

3 Count it twice

made · bought

- **Territorial** = the chimney count, made inside the borders · **consumption-based** (Global Carbon Project)
  `= made − inside exports + inside imports`
- **Coralia** (importer) 2026: `60 − 10 + 60 = 110` → chimneys **−40%**, bought **+10%** since 2006 · **Kelua** (exporter, practice): `80 − 30 + 10 = 60` → chimneys −20%, bought −40% ⇒ importer's bought count higher, exporter's lower
- **UK**, 1990 = 100, 2021: GDP **172** · made in the UK **47** (−53%) · bought by the UK **76** (−24% since 1990, peak 2007) · **carbon footprint** = UK name for the bought count · made abroad **31%** (1996) → **54%** (2021) ⇒ real cuts **and** smoke that moved (ONS, Office for National Statistics, 2024)



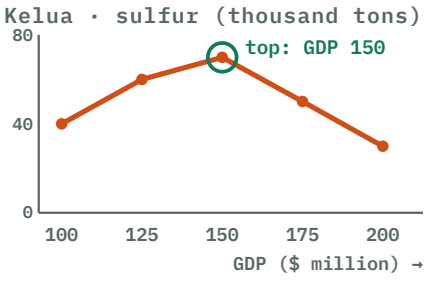


ONS 2024 · DEFRA 2026

4 The hump

a hypothesis

- Smoke vs income → up, over, down · **Simon Kuznets** (American, b. 1901 Pinsk, Nobel 1971) drew the hump for inequality, 1955 · Grossman & Krueger for pollution: sulfur dioxide and smoke, cities of 42 countries; turning points mostly below **$8,000** per person (1995) ⇒ **environmental Kuznets curve**
- Mixed record: Harbaugh, Levinson & Wilson 2002, ten more years of data → "little empirical support" · world fossil CO_2: record 2025 ≈ **38 billion tons** (Global Carbon Budget); 2026 edition: first small dip, "probably short-term" · physics: human warming "unequivocal" (IPCC, UN climate panel, 2021)
- The curve does **not** say growth cleans by itself: turns came with rules, prices, trade · practice: Kelua's sulfur 40, 60, **70**, 50, 30 → top at GDP 150; a pattern, not a law



5 So what

question 8

- **For growth with cleaner technique**: UK economy +72% with half the chimney smoke; richer countries can pay for cleaner furnaces; the poorest need growth most · **for less growth (degrowth)**: UK bought count only −24%, the world's line has not turned, every doubling of GDP needs a halving of smoke per dollar · open debate, no verdict · university: "decomposition analysis"
- **Ten questions to ask about any green policy** (so far): **1** · What does the smoke really cost, and who pays that cost now? · **2** · Who owns the resource? · **3** · Does it cut where cutting is cheapest? · **4** · Price or quantity, and which mistake is worse here? · **5** · The cheap fix, the visible one, or the next invention? · **6** · Does it work at the peak, or only on the average day? · **7** · What is a dollar of damage in 2100 worth today, and at which discount rate? · **8** · **Did the smoke really fall, or did it just move abroad?**

Watch out: one country's falling line ≠ the planet's · a falling chimney count ≠ a falling footprint (UK 47 vs 76) · the hump ≠ "wait and it cleans itself" · "smoke fell 40%, we did our part" skips question 8: put **both counts** on the table