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# Measuring for the Future, not the Past

Global Solutions

September 18th 2023

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# Outline

1. Reflecting **risk** in natural capital accounts
2. **Inequality** and natural capital
3. Use cases: natural capital and **productivity**
4. Final thoughts

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# 1. How could we reflect risk in natural capital accounts?

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# NatCap has a unique risk profile

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- Natural *capital* enables to bring capital theory to the management of nature
- Natural capital is best thought of as a portfolio of interconnected assets
- Efficient portfolio management entails the risk-free return on assets to be equal to the return earned by investing in a numeraire capital stock
- Yet, *natural capital* has peculiarities
    - Non-market capital services
    - Public, quasi-public, and private good characteristics
    - Subject to ecological complexities and dynamics

# What risks might we want to reflect?

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- Return on risk adjusted capital:
  - Capital stock is at risk, but the ES flows are assumed to be safe
- Risk-adjusted return on capital:
  - Stock is not at risk, but the value of ES flows is
- Risk-adjusted return on risk-adjusted capital
  - Both the stock and flows are at risk
- **A thought experiment:**
  - Country A has 1 million ha of pristine forest and your job is to record this in the NCA
  - But you know there's a 50% chance it burns or is logged in the next 30 years
  - How should we adjust the valuation formula?

# A thought experiment

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- Ecosystem of size K, yields a flow of P dollars per unit of forest, discounted at r > 0
- **If the ecosystem remains intact, the flow of benefits is PK and its value is PK/r**
- Imagine the ecosystem is being degraded and we expect collapse T years from now
  - Uniform distribution of the risk: at t = 0, there is a constant probability of rate 1/T that the ecosystem is destroyed in the interval [0,T]
  - Conditional on surviving until t, the probability of destruction at any date [t, T] = 1/(T-t)
  - At t = 0, probability of surviving until t = (T-t)/T
  - **Hazard Rate = 1/(T-t)** which goes to infinity as t goes to T

*Acknowledgement: Thanks to Prof. Sir Partha Dasgupta*

# Risk-adjusted natural capital

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As the probability that the forest will exist until t is (T-t)/T, the expected worth of the ecosystem to the firm is

$$PK\left(\int_0^T \frac{e^{-rt}(T-t)}{T}\,dt\right) = \left(\frac{PK}{r}\right)(1-e^{-rT}) - \left(\frac{PK}{T}\right)\left(\int_0^T (te^{-rt})dt\right)$$

Write the risk adjusted value of K as a function of T as F(T). Then integrating the final term on the right-hand side to equation (1) by parts yields:

$$F(T) = \left(\frac{\boldsymbol{PK}}{\boldsymbol{r}}\right)\left(\mathbf{1} - \frac{(\mathbf{1}-\boldsymbol{e}^{-\boldsymbol{rT}})}{\boldsymbol{rT}}\right)$$

The risk adjustment term is thus R:

$$\boldsymbol{R} = \left(\mathbf{1} - \frac{(\mathbf{1}-\boldsymbol{e}^{-\boldsymbol{rT}})}{\boldsymbol{rT}}\right)$$

# Features of R

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$$R = \left(1 - \frac{(1 - e^{-rT})}{rT}\right)$$

- dF(T)/dT > 0. Thus, F(T) is a monotone increasing function of T in the interval [0, ∞).
- F(T) → 0 as T → 0 and F(T) → PK/r as T → ∞. Both limits are intuitive.
- The risk-adjustment factor, R, lies between 0 and 1, exactly as one would expect

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# 2. How does natural capital loss affect inequality: some evidence

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# NatCap loss exacerbates inequality

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- Greater exposure to physical risks among low-income households
  - Less likely to hold disaster insurance
  - Livelihoods more dependent on natural capital, outdoor work, or local natural capital for food
  - Erosion of natural capital may represent a greater proportion of total wealth

- Greater exposure to negative trade-offs associated with NatCap policy (Peñasco et al, 2021)
  - Skills are less transferable in the transition
  - Whilst they may gain from environmental improvement, some green policies have regressive consequences

- Transition to decarbonised energy system by 2050 would save $12 trillion globally compared to BAU fossil fuel use (Way et al 2022)
  - But how these savings are distributed matters

- Most research on distributional impacts of environmental policy focus on **income**
  - But need to consider impacts on the assets people can draw upon to support welfare (health, skills, etc)

# NatCap loss exacerbates inequality …both within and… between countries

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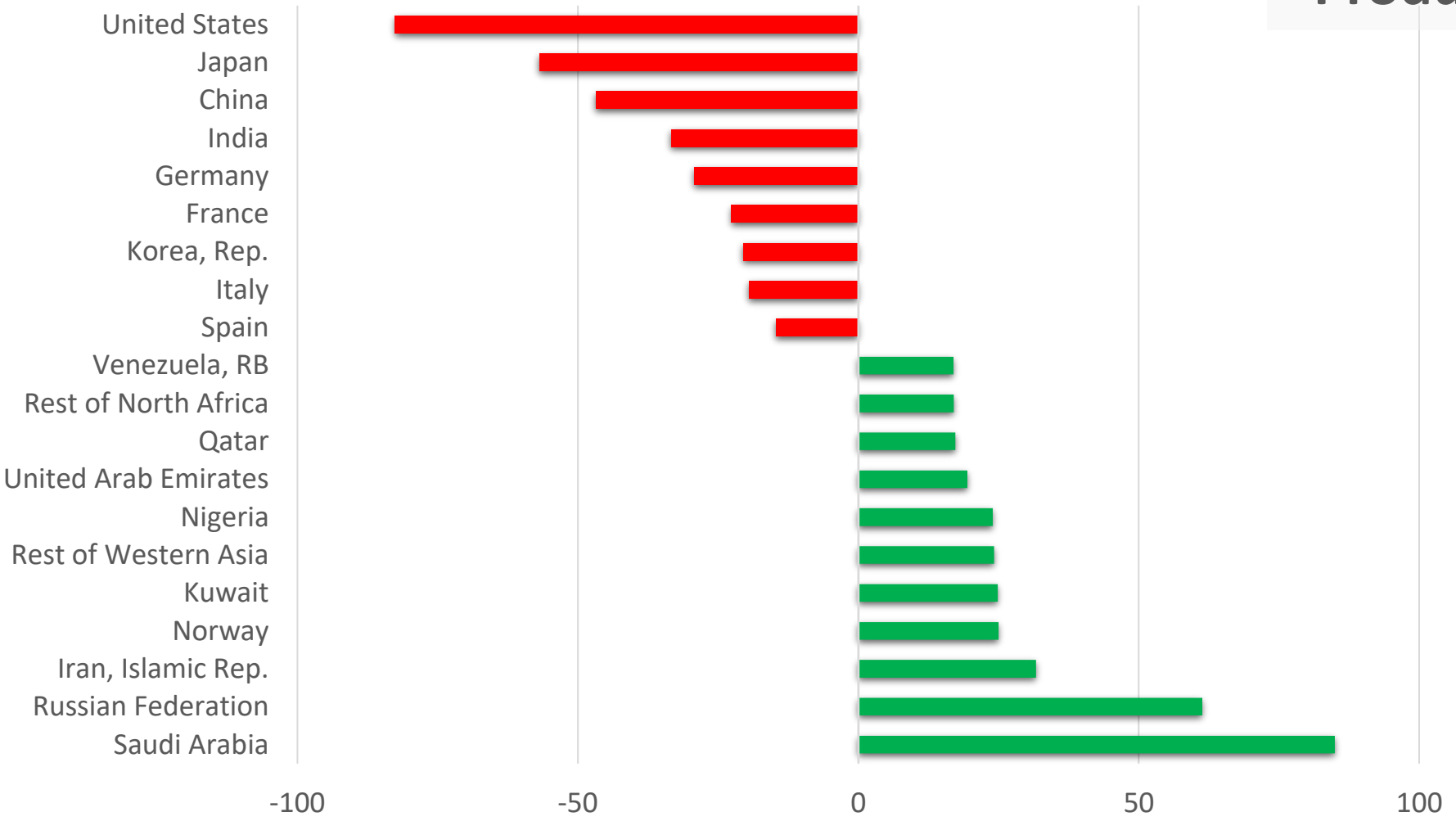
- Wealth accounting generally use territorial accounts to describe natural capital stocks within a country's borders
- Trade enters through the effect of net exports on national savings. Yet, international trade is a large part of the global economy – and increased 260-fold since 1950-
- Need to re-examine if territorial natural capital accounts are fit for purpose when measuring national and global sustainability.
- Atkinson et al (2012) & Agarwala (2020) propose complementary natural capital accounts: production & consumption and extend the debate to natural capital assets beyond carbon (Davis et al. 2011; Steininger et al. 2016; Afionis et al. 2017) with the objective of examining damage accounts (Arrow 2012, Dasgupta, 2021)
- If natural resources are exchanged on international markets at prices that deviate from their optimum shadow price, then international trade entails transfers of 'virtual sustainability' between exporters and importers.

# What new thing do we learn if we use prod vs cons accounts for Nat cap?

**Resource Depletions:**
**Production - Consumption**




Production minus consumption based resource depletions, billions of 2011 USD.

**Expanding beyond GHGs**:
- Coal, oil, gas, minerals
- Fisheries, timber
- GHGs not included here

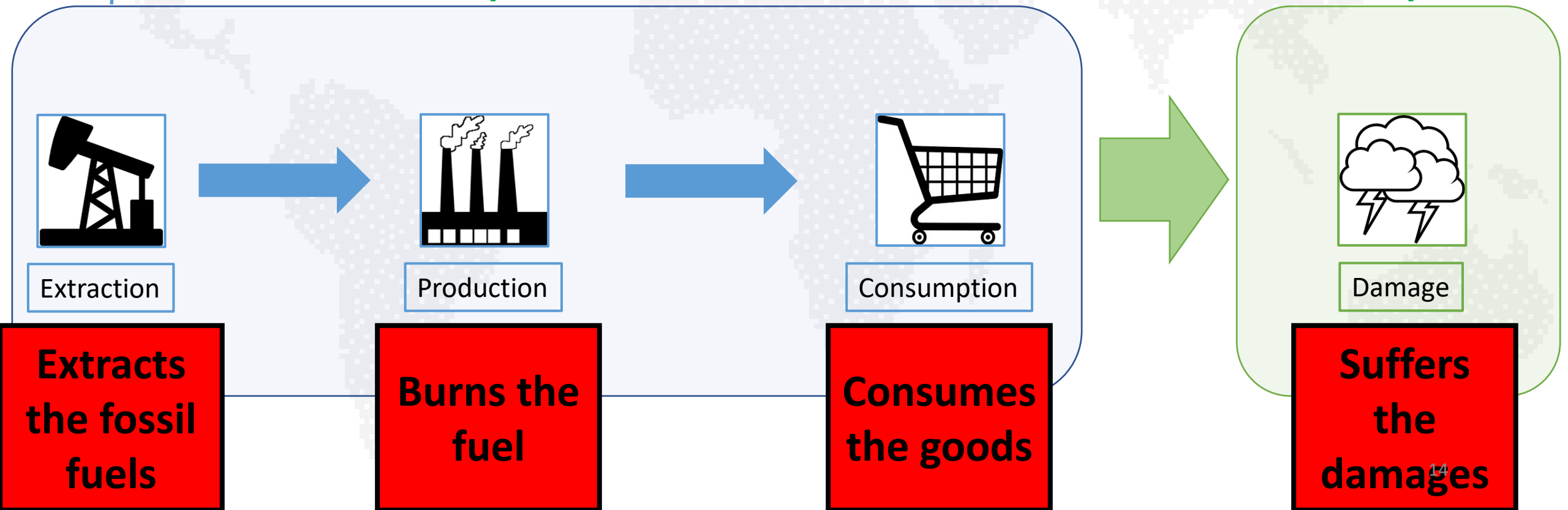
**Data**
- GTAP_v9 MRIO
- 140 regions, 57 sectors

**Source**
- Atkinson et al (2012)
- Agarwala (2020)

# From carbon to wealth accounting across borders.

**Carbon Accounting:**
Attribution based on location of *emissions.*
Informs carbon policy based on national borders & international law.

**Wealth Accounting:**
Attribution based on location of *damages.*
Informs sustainability policy based on economic theory & climate science.



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# 3.Environmentally-adjusted productivity measures

What can natural capital accounts tell us about the world that we didn't already know?

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# Disclaimer

- All views are our own
- This research does not reflect the views of:
  - The Productivity Institute
  - UK Office for National Statistics
  - Bank of England or any of its committees
  - ESCoE

Work in progress – results subject to change.

Thanks to Cain Baybutt (ONS).

# Productivity is simple

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$$\text{Productivity} = \frac{Output}{Input(s)}$$

$$\frac{Gross\ Value\ Added\ (GVA)}{Hours\ worked}$$

Unprecedented sectoral detail (42 sectors)

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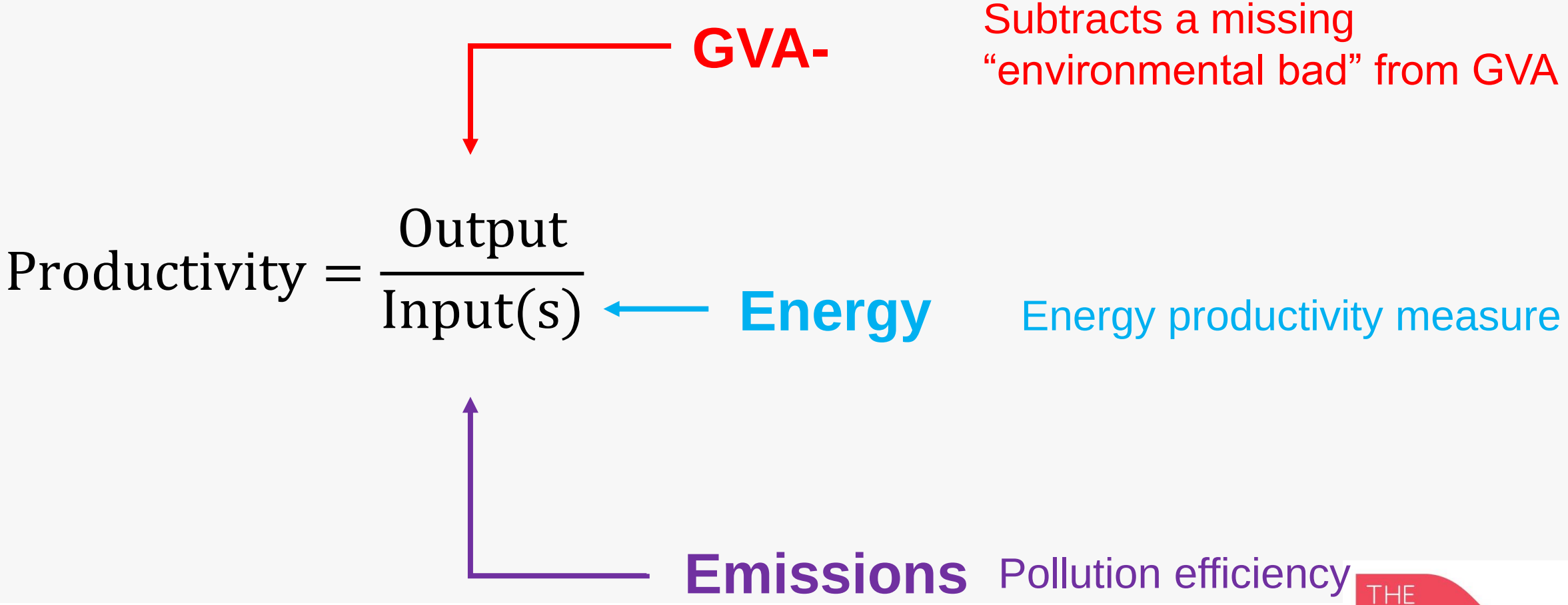
# Variations on a theme



# Productivity growth has been slow, but is that because of increasing work to reduce environmental damage?

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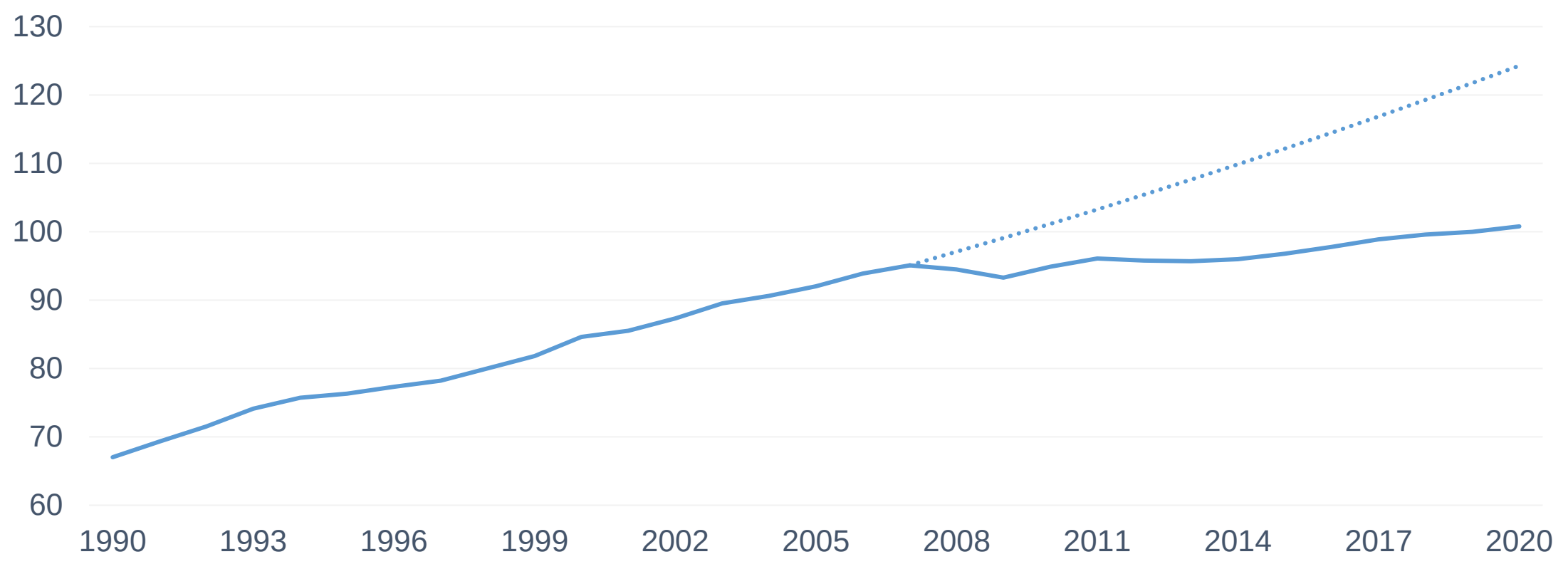
Output per hour worked (£), outturn and trend, UK, 1990 to 2020




Source: ONS – Labour productivity

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# GDP has risen while energy use and emissions have fallen

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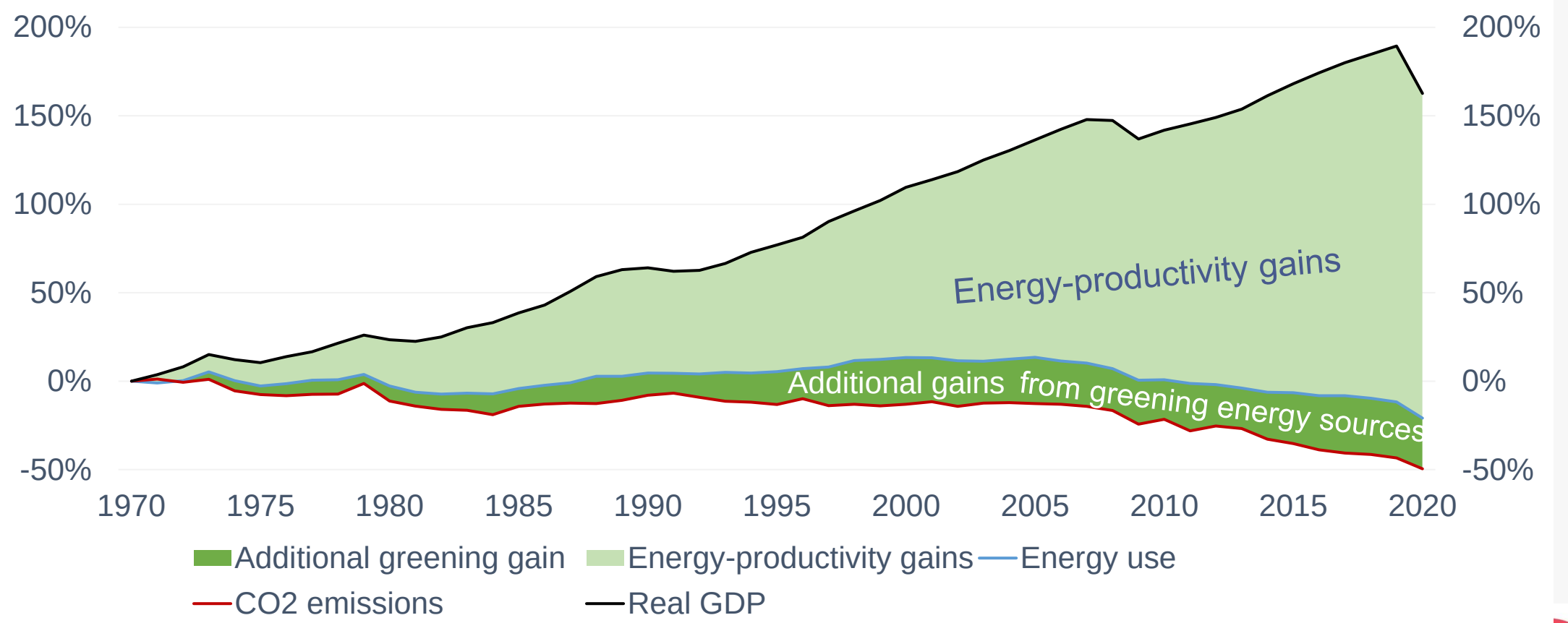
Real GDP, volume of energy used and volume of CO2 emissions, UK, 1970 to 2020, changes relative to 1970




Sources: ONS – GDP CVM; BEIS – Energy use (DUKES); Our World in Data – CO2 emissions (production based); authors' calculations

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# Whole economy productivity growth would be faster if adjusting for emissions and pollutants; but "puzzle" remains

$$\frac{GVA\ minus}{Hours\ worked}$$

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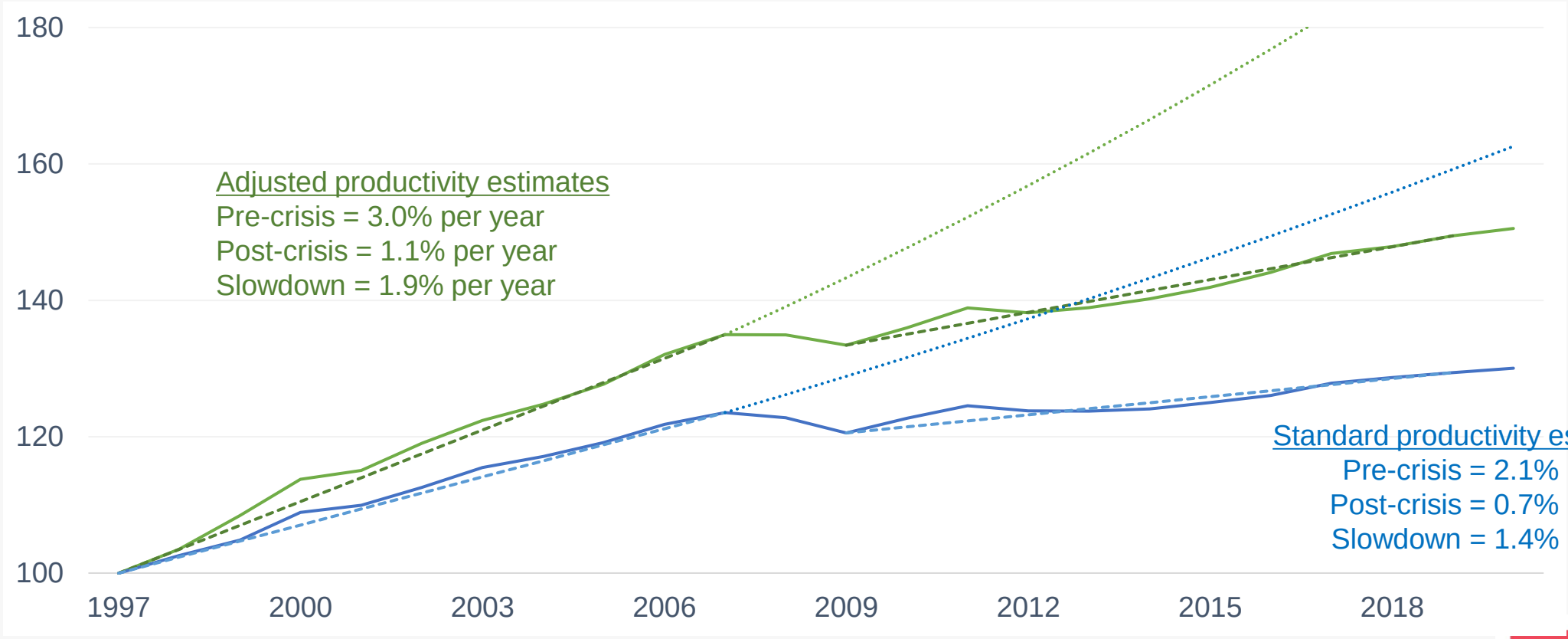
## Output per hour worked, with and without an emissions adjustment, UK, 1997 to 2020, index 1997 = 100




Sources: ONS – GDP excluding imputed rental, Labour productivity hours worked, atmospheric emissions; BEIS and Defra – carbon and other prices; authors' calculations

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# Final thoughts…

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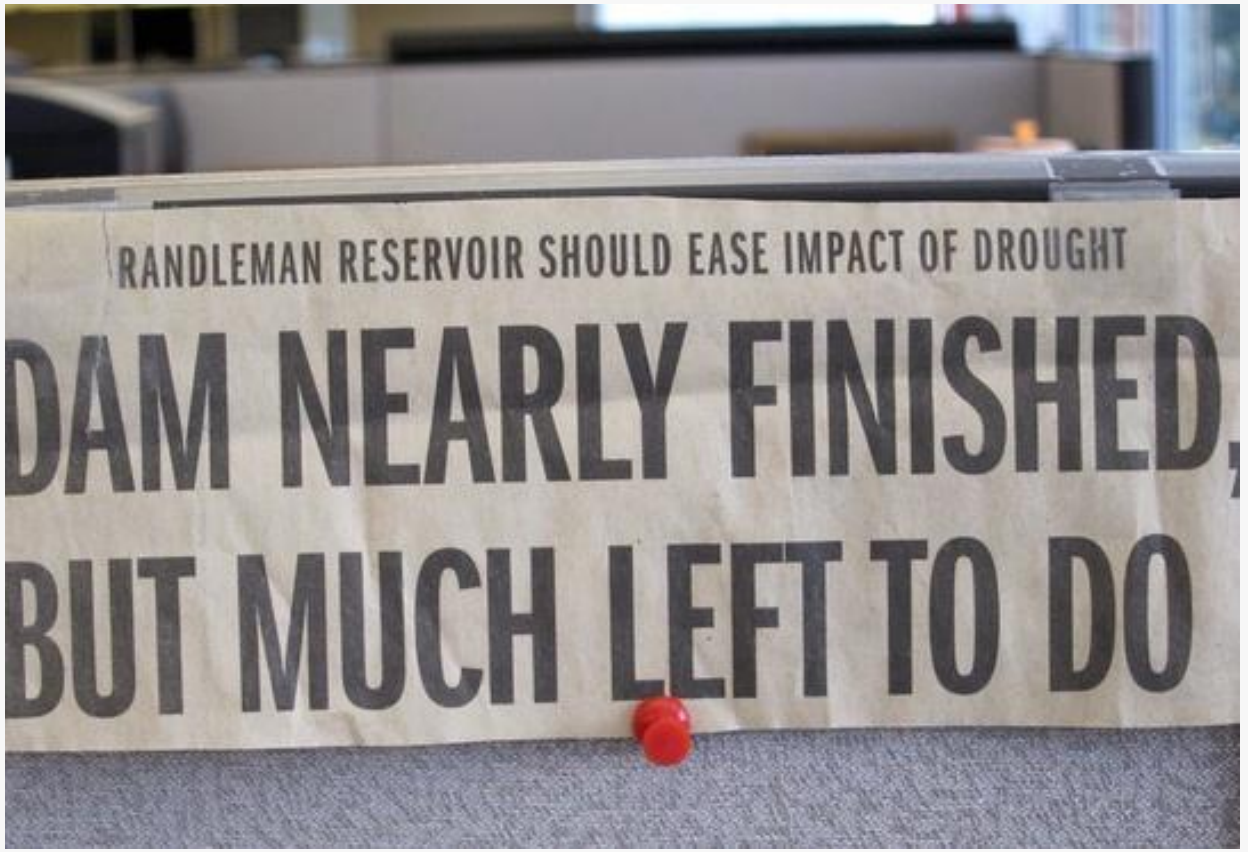
- Accounts exist to provide a clear view of economic trends to make good choices
- The SNA supported this in the context of the challenges facing economies when developed
- Now we face different challenges
- We need different accounts to help us make good decisions
- We can begin to use them to understand risk, inequality, and productivity

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# Thanks so much – Questions?

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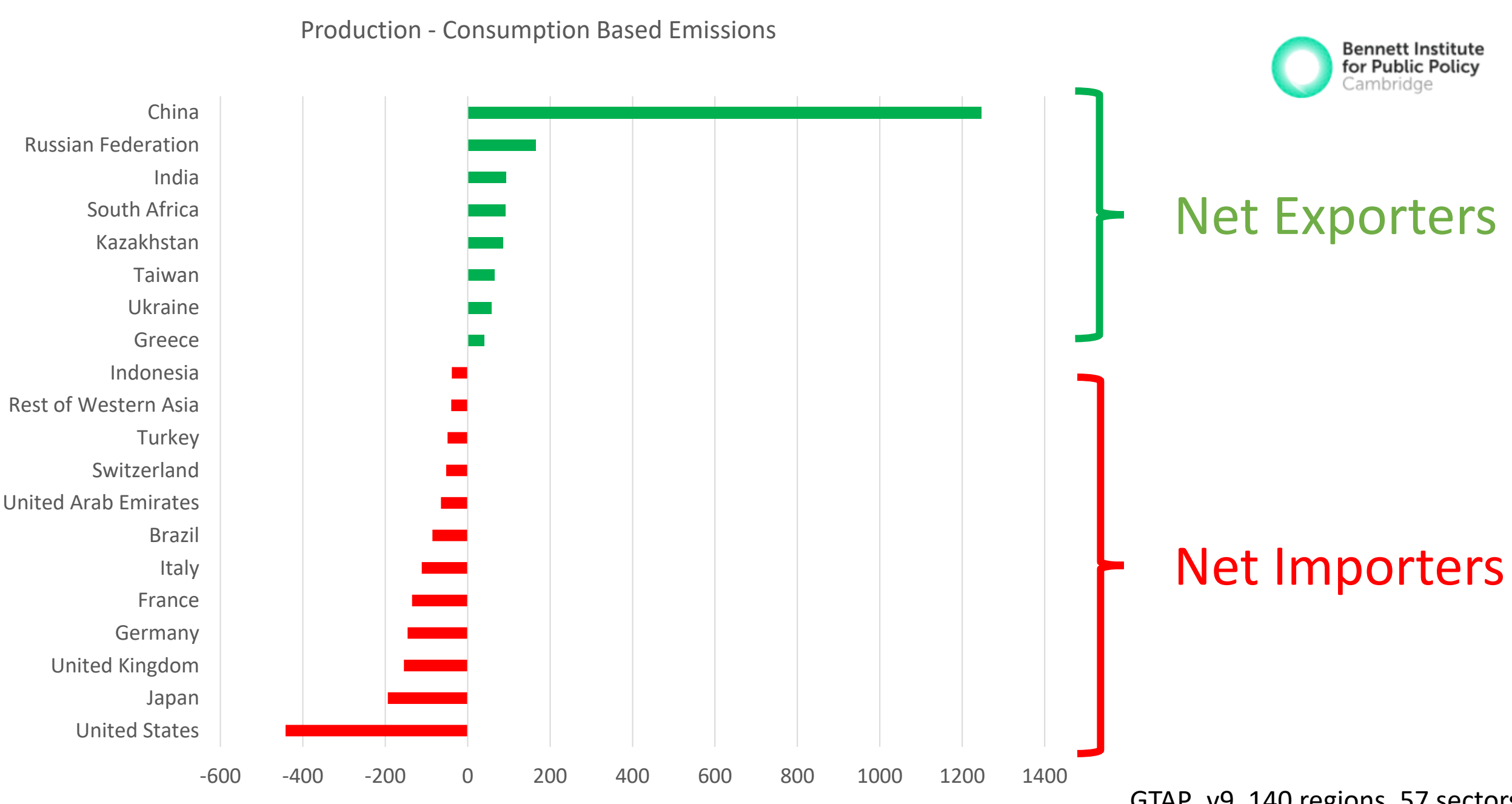


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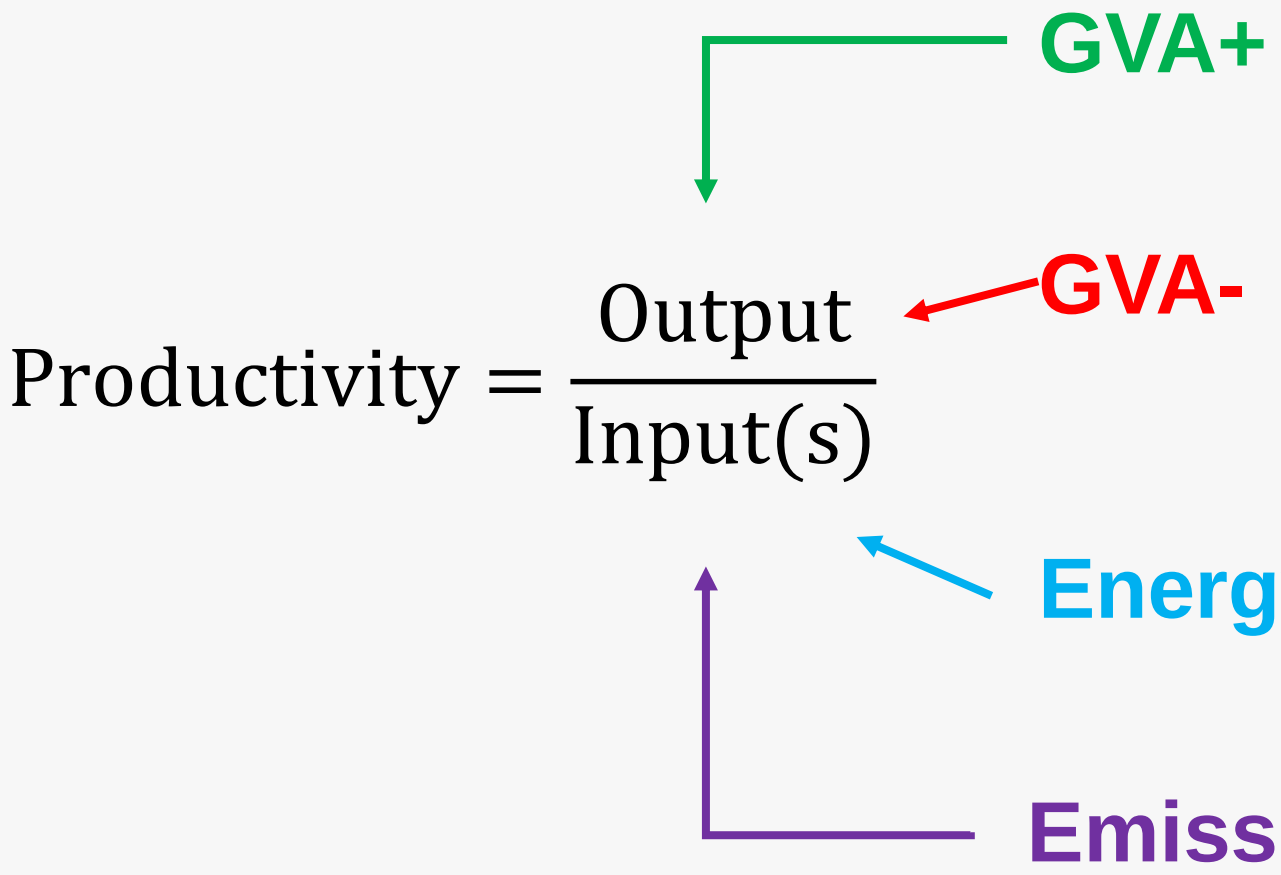
GTAP_v9. 140 regions, 57 sectors

Atkinson et al (2012), Agarwala (2020)

# Variations on a theme




Adds a missing "environmental protection" output to GVA

Subtracts a missing "environmental bad" from GVA

Energy productivity measure

Pollution efficiency

# 21st Century Trilemma

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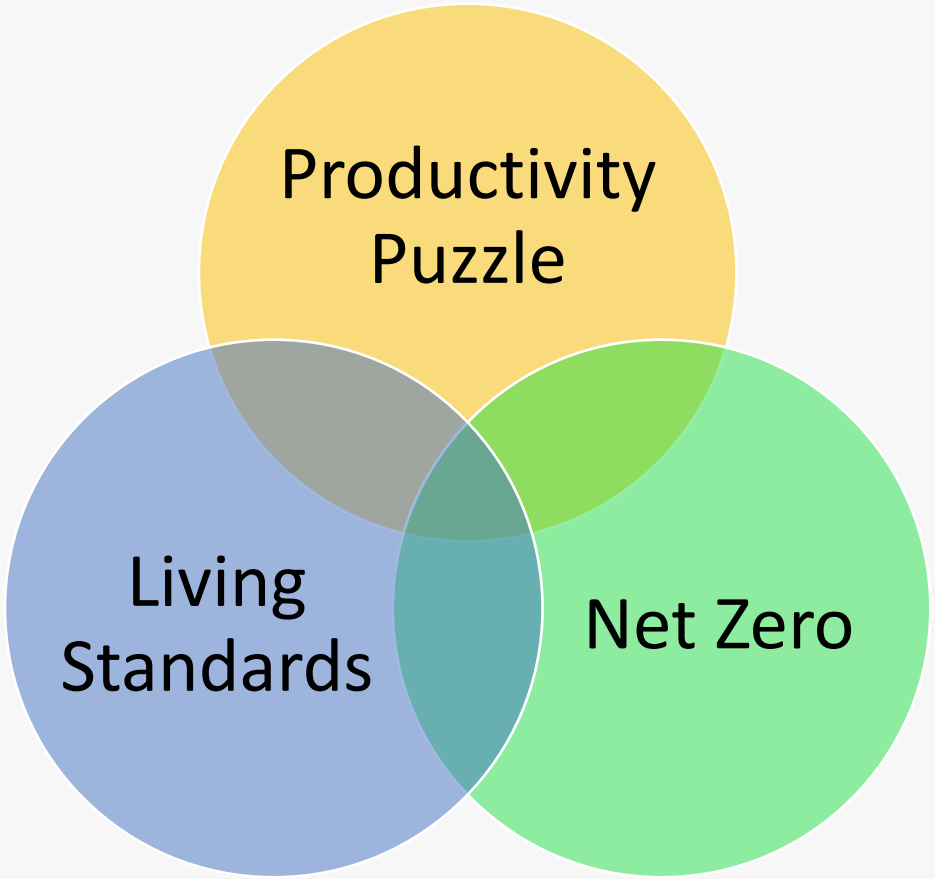


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# Energy productivity: how efficiently we turn energy into GDP

$\frac{GVA}{Energy}$

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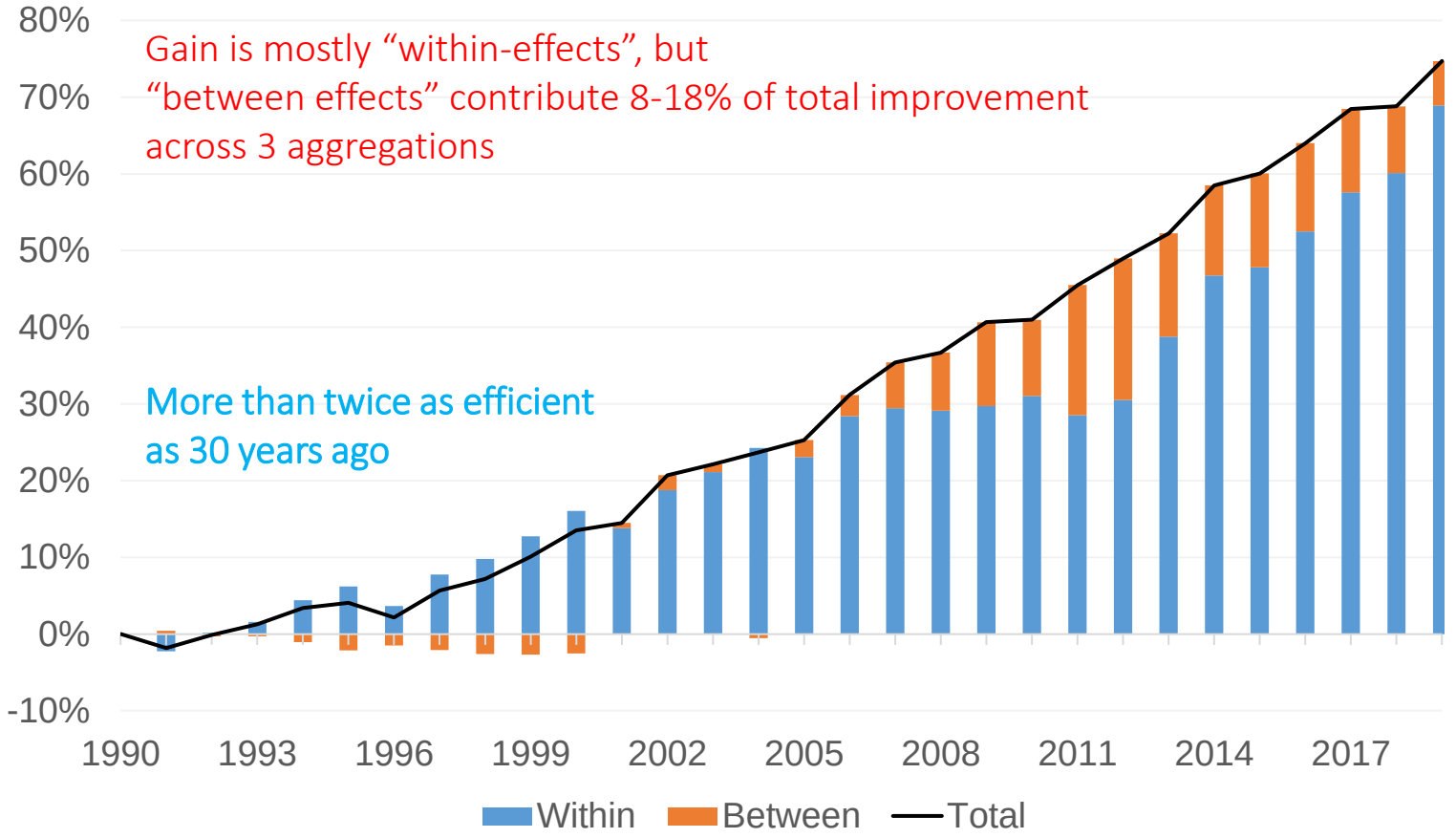


Notes: In log points rather than percentages, for additivity. The 75% increase in log points corresponds to a 111% increase between 1990 and 2019. Uses Aggregation 1 in Table 2 (Agarwala & Martin 2022) – that is, 42 sectors.

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# Contributions to adjusted-GDP by emissions and pollutant type, 1990 to 2020

$$\frac{GVA}{Emissions}$$

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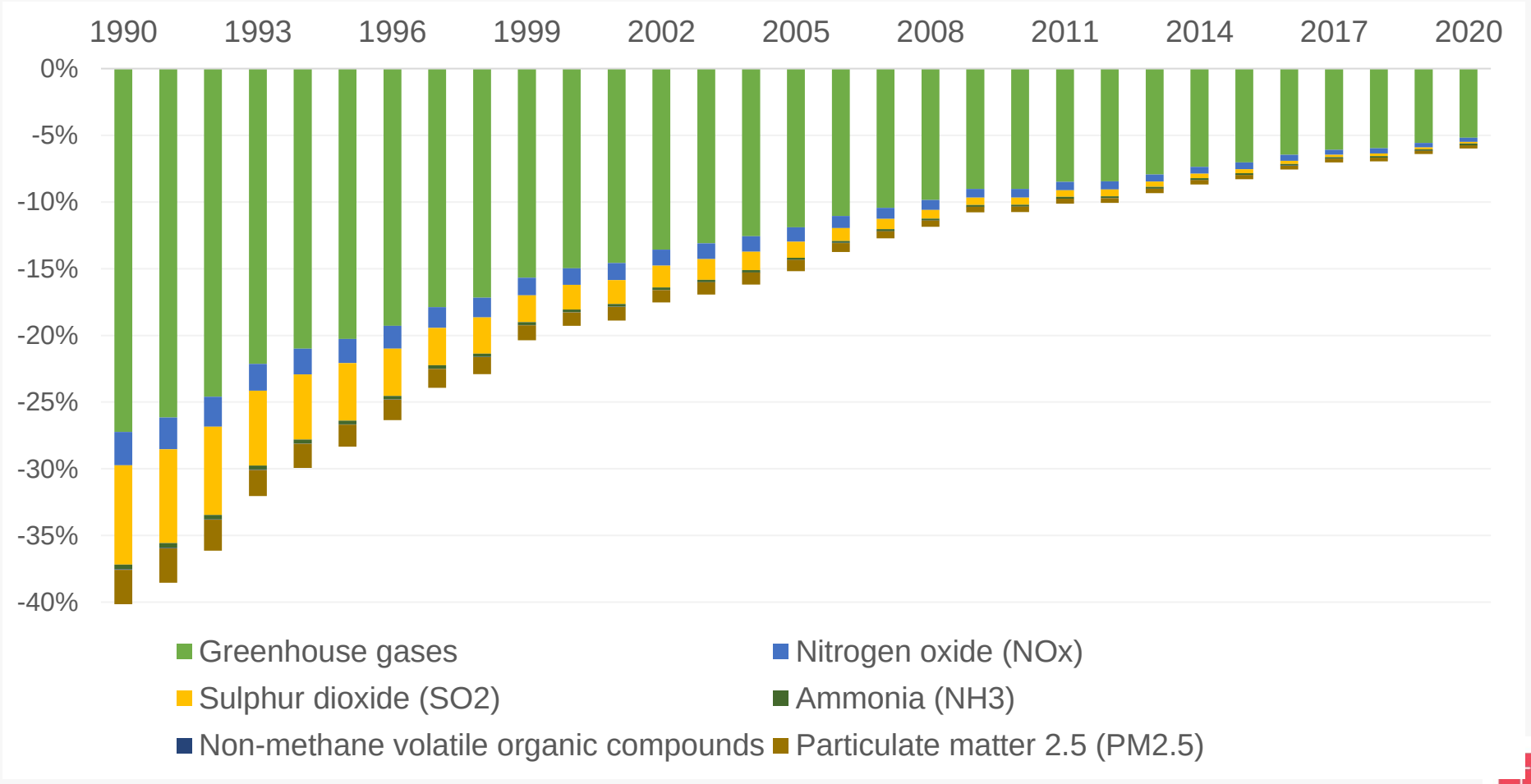


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# Adjusting for emissions would cause productivity to fall slightly faster in mining, but rise much faster in manufacturing

$$\frac{GVA\ minus}{Hours\ worked}$$

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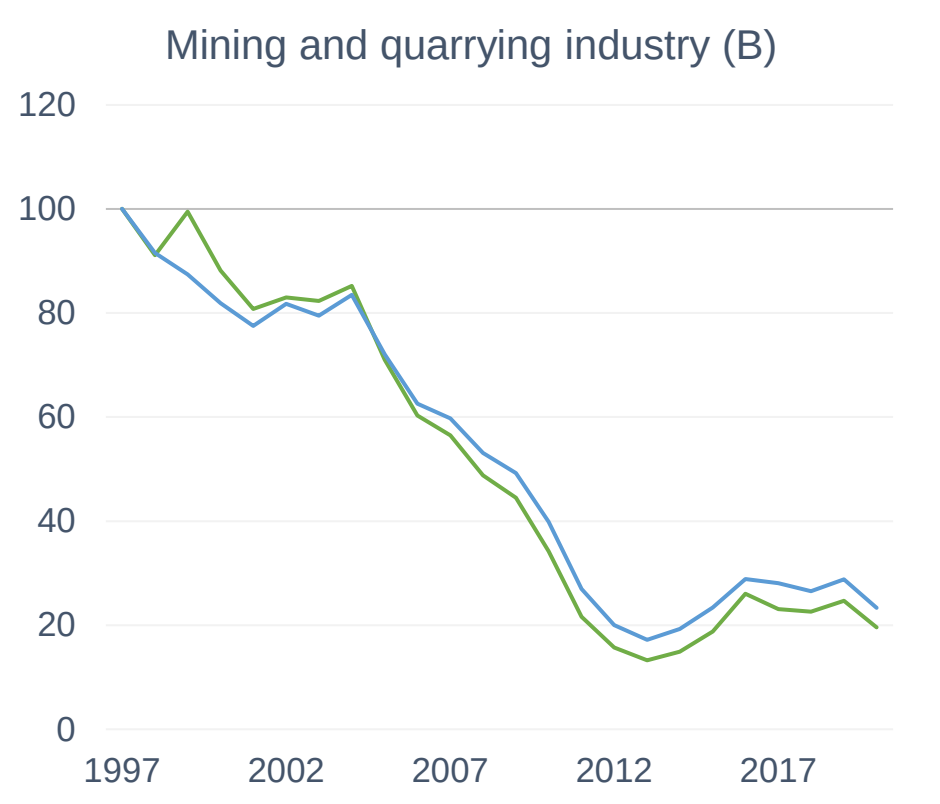
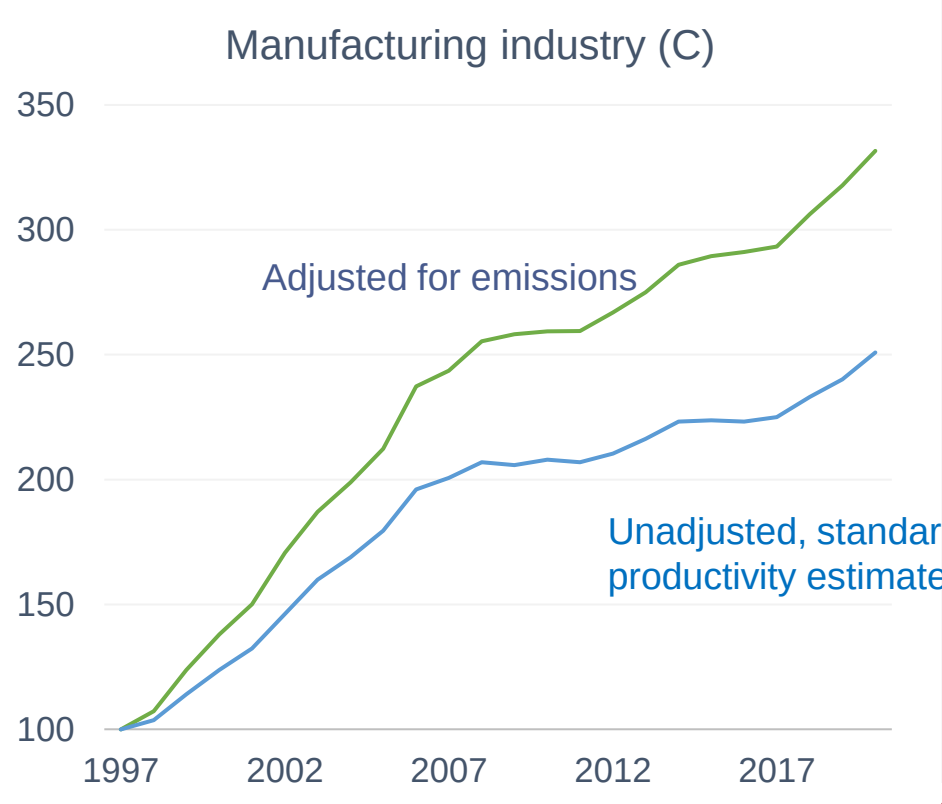
Output per hour worked, with and without an 'bad output' adjustment, UK, 1997 to 2020, index 1997 = 100




Sources: ONS – GDP excluding imputed rental, Labour productivity hours worked, atmospheric emissions; BEIS and Defra – carbon and other prices; authors' calculations

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