

May 26th, 2023

AIECE Spring Meeting, *Ljubljana*

GDP, Energy and CO₂

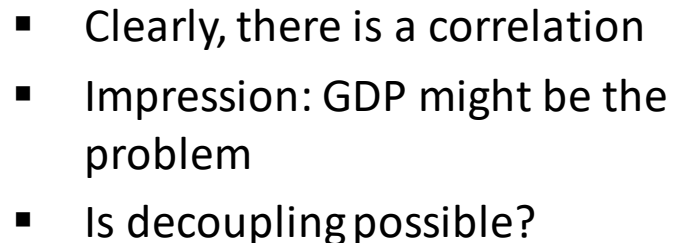
In the World economy, in Europe and in different sectors

Ulrich Stolzenburg

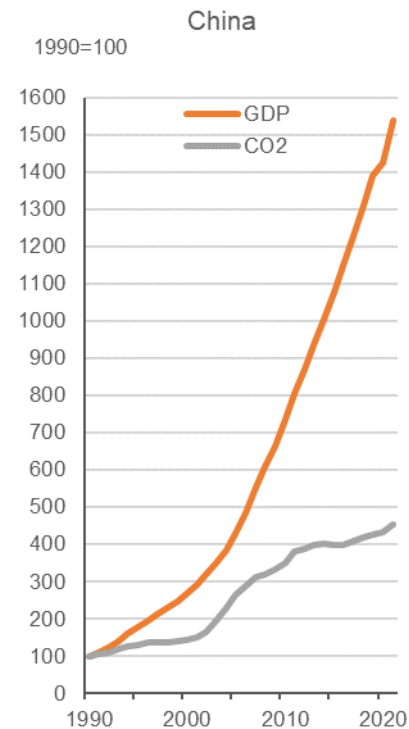
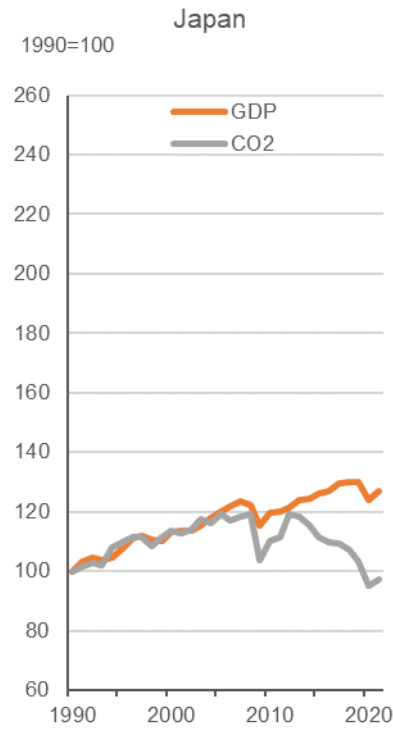
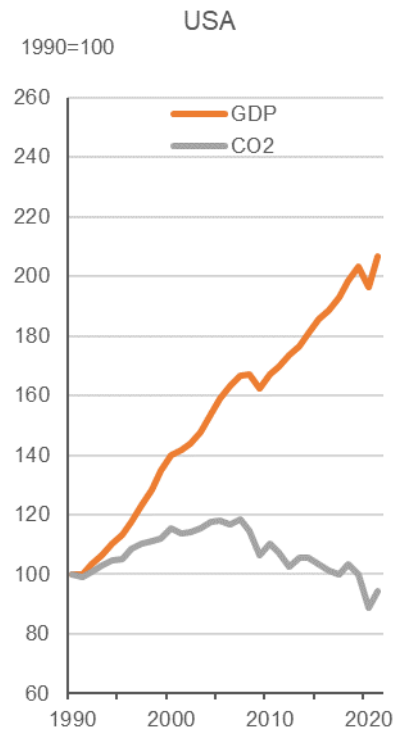
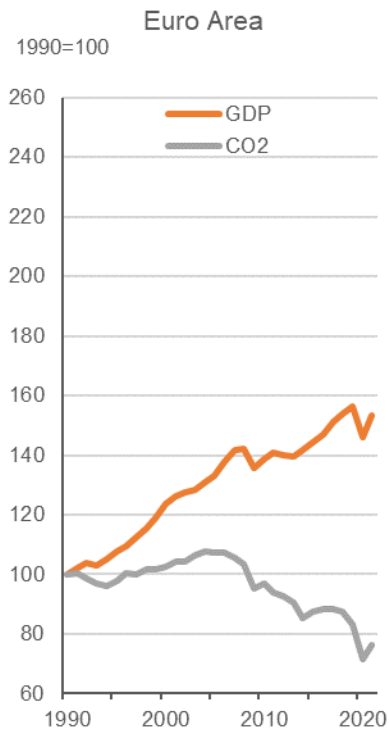
Research Center Business Cycles and Growth

Kiel Institute for the World Economy





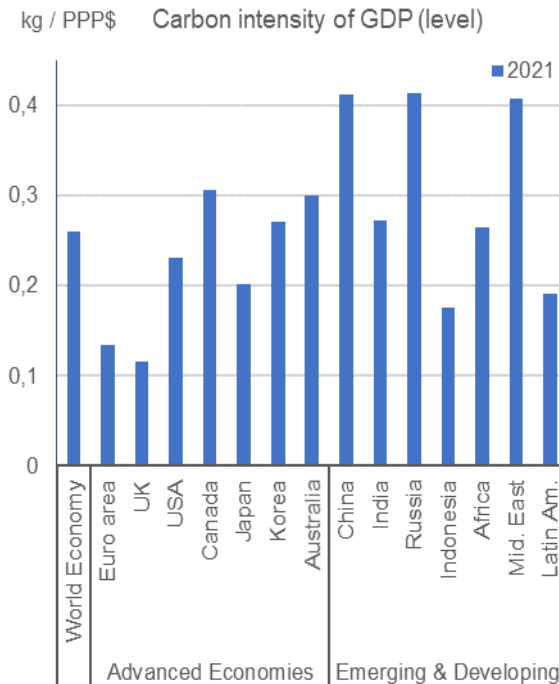
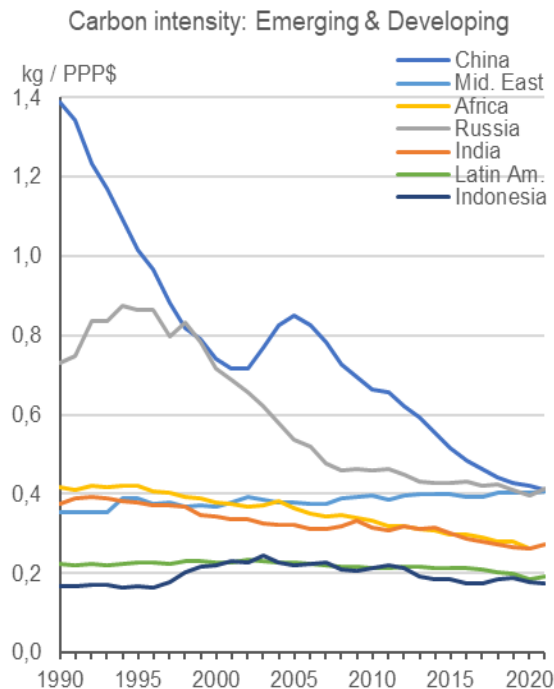
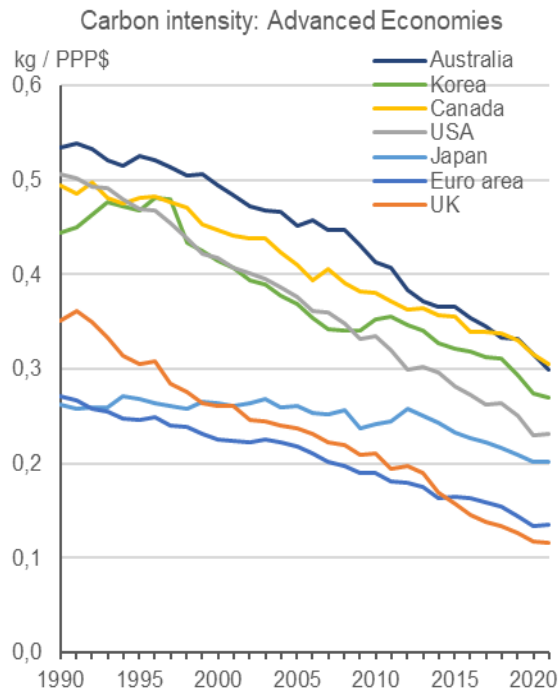
GDP growth vs. growth of CO2 emissions



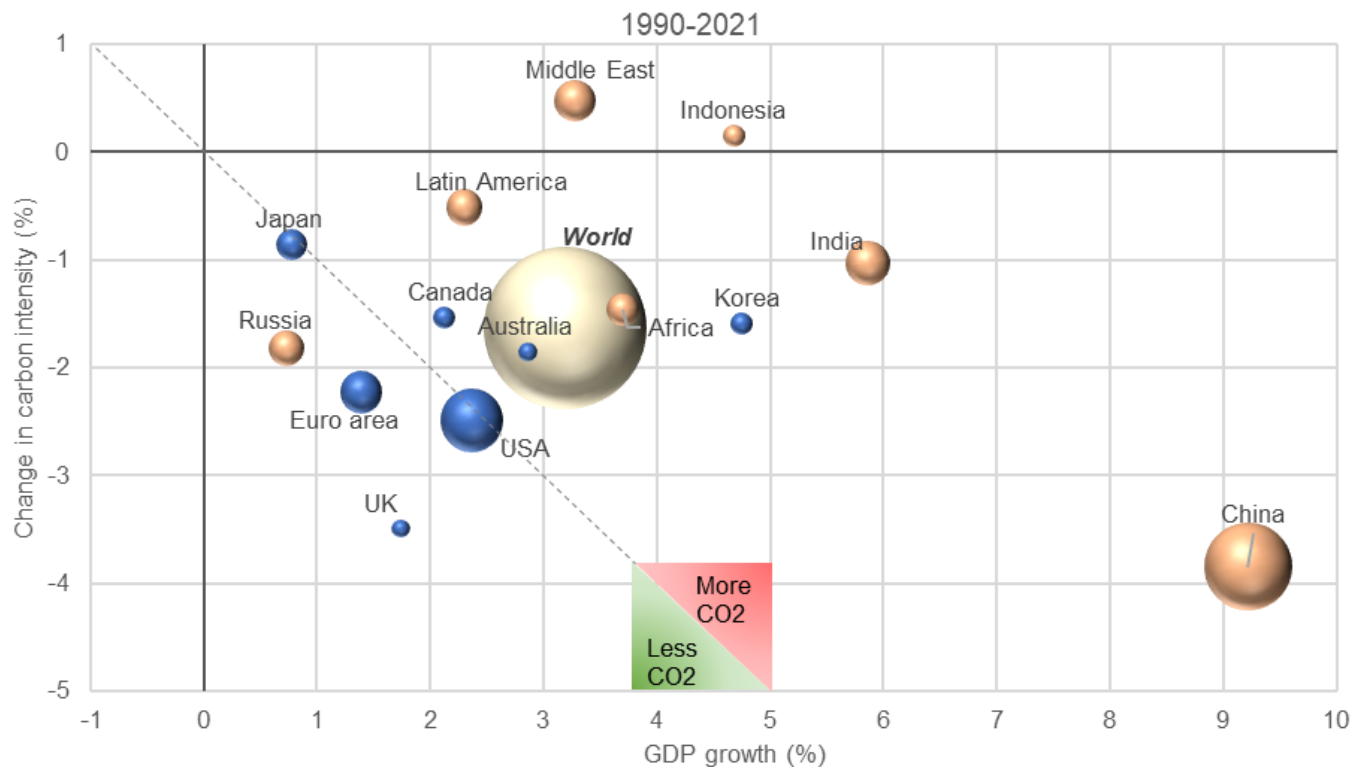
GDP vs. CO2 Emissions

- Economic development/activity desirable for most countries
- But we need less CO2 emissions
- Wanted: As much economic output per unit of emissions as possible
- A variable to look at is **Carbon intensity**: Emissions per unit of GDP, $\left[\frac{\text{kg CO}_2}{\text{const. PPP \$}} \right]$
- **Decarbonization rate**: the rate by which carbon intensity is falling

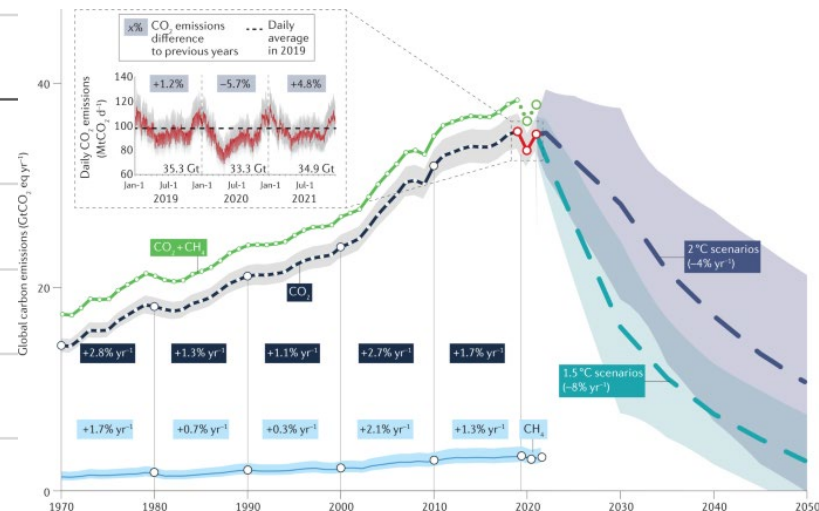
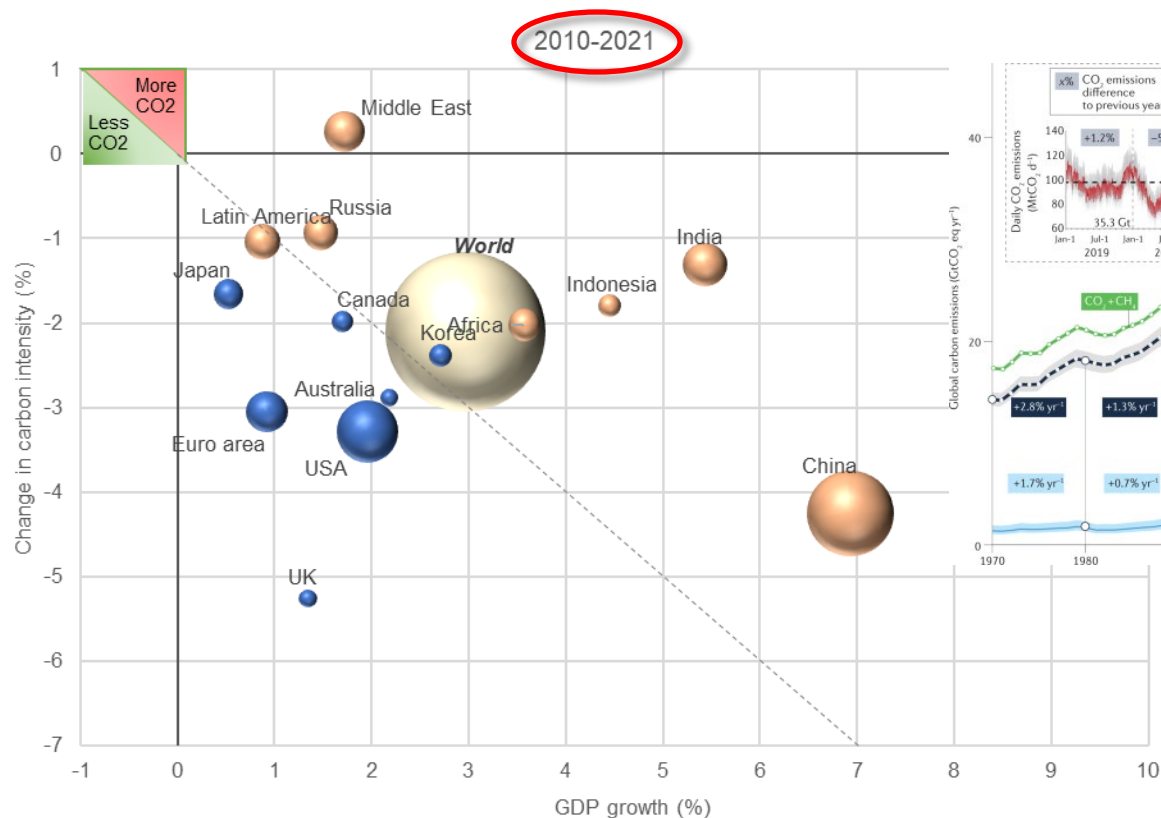
GDP vs. CO2 Emissions



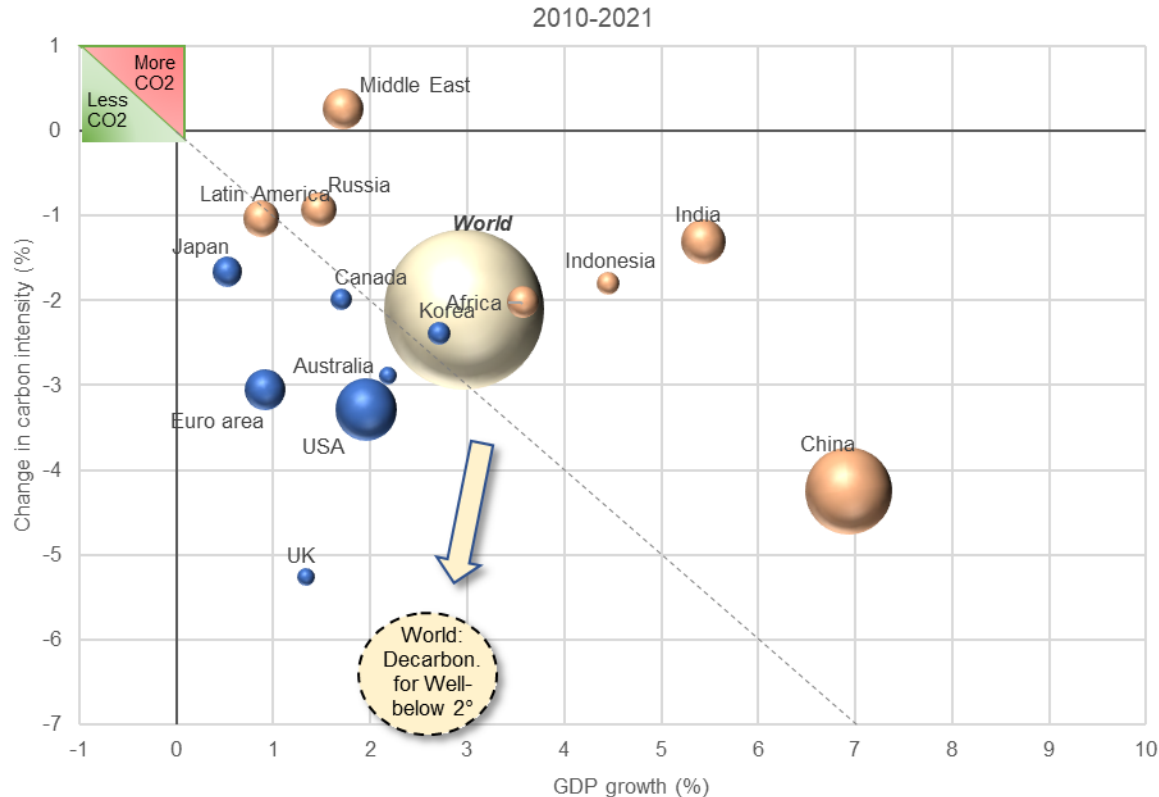
GDP growth vs. Decarbonization rate



GDP growth vs. Decarbonization rate



GDP growth vs. Decarbonization rate

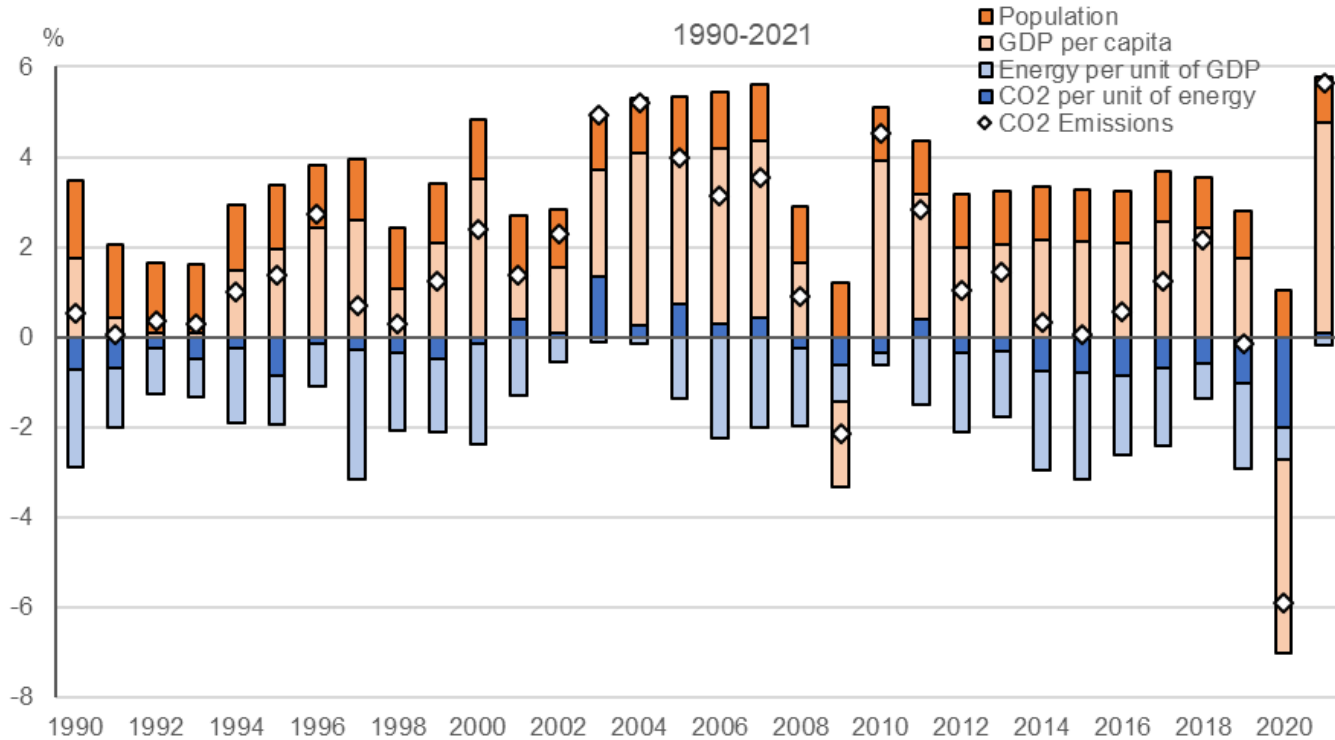


Kaya Identity

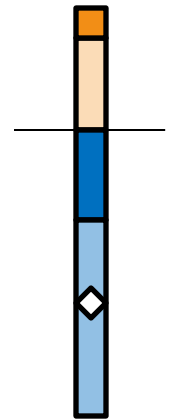
$$\begin{aligned}
 \text{CO}_2 &= \frac{\text{CO}_2}{Y} \cdot Y \\
 &= \frac{\text{CO}_2}{\text{En}} \cdot \frac{\text{En}}{Y} \cdot Y \\
 &= \frac{\text{CO}_2}{\text{En}} \cdot \frac{\text{En}}{Y} \cdot \frac{Y}{\text{Pop}} \cdot \text{Pop}
 \end{aligned}$$

$$\begin{aligned}
 \text{Change in CO}_2: \widehat{\text{CO}_2} &= \underbrace{\left(\frac{\widehat{\text{CO}_2}}{Y} \right)}_{\text{Decarbonization (rate) of GDP}} + \underbrace{\hat{Y}}_{\text{GDP growth}} \\
 &= \underbrace{\left(\frac{\widehat{\text{CO}_2}}{\text{En}} \right)}_{\text{Decarbonization of the energy system}} + \underbrace{\left(\frac{\widehat{\text{En}}}{Y} \right)}_{\text{Energy efficiency}} + \hat{Y} \\
 &= \left(\frac{\widehat{\text{CO}_2}}{\text{En}} \right) + \left(\frac{\widehat{\text{En}}}{Y} \right) + \underbrace{\left(\frac{\widehat{Y}}{\text{Pop}} \right)}_{\text{GDP p.c. growth}} + \underbrace{\widehat{\text{Pop}}}_{\text{Population growth}}
 \end{aligned}$$

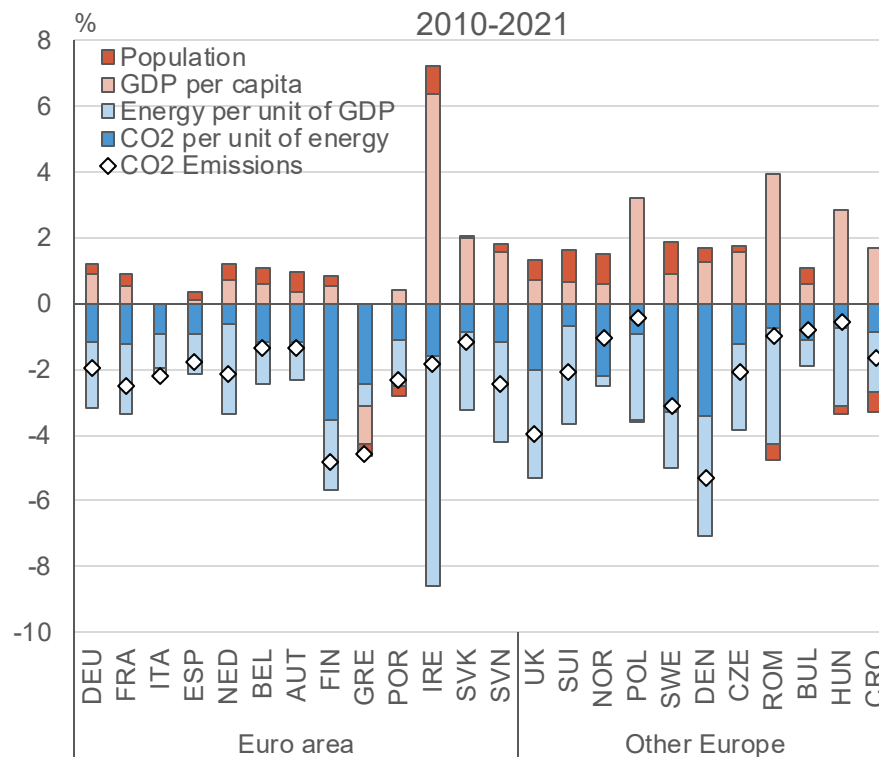
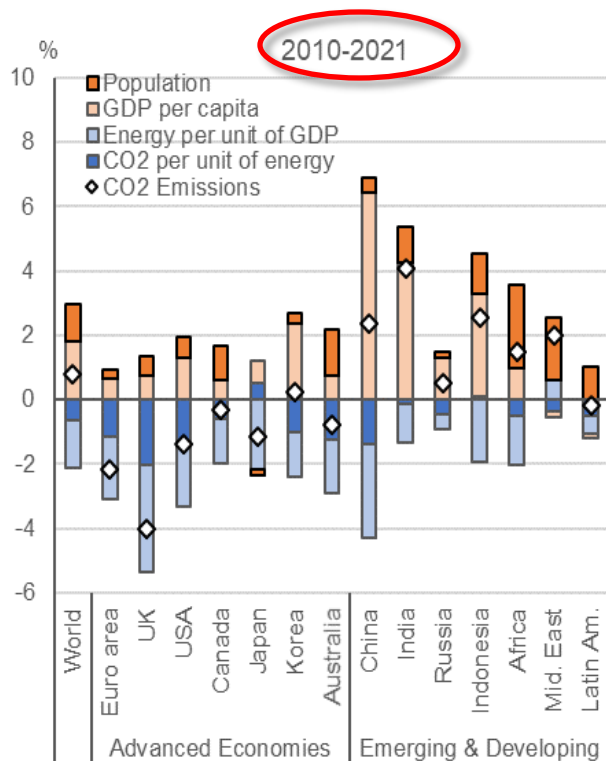
Kaya Identity: World economy



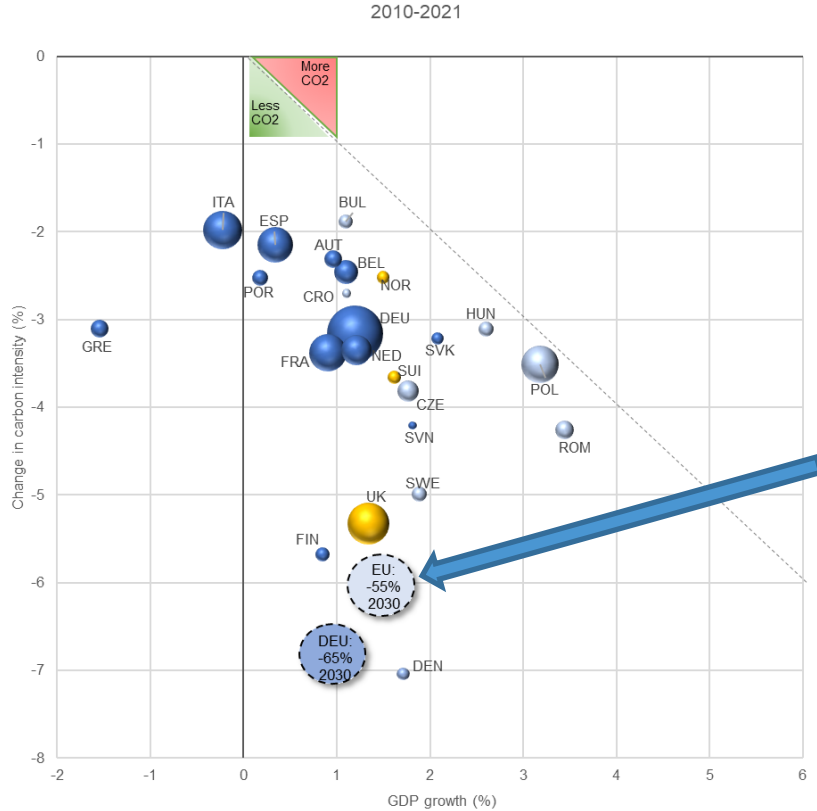
Next 30 years:
(on average)



Kaya Identity 2010-2021: World / Europe

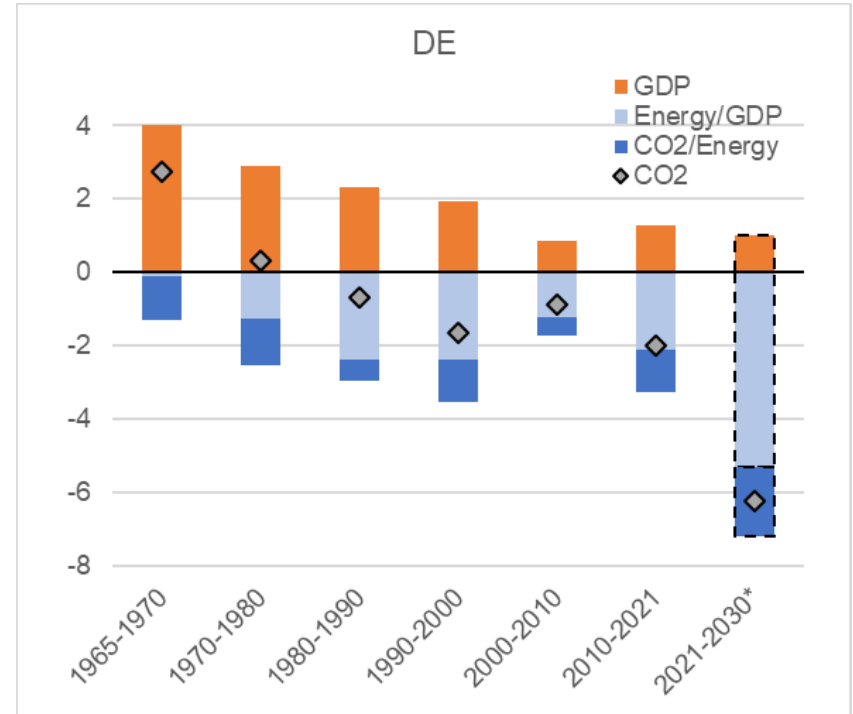
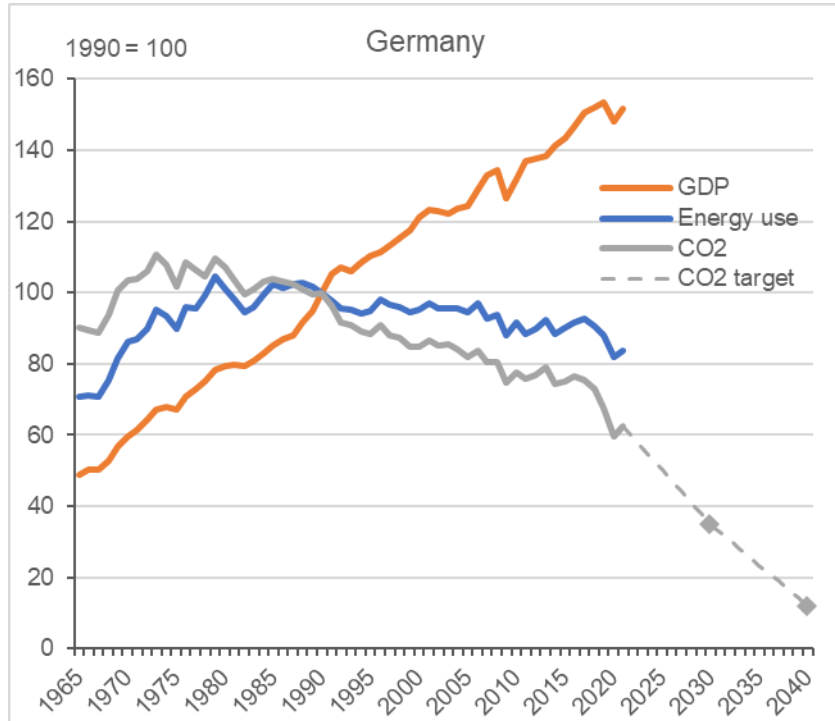


GDP growth vs. Decarbonization rate: Europe

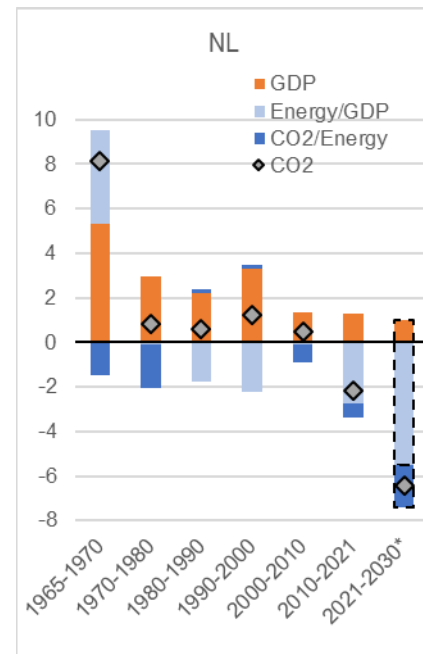
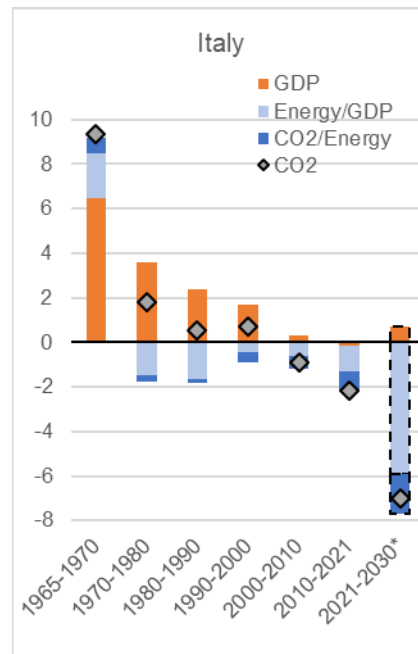
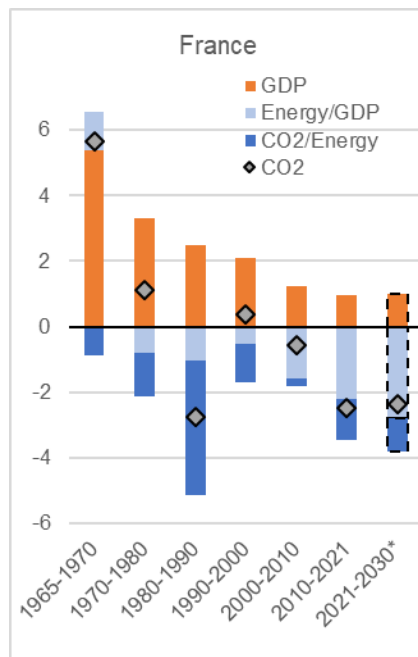
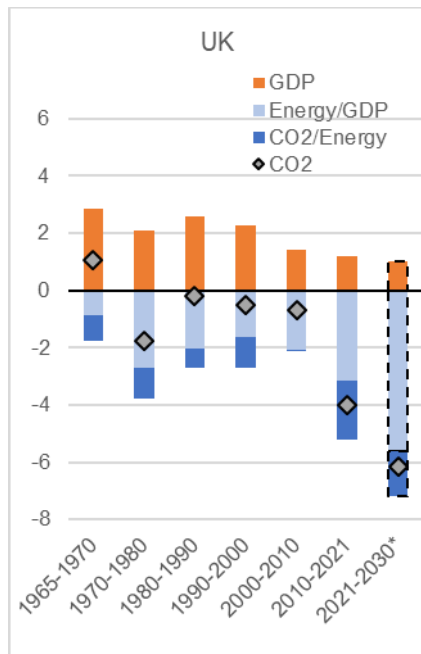


- Decarbonization rate over the past decade by far insufficient to reach 2030 targets

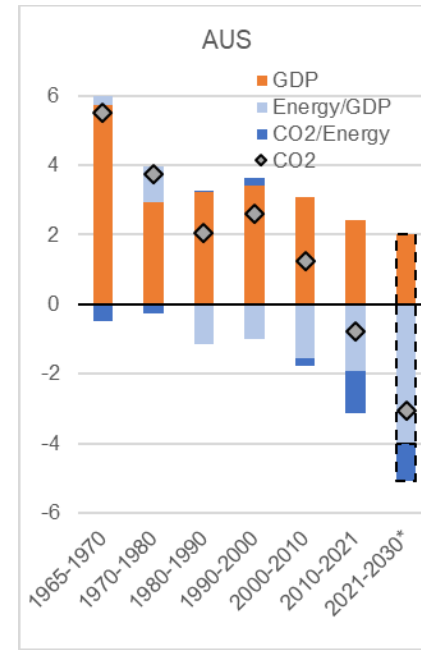
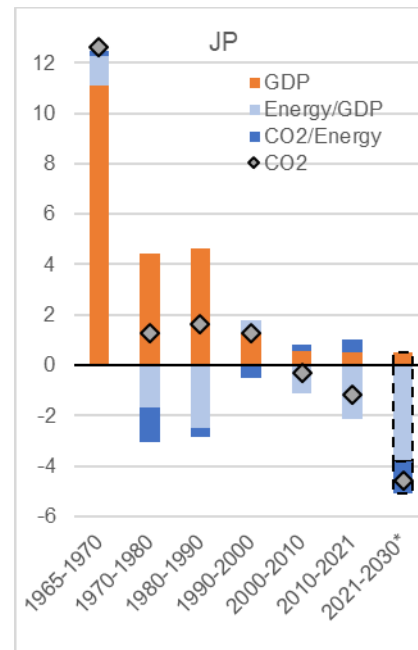
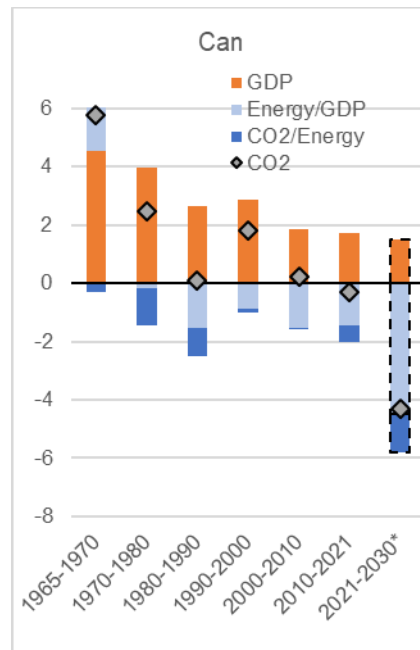
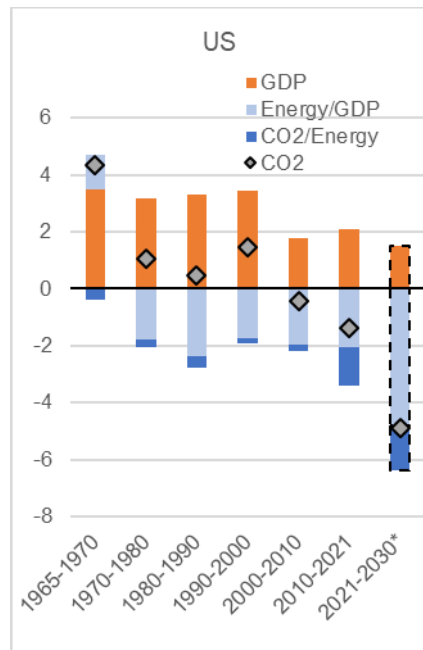
Kaya Identity over the decades: Germany



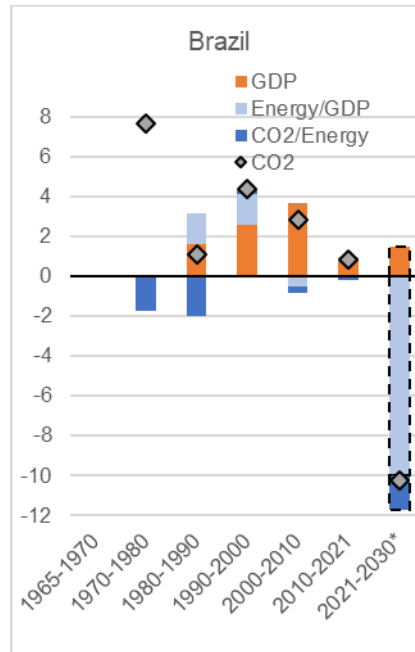
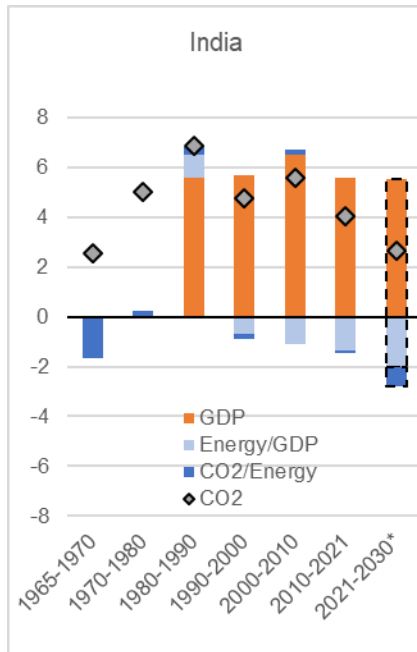
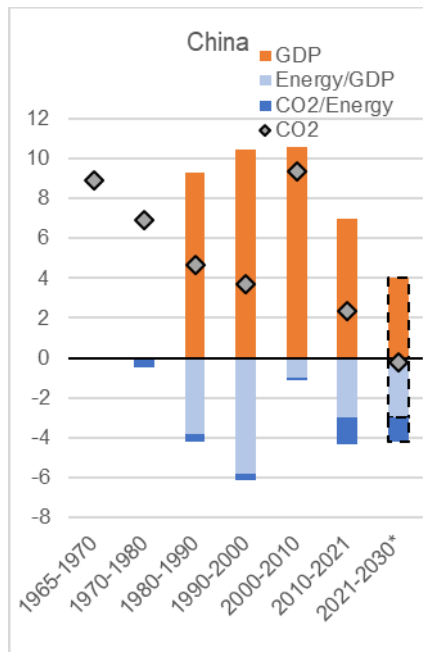
Kaya Identity: UK, France, Italy, Spain



Kaya Identity: US, Canada, Japan, Australia



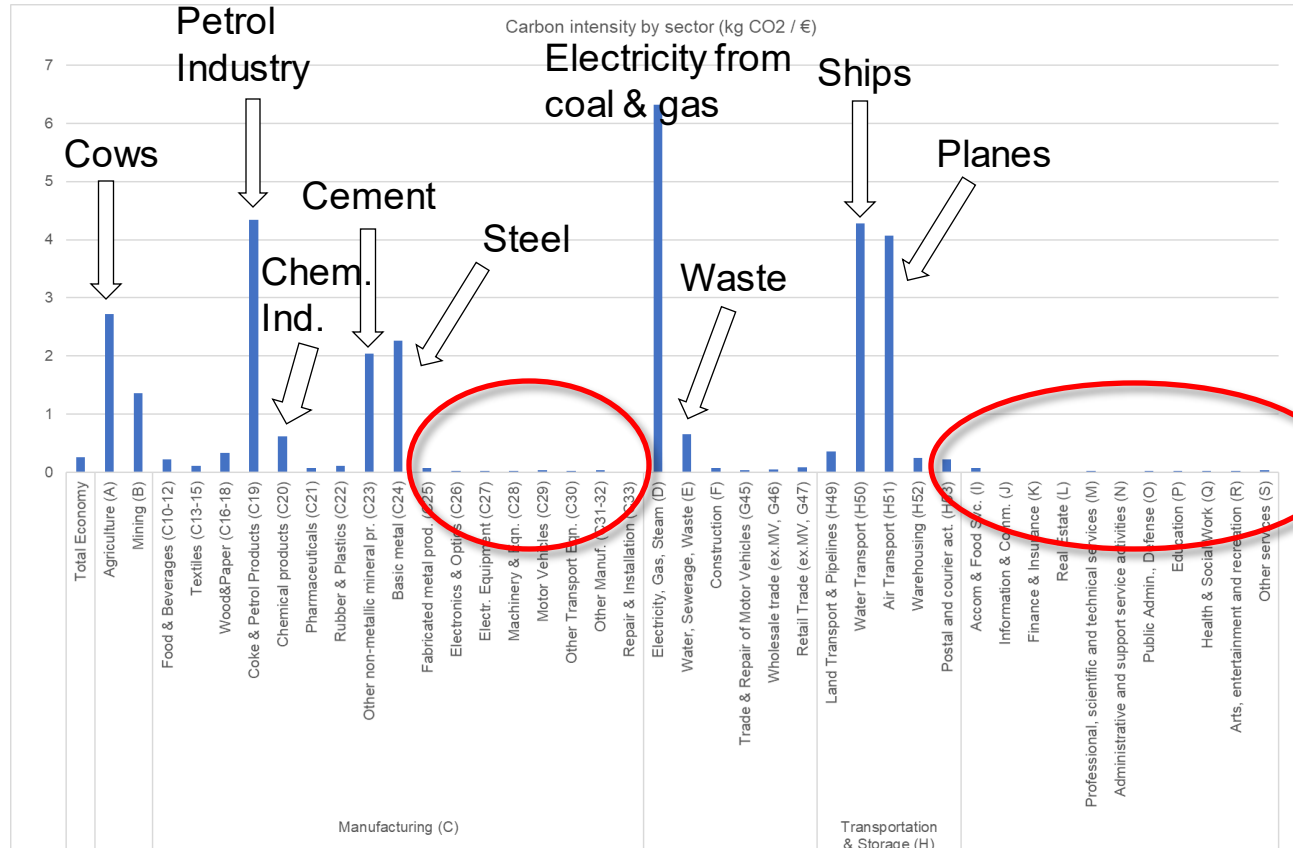
Kaya Identity: China, India, Brazil



CO₂ intensity by sector

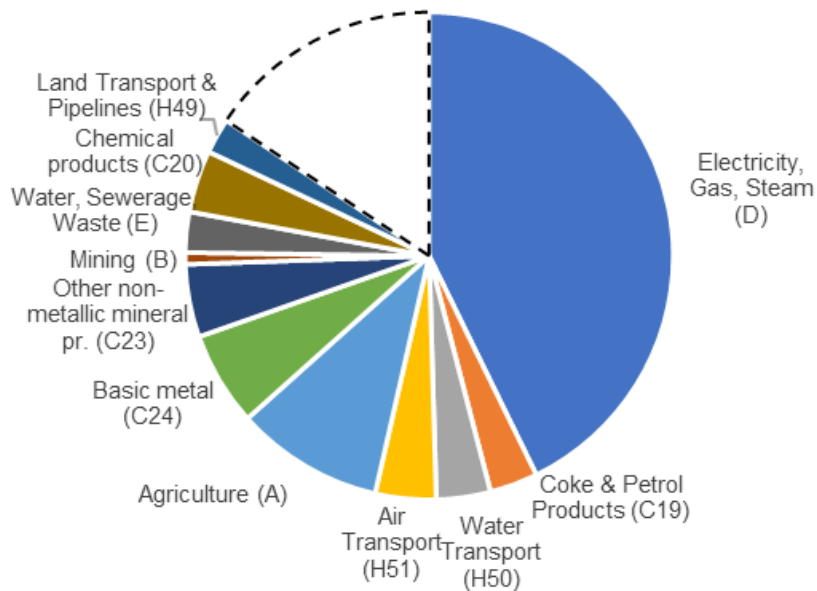
- Sectoral CO₂ intensity = CO₂ equiv. by sector/GVA by sector (for 2017)
- Data sources:
 - » GVA by Sector (ISIC Rev. 4): OECD STAN database
 - » CO₂ by Sector (ISIC Rev. 4): OECD Air Emission Accounts

CO₂ intensity by sector: Germany



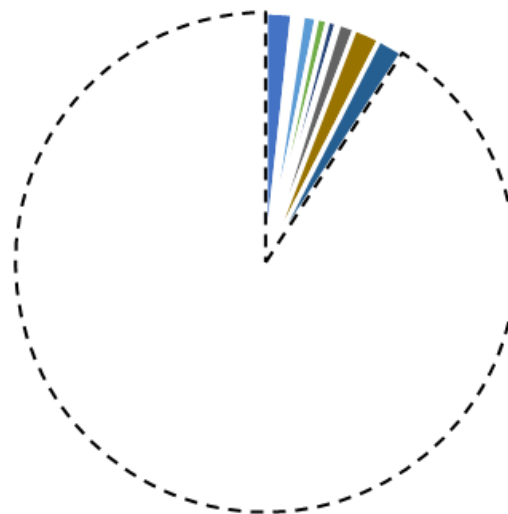
CO₂ intensity by sector: Germany

% GHG Emissions by sector



85% of emissions

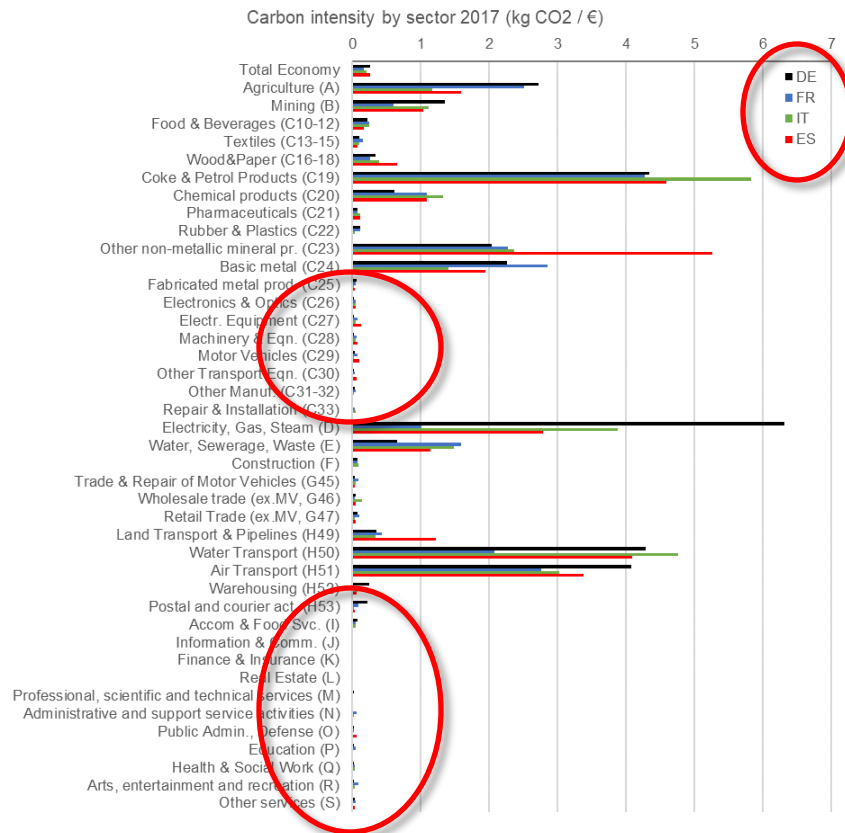
% Value added by sector



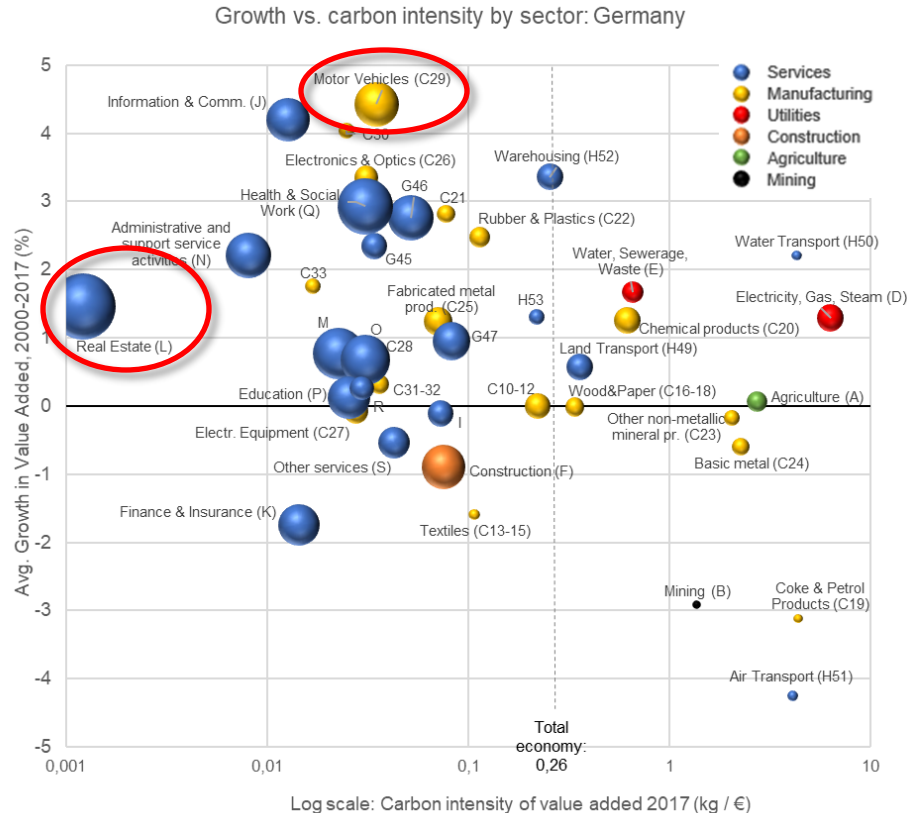
9.2% of value added

CO₂ intensity by sector: Big 4 euro area countries

- Similar sectoral CO₂ intensity in different economies



Growth vs. CO₂ intensity by sector: Germany

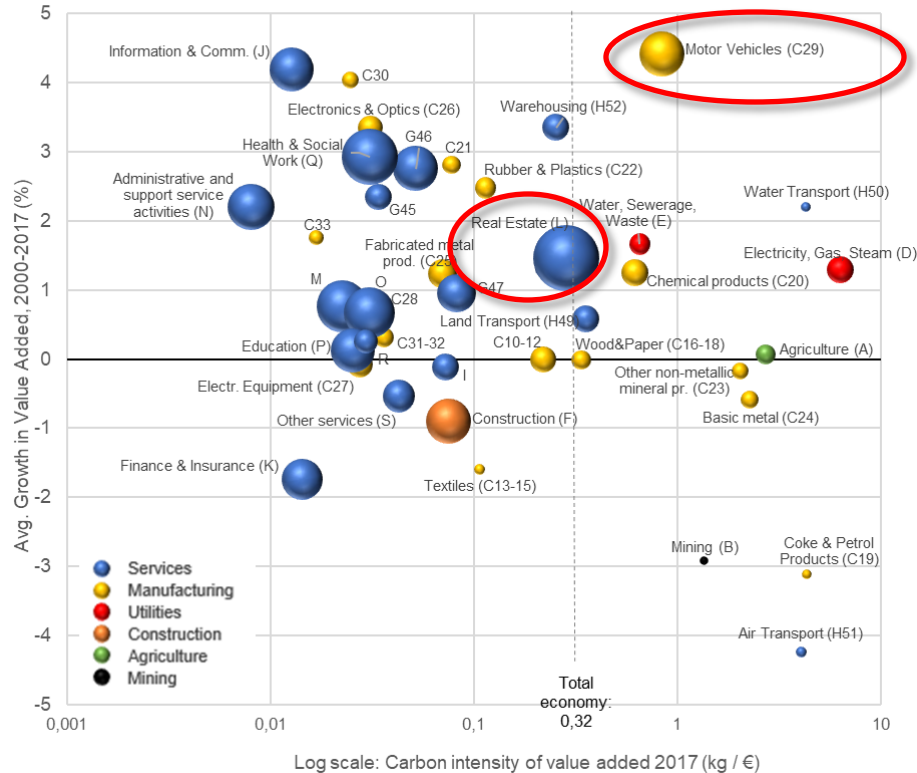


- X-Axis: log. CO₂ Intensity 2017
 - Y-Axis: GVA growth 2000-2017
 - Bubble size: GVA
- >> Sectors with low CO₂ intensity have been engines of growth!

Missing here: household emissions for mobility and heating

Growth vs. CO₂ intensity by sector: Germany

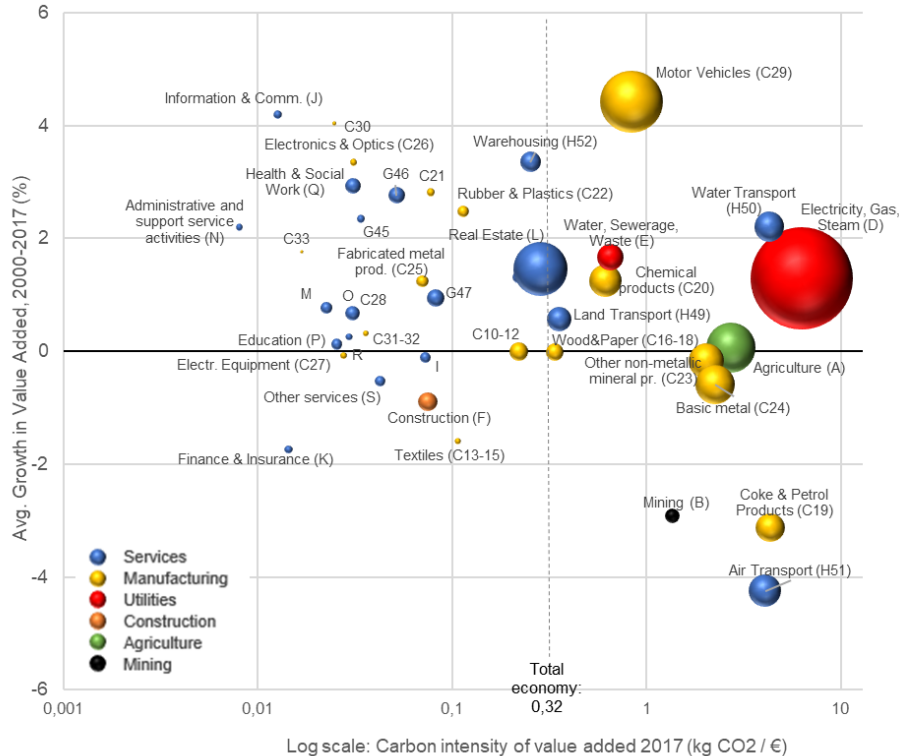
Growth vs. carbon intensity by sector: Germany



- Household emissions for mobility added to Production of Motor Vehicles (C29)
- Household emissions for heating added to Real Estate sector (L)

Growth vs. CO₂ intensity by sector: Germany

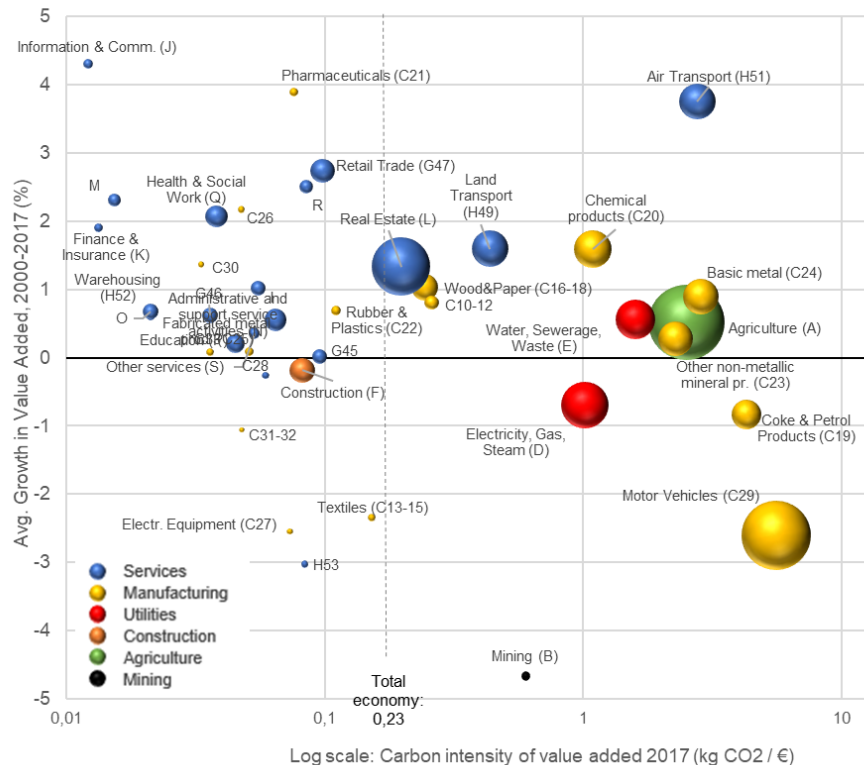
Growth vs. carbon intensity by sector: Germany



- Now: Bubble size relative to CO₂ emissions instead of GVA
- Only few sectors responsible for the bulk of emissions

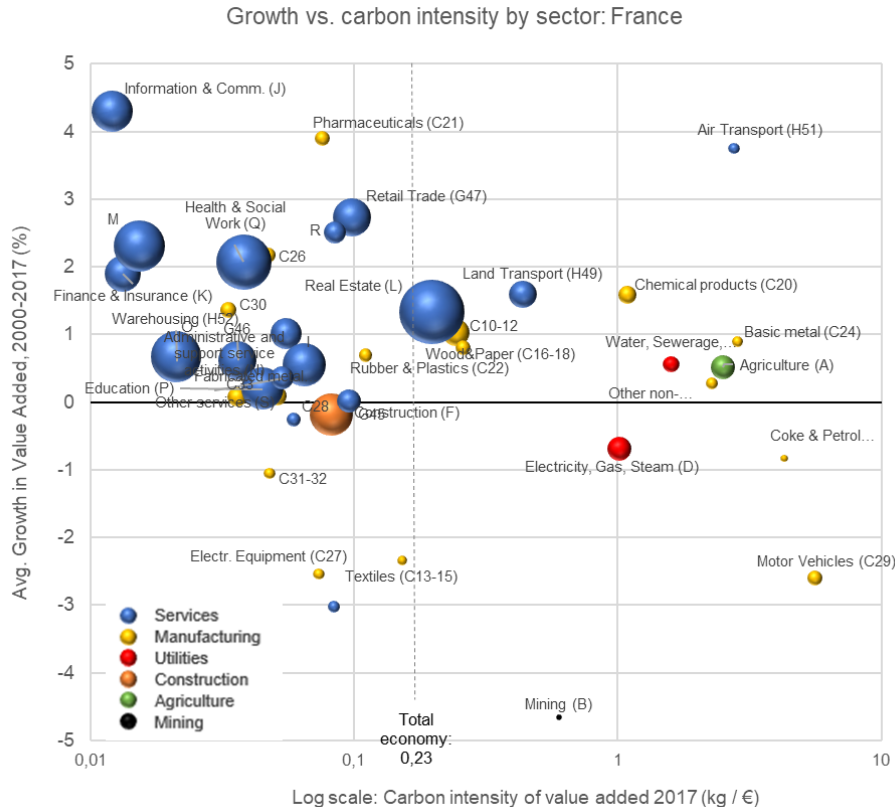
Growth vs. CO₂ intensity by sector: France

Growth vs. carbon intensity by sector: France



- Bubble size relative to CO₂

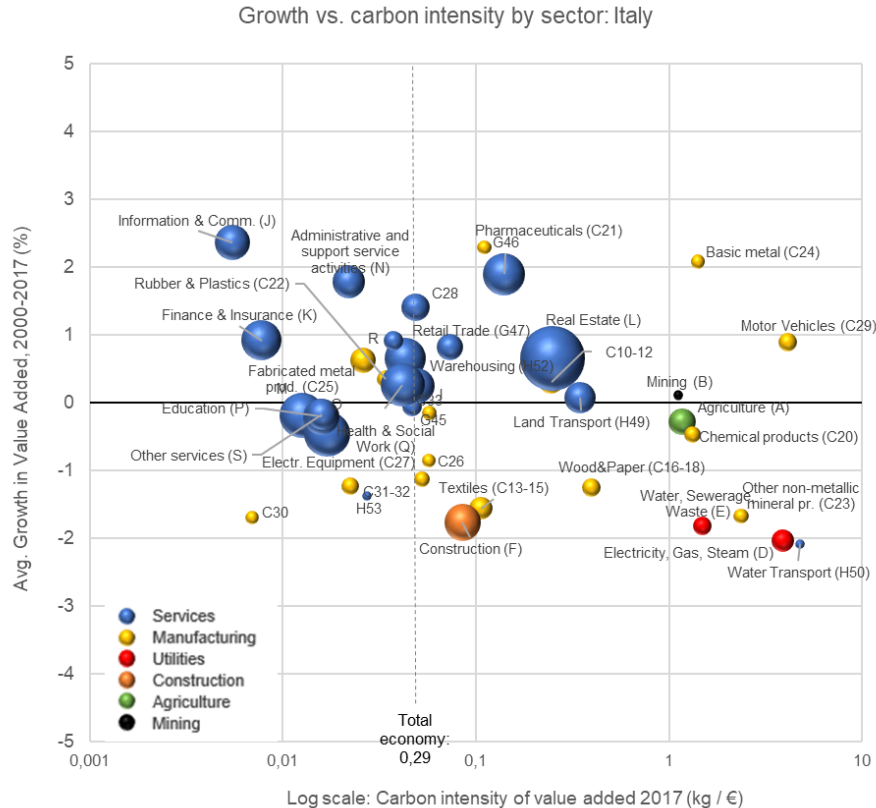
Growth vs. CO₂ intensity by sector: France



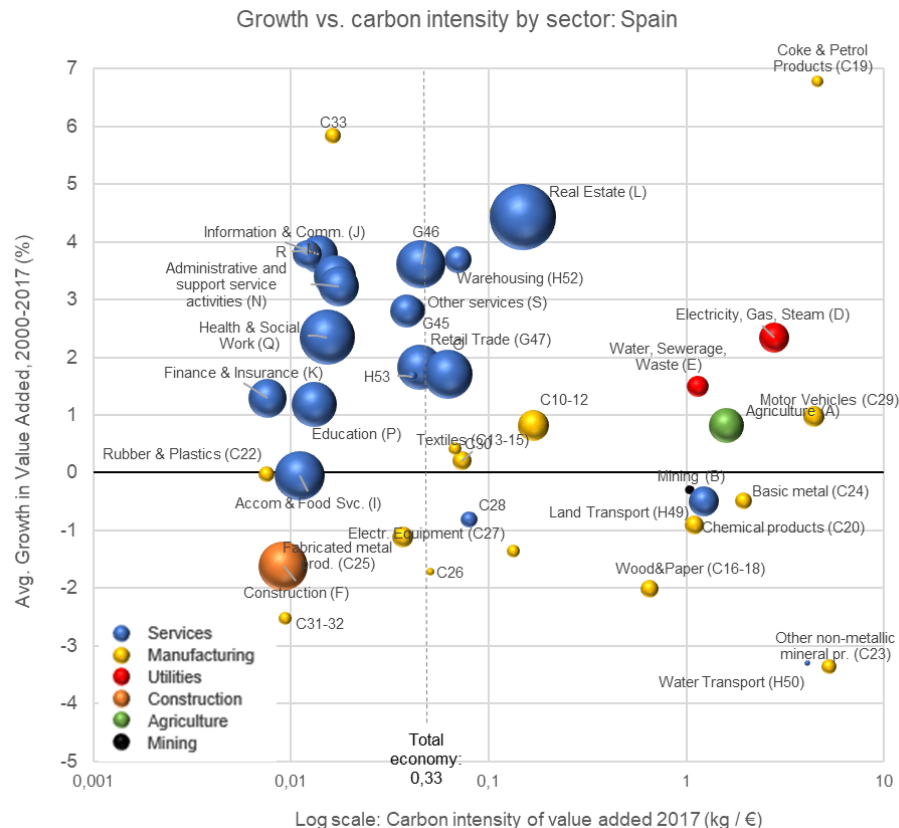
- Bubble size relative to GVA again

Growth vs. CO₂ intensity by sector: Italy

- Bubble size relative to GVA



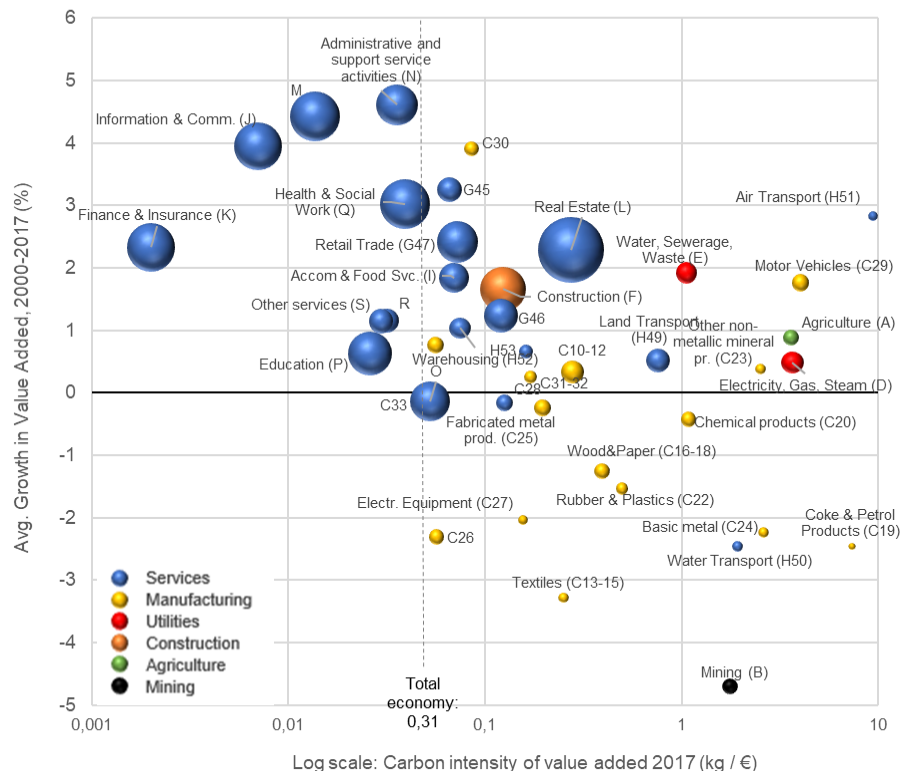
Growth vs. CO₂ intensity by sector: Spain



- Bubble size relative to GVA

Growth vs. CO₂ intensity by sector: United Kingdom

Growth vs. carbon intensity by sector: UK



- Bubble size relative to GVA

Decarbonization and its effect on GDP growth

On the one hand:

- Only few sectors are responsible for the bulk of emissions
- Growth in advanced economies primarily took place in low-carbon sectors
- In the past, we have seen economic growth in combination with a decline in energy consumption and emissions

>> There will still be GDP growth

Decarbonization and its effect on GDP growth

On the other hand:

- A formerly free resource (the atmosphere) will be restricted / costly to use.
 - Cheap fossil fuels have to be replaced by energy sources that require much more land area, capital, technological knowledge
 - Green investments: The current capital stock will be **replaced** by a new low-carbon capital stock, which offers basically the same economic output (mobility, heating, living). It is much more energy-efficient, but there is **no relevant buildup of production capacity** from these investments.
 - Many economic resources will have to be channeled into the transition to a low-carbon economy (capital, R&D, engineers, workers, political capital). There are **opportunity costs** to that (e.g. less R&D for other purposes, lower TFP growth).
- >> Decarbonization is probably not a growth strategy.

Questions?



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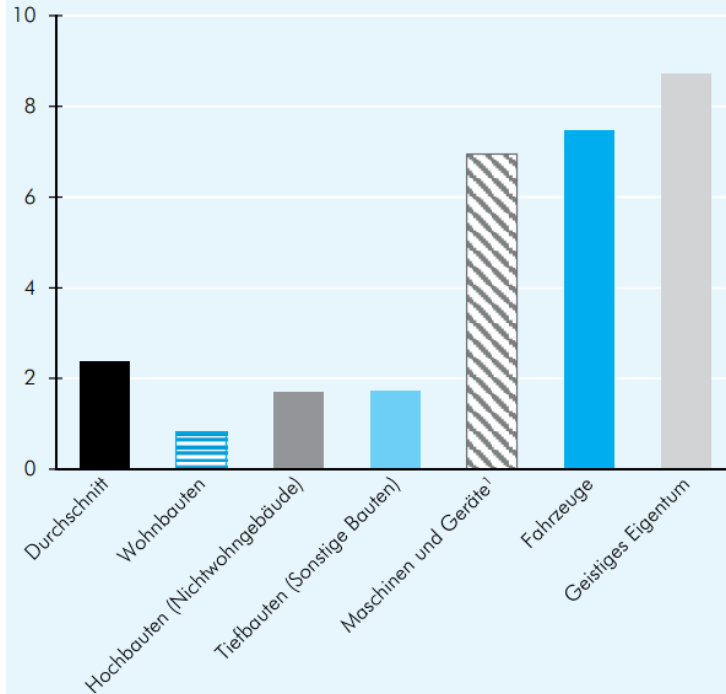
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Capital stock: structure and depreciation

(a) Abgänge vom Anlagevermögen im Jahr 2020 in Relation zum Bestand am Jahresende 2019 in %



(b) Anteile der Vermögensarten am Bruttoanlagevermögen im Jahr 2020 in %

