CO2 emissions and energy technologies in Western Europe

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Motivation

The big question

- The goal of the European Green Deal is to be climate-neutral by 2050.
- Target: Reducing, at least, 55% of 1990 emissions by 2030
- Context to this number:

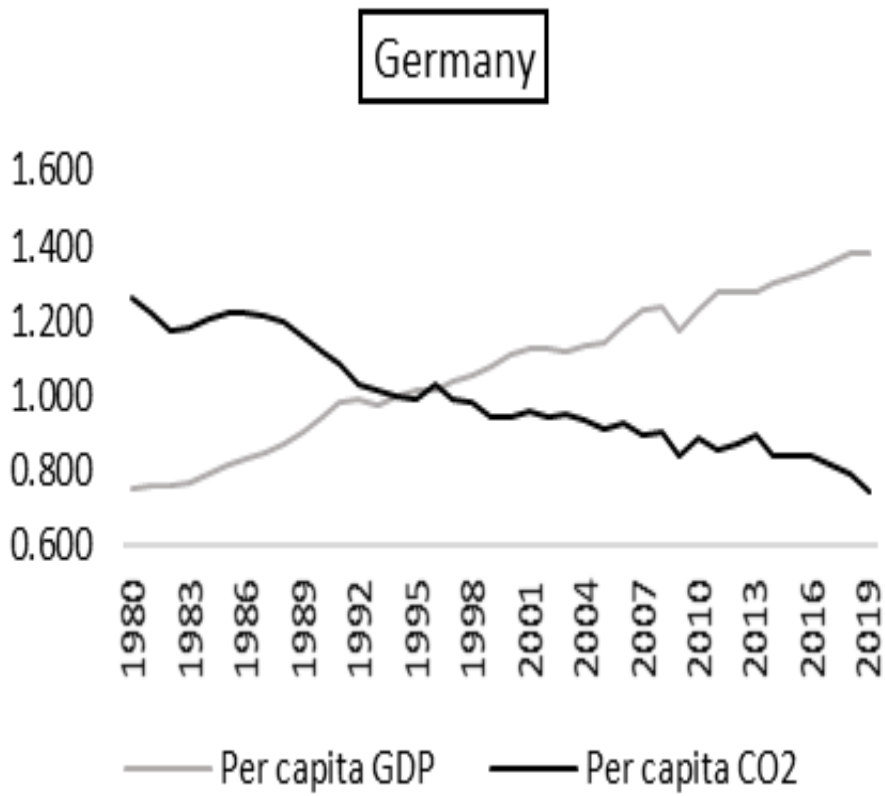
	% of EU CO2 Em. 2019	2020 CO2 Em. / 2030 Target	Growth rate (%) 20-30	90-19	19-20
EU		1.51	-4.04	-0.84	-13.14
France	10.18	1.52	-4.10	-0.71	-16.01
Germany	23.21	1.33	-2.84	-1.34	-11.24
Italy	11.25	1.58	-4.47	-0.69	-13.06
Spain	9.23	2.28	-7.92	0.81	-18.68

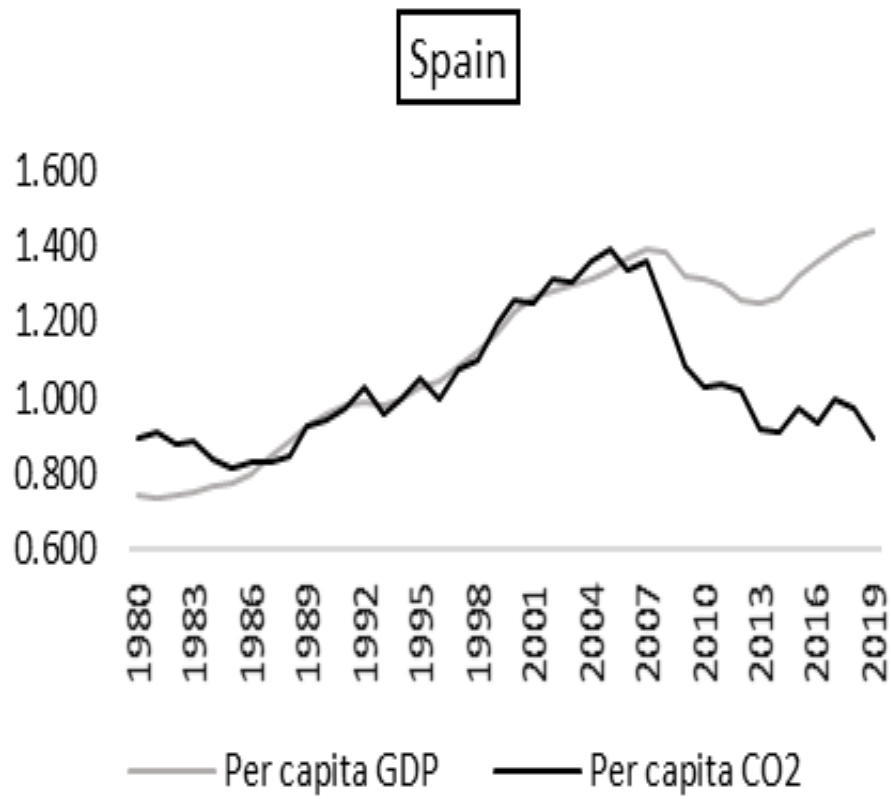
Source: BP Stats review 2021.

To calculate the costs of achieving this goal we need to study short run determinants of CO2 emissions.

CO2 emissions and economic activity

Related ...

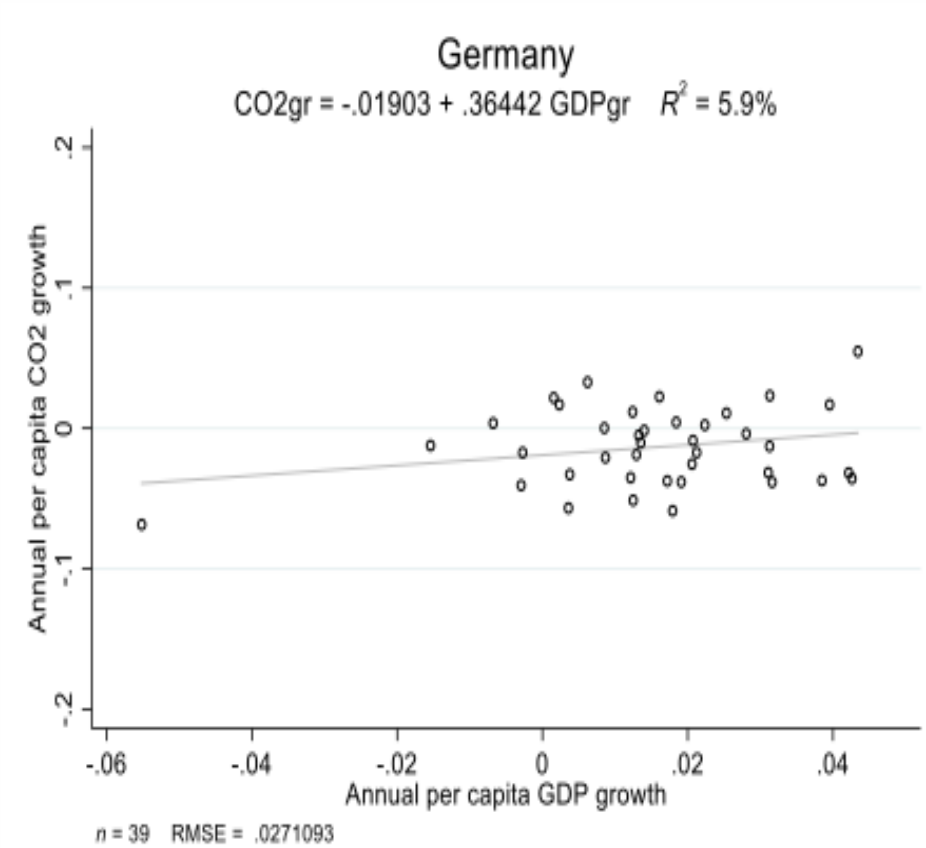


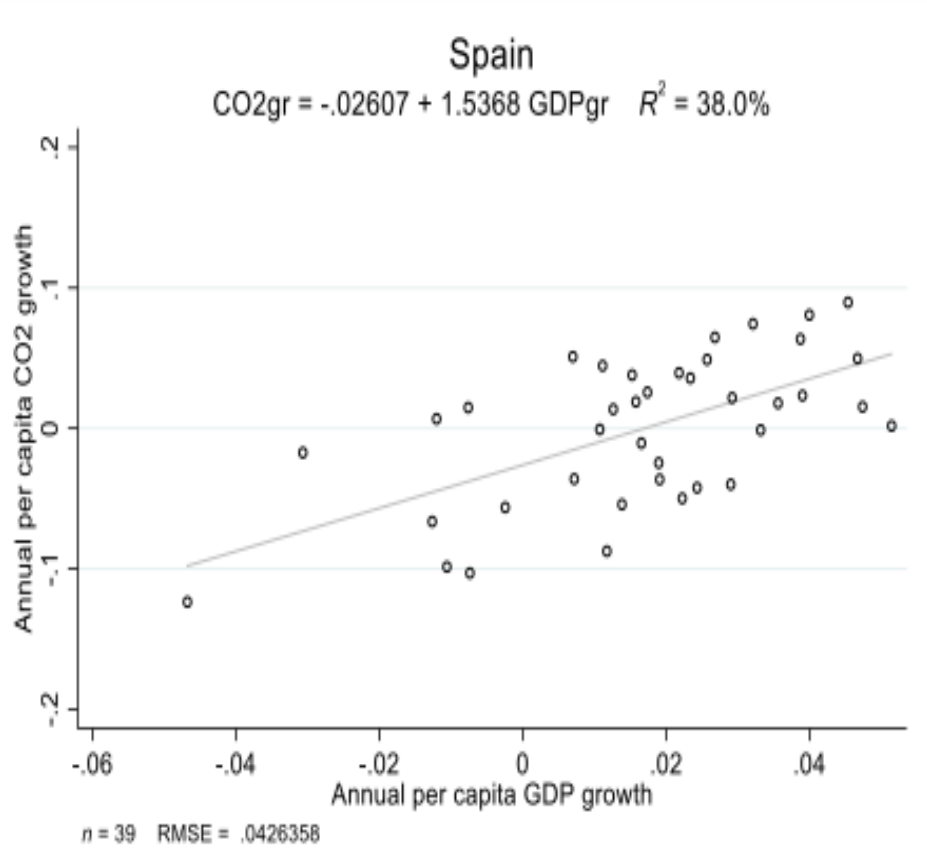


Avge GDPpc growth: 1.54% vs 1.69%; Avge CO2pc growth: -1.34% vs -0.01%

CO2 emissions and economic activity

... but can we infer CO2-GDP elasticity?

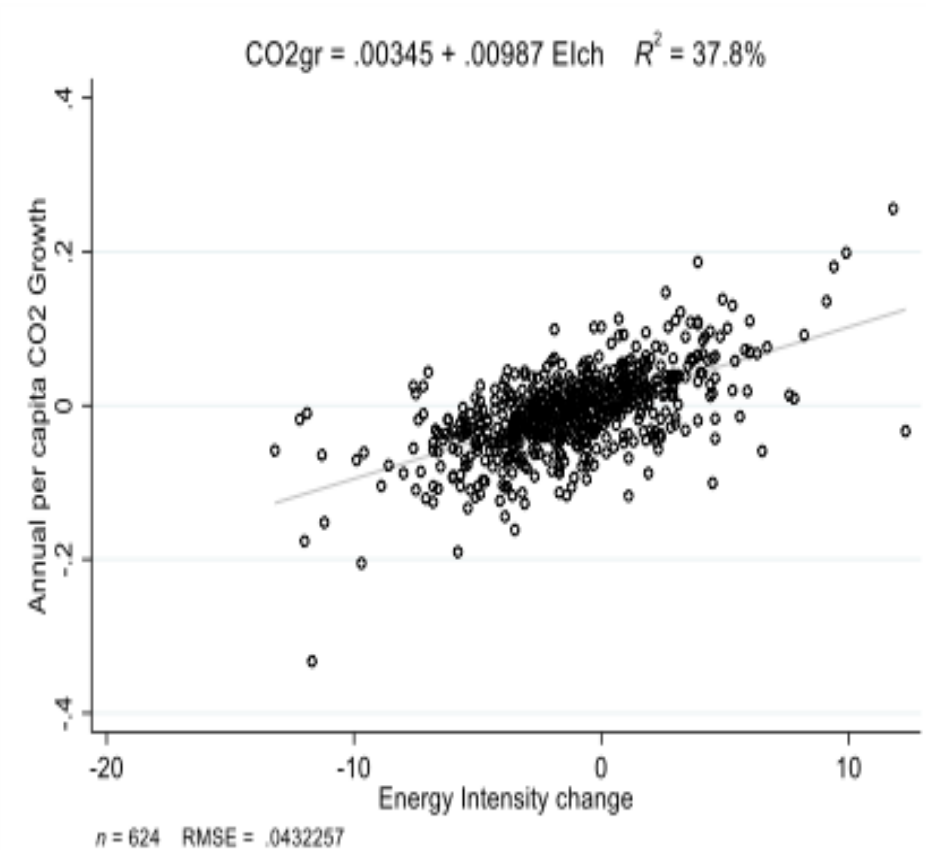


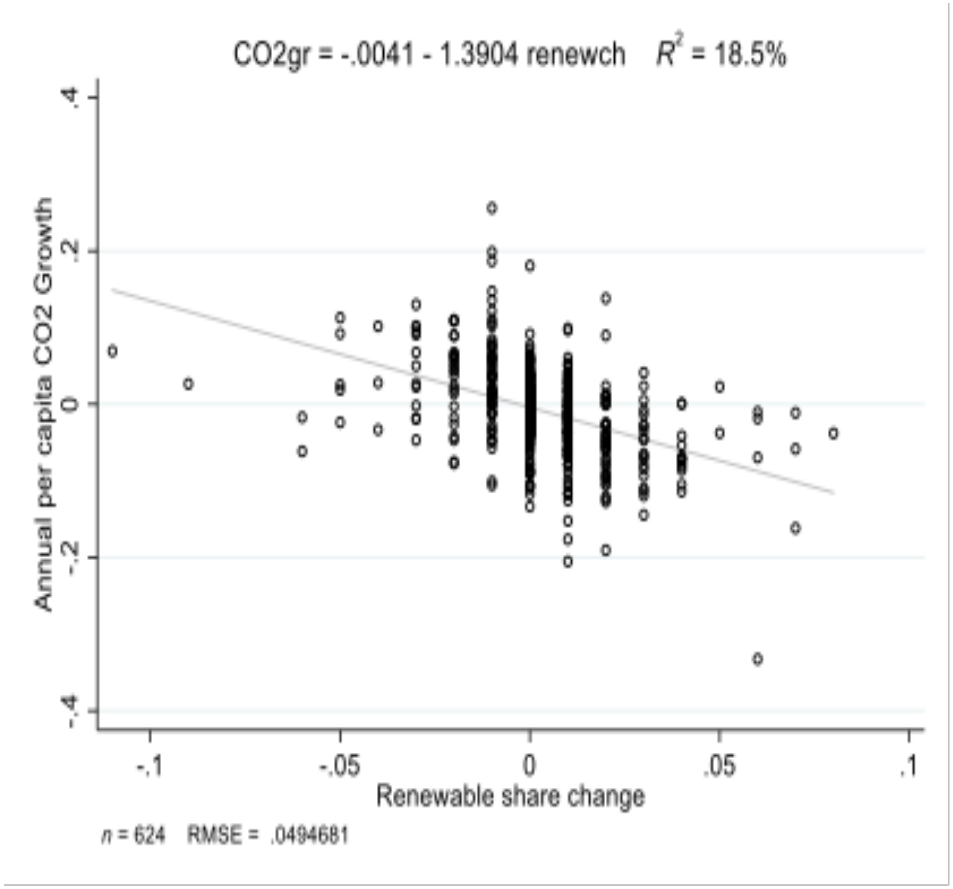


How much of the relationship is trend? cycle?

Energy Technologies

matter for the connection CO2-GDP – a lot of heterogeneity





CO2 Emissions growth in the pool: significant and, positive correlation with EI change; negative correlation with RES change.

Energy and the Macroeconomy

The intuition

- We want to look at the relationship CO2-GDP with the lenses of a macro model.
- The key issue is the energy technology.
- We build on Díaz & Puch (2019) who study a model economy where capital and energy are complementary in the short run.
- Investing in efficient capital reduces energy requirements and the energy bill, but it takes time (and, perhaps, productivity).
- Investing in renewables breaks the link between energy intensity and emissions.

Energy and the Macroeconomy

To fix ideas

- Gross production (per unit of labor) requires k and e (whatever the source),

$$y_t = \begin{cases} A_t\, k_t^{\alpha}\, e_t^{\theta}, & \text{if } e_t = v_t\, k_t; \\ 0, & \text{otherwise,} \end{cases}$$

  where v_t is a technological (energy saving) index of the unit of capital, and $\widetilde{A}_t$ is an unadjusted measure of total factor productivity.

- This can be rewritten:

$$y_t = A_t\, v_t^{-\alpha}\, e_t^{\theta}.$$

$\Rightarrow$ higher production, y, higher energy use, e, higher emissions.... unless using efficient technologies (low intensity, v), or using renewables.

Estimation results: DPD with fixed effects

Positive elasticity of CO2 emissions to GDP: the cycle matters...

	CO2pc growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Western Europe 16						
Lag of emissions (trend)	-0.0227***	-0.0367***	-0.0888***	-0.0422***	-0.0845***	-0.0449***
	(0.00772)	(0.0140)	(0.0169)	(0.0127)	(0.0148)	(0.0123)
GDPpc growth	0.652***	0.683***	0.434***	0.813***	0.392***	0.754***
	(0.0937)	(0.0956)	(0.121)	(0.109)	(0.109)	(0.103)
EI change				0.034***		0.031***
				(0.003)		(0.003)
REShare change					-0.918***	-0.008***
					(0.003)	(0.002)
Constant	0.184***	0.316**	0.744***	0.360***	0.712***	0.385***
	(0.0683)	(0.125)	(0.151)	(0.111)	(0.132)	(0.107)
Country fixed effects	No	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	No	Yes	Yes	Yes	Yes
R^2	0.095	0.127	0.372	0.630	0.468	0.649
N	624	624	624	624	624	624

$$\Delta \ln p_{i,t} = \beta_0 + \alpha_i + \eta_t + \beta_1 p_{i,t-1} + \beta_2 \Delta \ln y_{i,t} + \beta_3 \Delta EI_{i,t} + \beta_4 \Delta RES_{i,t} + \varepsilon_{i,t}$$

(6) Trend brings a reduction rate of 0.05% emissions for 1% GDP. Not enough.
The cycle matters (GDPpc growth) and energy intensity (EI change).

Estimation results: DPD with fixed effects

... but its size depends on energy intensity, renewables are a bonus

	CO2pc growth				
	(1)	(2)	(3)	(4)	(5)
Western Europe 16					
Lag of emissions	-0.0481***	-0.0447***	-0.0485***	-0.0476***	-0.0499***
	(0.0121)	(0.0121)	(0.0119)	(0.0119)	(0.0133)
GDPpc growth	0.100	0.744***	0.107	0.0591	-0.634
	(0.165)	(0.129)	(0.173)	(0.326)	(0.575)
EI change	0.031***	0.031***	0.031***	0.031***	0.031***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
REShare change	-0.008***	-0.008***	-0.008***	-0.008***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
GDPpc growth $\times$ EI$_{t-1}$	0.137***		0.139***	0.146**	0.244**
	(0.0356)		(0.0353)	(0.0572)	(0.0949)
GDPpc growth $\times$ REShare$_{t-1}$		0.0107	-0.0160	0.00811	0.137
		(0.0892)	(0.0893)	(0.0970)	(0.153)
Constant	0.413***	0.382***	0.416***	0.407***	0.426***
	(0.106)	(0.105)	(0.103)	(0.104)	(0.117)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
R^2	0.654	0.649	0.654	0.653	0.631
N	624	624	624	610	560

$\Delta \ln p_{i,t} =$ **above** $+ \beta_{21} \Delta \ln y_{i,t} \times EI_{i,t-1} + \beta_{41} \Delta \ln y_{i,t} \times RES_{i,t-1} + \varepsilon_{i,t}$

It is not GDP growth. It is GDP growth whenever Energy Intensity is high. (4&5): not driven by extreme values (bottom/top 1%&5% GDP growth).

Estimation results: DPD with fixed effects

Back of the envelope estimates

Can we achieve 2030 target without GDP falling?

- Keeping constant renewables share, a growth rate of 2% of GDP together with a reduction of emissions of 4% requires reducing energy intensity by one fourth... in a year.
- Augmenting the renewables share in 1σ ($\sim 1.7\%$) reduces emissions in $\sim 1\%$. That is, augmenting the share in 6.8% points... in a year.

Policy Implications

Cyclical concerns

- It is GDP growth whenever Energy Intensity is high that triggers the alarms.
  - Absolute priority for policies to achieve *conditional convergence in energy intensity* standards across Western European countries (fostering integration).
  - Renewables do not play much on CO2-GDP elasticity (w/ exceptions), by now, but still low levels of renewables. Díaz, Marrero, Puch & Rodríguez find frontier renewables increase productivity. (2019)
- Immediate action:
  - A recommendation for tax-based (and subsidies) cyclical stabilization (as a complement to cap and trade) Díaz & Puch (2016).
  - For instance, procyclical fuel taxes and fuel economy standards in the transport sector, as well as procyclical regulations towards energy efficiency and inducement for renewable energies in the power sector.