Net zero emissions and energy price signaling

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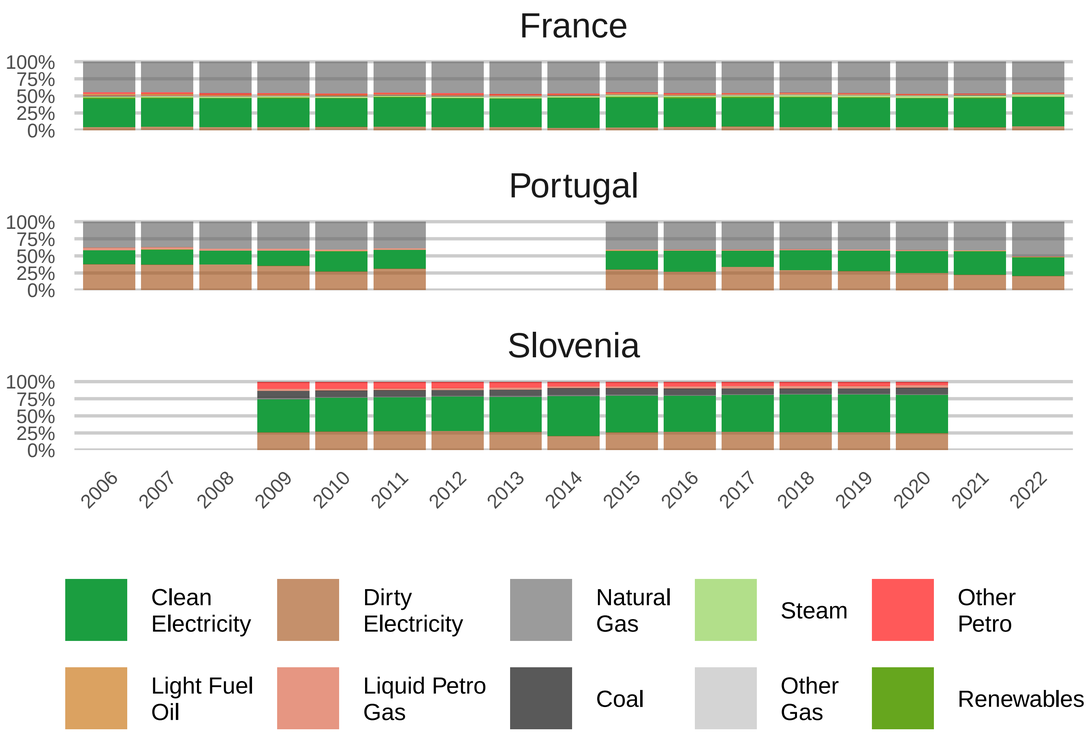
Introduction

- Energy price signals encourage firms to direct their technology (Hémous and Olsen, 2021), improving efficiency and/or adjusting their energy mix.
- Carbon taxes direct future energy mixes via energy prices, but taxes' optimal level depends on the elasticity of substitution (Acemoglu et al. 2012).
- This project: uses MDI firm-level data to study how energy prices drive the green transition by prompting firms to adjust their energy mixes.

Energy mix & prices

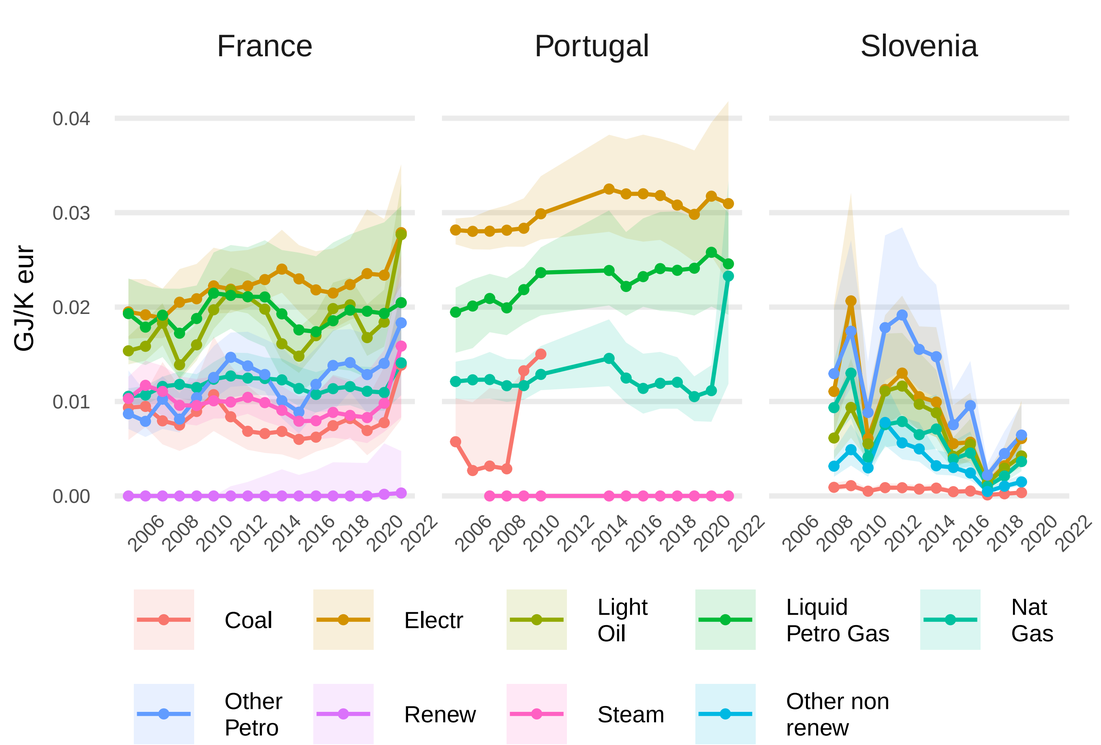
Energy mix

Manufacturing sector



Energy prices

Median, 25th and 75th percentiles



Electricity is separated between clean and dirty using IEA data about countries' electricity generation sources.

Elasticities

How do energy prices impact firm-level energy consumption in the short-term?

$$E_{j,i,s,t} = \beta_j P_{i,s,t} + \theta_i + \theta_{s,t} + \epsilon_{i,s,t} \qquad (1)$$

E and P are firms' (i) energy source j consumption and price. s and t are sector and year.

Identification: Shift-share IV à la Fontagné, Martin, and Orefice 2024; $P^{IV}_{i,s,t} = \left[\frac{p_{i,s,t_0}}{\overline{p}_{i,t_0}}\right] \times \overline{p}_{s,t}$

Table 1: Price elasticity of energy demand

	FR	PT	SI
Clean	-1.105***	-0.649*	-0.079
	(0.375)	(0.349)	(0.856)
Obs	71,833	35,566	3,404
F-1st	33.645	12.888	0.004
Dirty	-0.969***	-0.227	-0.620**
	(0.302)	(0.390)	(0.245)
Obs	82,167	37,666	1,654
F-1st	40.901	4.188	5.603

Why such a difference between countries?

Start with the firms' problem (CES). Production (Y) function of energy (E) and other inputs (X). Clean (E_c) and dirty (E_d) energy form E.

$$Y = \left[\delta\, X^{\phi} + (1-\delta)\, E^{\phi}\right]^{\frac{1}{\phi}} \qquad (2)$$

$$E = \left[\alpha\, (E_c)^{\rho} + (1-\alpha)\, (E_d)^{\rho}\right]^{\frac{1}{\rho}} \qquad (3)$$

Minimizing energy costs w.r.t E yields:

$$\frac{E_c}{E_d} = \frac{\alpha}{1-\alpha}\left(\frac{p_d}{p_c}\right)^{\frac{1}{1-\rho}} \qquad (4)$$

$\sigma_{cd} = \frac{1}{1-\rho}$: elasticity of substitution between E_c and E_d. To identify σ_{cd} I log-linearize (4).

Shaping future energy mix

σ_{cd} measures firms' ability to substitute across energy sources when one input's cost rises.

$$\ln\left(\frac{E_d}{E_c}\right) = -\ln\left(\frac{\alpha}{1-\alpha}\right) + \frac{1}{1-\rho}\left[\ln\left(\frac{p_c}{p_d}\right)\right] \qquad (5)$$

Within variation captures short-run substitution, while cross-sectional variation identifies long-run substitution (e.g., capital adjustments) (Jo, 2024).

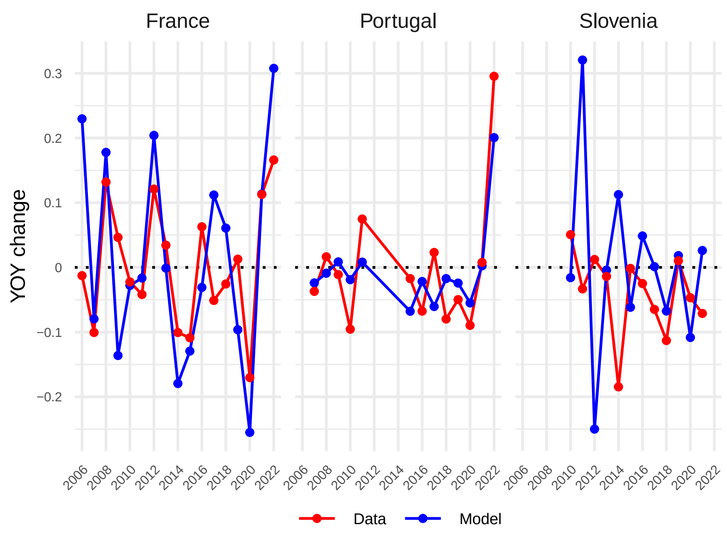
Table 2: Long-Run Elasticity of Substitution

	FR	PT	SI
$\ln(P_c/P_d)$	3.160***	2.420***	1.294**
	(0.077)	(0.412)	(0.593)
Obs	52,735	22,263	1,247
F-1st	8,336.035	116.320	19.352

Intuitively, keeping Y constant, following an ↑ in P_E a high σ_{cd} allows firms to buffer ↑ P_E by switching energy mix; a low σ_{cd} forces a stronger ↓ overall E.

How would changes in relative prices shape energy mixes?
We simulate an increase of +1%/year in P_d and decrease of -1%/year in P_c.

Dirty energy YOY % change

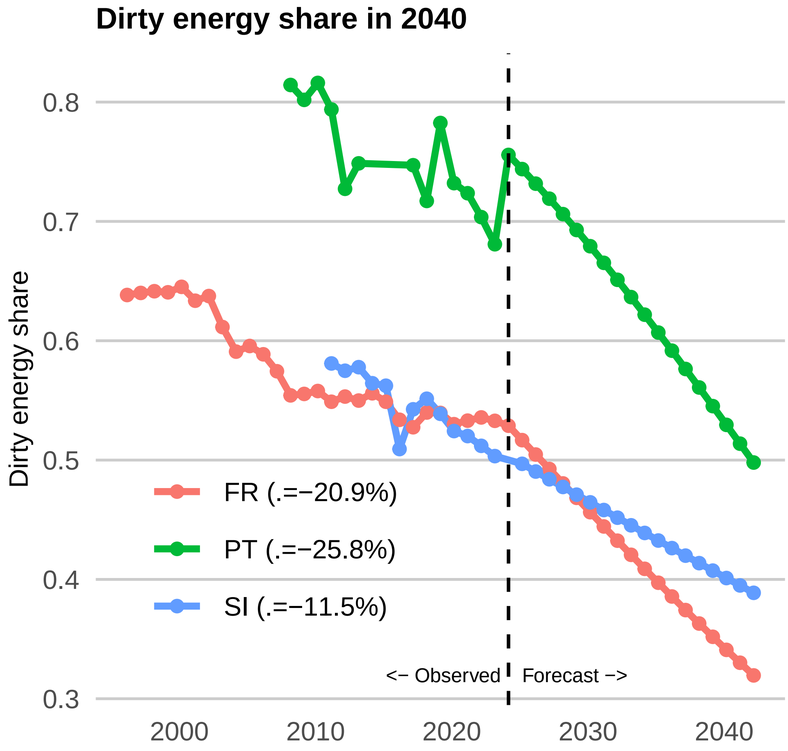


Calibration: mean parameters.

Country	$\bar{P}_c$	$\bar{P}_d$	$\bar{\theta}_E$	σ_{cd}	σ_{XE}
FR	0.022	0.015	0.014	2.42	1
PT	0.031	0.029	0.013	3.16	1
SI	0.015	0.022	0.023	1.29	1

$\sigma_{XE} = 1 \rightarrow$ Cobb-Douglas. θ_E: E costs. P in Keur/GJ

Dirty energy share in 2040



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