

The impact of carbon policy news on the national energy industry

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How does the energy sector respond to carbon policy news?

- The EU Emissions Trading System (EU ETS) is a cap-and-trade system that has been revised many times
- Carbon pricing cuts emissions in the EU (Martin et al. 2014; Andersson 2019; Bayer and Aklin 2020), but its economic consequences remain contested
- Policymakers need the full effect of their decisions, **especially when energy prices are high** and fall mainly on low-income families
- Little is known at the **sectoral level**, for a below-average-income EU country

Questions

How does the energy sector respond to *unexpected* changes in carbon policy? Does it change how the industry performs inside and outside the country? And what happens to the people working in it?

What the paper does

- **Portugal's energy industry**: monthly sectoral survey data from the national statistics institute, January 2005 to December 2019
- Six variables: **domestic and non-domestic turnover, wages, hours worked, output prices** at home and abroad
- A **Bayesian structural VAR**. Carbon policy surprise shocks are identified through **correlation restrictions**, with the surprise series of Diego R Känzig (2023) as a proxy
- Impulse responses, variance decomposition and historical decomposition, then sensitivity checks

Preview of results

- **Turnover:** a small boost to domestic turnover; the non-domestic counterpart does not follow
- **Prices:** internal prices rise on impact. External prices show no significant change on impact, then a persistent rise **twice as pronounced** as the internal one
- **Labour:** higher wages and more hours worked
- **History:** the shocks account for a substantial part of past fluctuations in the Great Financial Crisis, around the permit-purchase rule for power plants, and around a court ruling
- Results hold up when the pandemic and the war are added, and across specifications

The paper reads these as suggestive of limited export capacity in green industry; it does not test that channel.

1. **Macroeconomic effects of carbon pricing:** no GDP effect of the British Columbia carbon tax (Gilbert E. Metcalf 2019; Bernard and Kichian 2021); no negative effect on employment and output in Europe (Metcalf and Stock 2020; Metcalf and Stock 2021); insubstantial inflation effects (Konradt and Mauro 2023)
2. **Contractionary and inflationary views:** general-equilibrium models show contractionary effects (McKibbin et al. 2017; Goulder and Hafstead 2017; Benmir and Roman 2022); short-term inflation rises (Krämer and Solveen 2021; Santabárbara and Suárez-Varela 2022; Moessner 2022)
3. **Beyond the macro aggregate:** power-sector effects depend on permit allocation and market concentration (Diego R. Känzig and Konradt 2023); poorer Euro Area countries are more sensitive (Mangiante 2023)

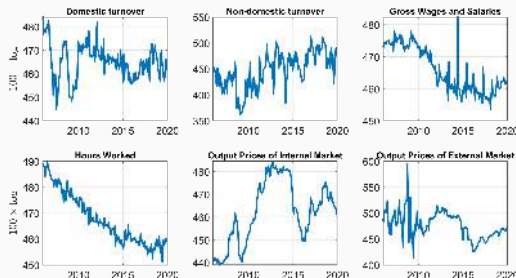
- **Sectoral evidence** from an EU country with below-average income: how the Portuguese energy industry responds to carbon policy news
- **A short methodological contribution:** motivated by the criticism of recursive identification (Kilian et al. 2022), the carbon surprise series enters as an **external variable** identified by correlation restrictions (Ludvigson et al. 2020), instead of a recursive ordering
- Same idea as other commodity-price proxies: gold (Piffer and Podstawski 2018), oil (Diego R. Känzig 2021), carbon (Diego R Känzig 2023)

Closest papers

Diego R. Känzig and Konradt (2023) and Mangiante (2023) look beyond the macro aggregate; this paper looks at a single sector in a single country.

Data and Method

Data: the Portuguese energy industry

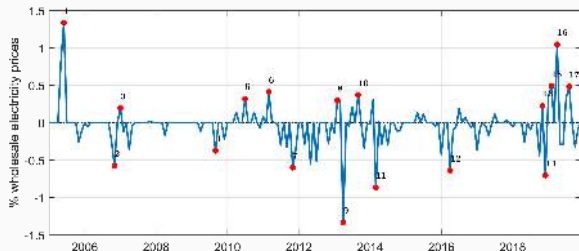


Notes: Baseline series, $100 \times \log$, seasonally adjusted. Panels in the order of the list at right.

- Monthly, 2005m1–2019m12, from the Portuguese statistics institute (INE)
- Index of **domestic turnover** t_t : revenue within Portugal
- Index of **non-domestic turnover** t_t^* : exports and international transactions
- Index of **gross wages and salaries** w_t
- Index of **hours worked** h_t
- **Output prices** π_t (home market) and π_t^* (foreign markets)
- Seasonal adjustment with X13; log levels

Data sources

The shock: carbon policy surprises



Notes: Carbon policy surprise series of Diego R Känzig (2023); the numbered dots are the regulatory events listed in the backup.

$$\text{CPSurprise}_{t,d} = \frac{F_{t,d}^{\text{carbon}} - F_{t,d-1}^{\text{carbon}}}{p_{t,d-1}^{\text{electricity}}}$$

- Change in the EUA futures price on the day of a regulatory event, scaled by the wholesale electricity price the day before; daily surprises are summed within each month
- The narrow event window is meant to isolate carbon price moves driven by regulatory news, with risk premia assumed constant
- The series comprises 126 regulatory events, as stated in the paper

Event list

Model and identification

Bayesian VAR with n endogenous and m exogenous variables:

$$y_t = \mathcal{A}_1 y_{t-1} + \dots + \mathcal{A}_p y_{t-p} + \mathcal{C}x_t + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(\mathbf{0}, \Sigma)$$

Structural shocks and the **correlation restriction** on the carbon policy shock $\eta_{1,t}$, given the surprise series S_t :

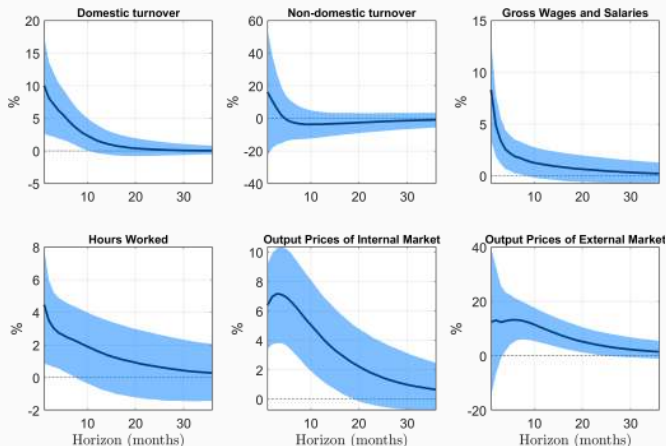
$$\varepsilon_t = A_0 \eta_t, \quad \eta_t \sim \mathcal{N}(\mathbf{0}, I), \quad \rho_1 = \text{corr}(S_t, \eta_{1,t}) \geq \bar{c}$$

- Six lags; a constant and the Portuguese Economic Policy Uncertainty index (Morão 2023) as exogenous terms
- Independent Normal–Wishart prior, Litterman-type (Litterman 1986); Gibbs sampler, 5,000 draws, burn-in 2,000 (Dieppe et al. 2016)
- IRFs normalized so that the shock raises domestic turnover by 10% on impact

Hyperparameters

Results

Impulse responses to a carbon policy shock



Notes: Normalized to raise domestic turnover by 10% on impact.
Solid line: posterior median; shaded: 68% bands.

- **Domestic turnover** jumps on impact; the positive effect wanes by the end of the second year
- **Non-domestic turnover:** a positive effect for about three months, with wide bands
- **Wages and hours** rise on impact and decline gradually
- **Prices:** both humped; the external response is larger

Turnover and labour: the paper's reading

Turnover

- Domestic boost: the paper links it to business of low-carbon firms and to investment in low-carbon technology, consistent with Dechezleprêtre et al. (2023) and Hoffmann (2007)
- Non-domestic: a small, short-lived gain; the wide bands signal **high uncertainty**

Labour market

- Wages: the paper reads the rise as a surge in demand for green-technology skills; part may reflect compliance consultancy
- Hours worked: new hires, training, new equipment; consistent with Marin et al. (2018)
- Hours decline more gradually than wages; higher costs normalize by the third year

Tighter carbon news does not make the sector crumble: domestic turnover, wages and hours all rise.

Output prices: internal versus external

- Both responses are **hump-shaped**. Internal prices rise on impact and fall persistently, back to pre-policy levels by the fourth year (text)
- External prices: no significant change on impact; over a one-year horizon the effect is **more powerful and more persistent** than the internal one
- The paper ties the larger external response to exposure to trade dynamics, exchange rates and global energy prices, consistent with Nagel et al. (2023)
- The paper reads the weak export turnover as a sign that Portugal has **not** fully turned its edge in green industry into export gains: *suggests*, not shown

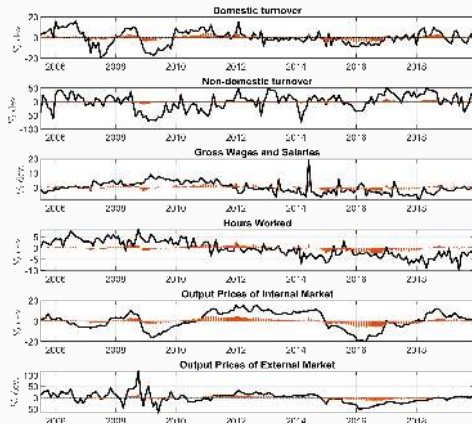
How much of the variance does the shock explain?

Horizon (months)	t_t	t_t^*	w_t	h_t	π_t	π_t^*
1	27.00	6.93	35.54	29.54	43.27	6.68
12	30.96	9.45	30.87	25.22	39.65	19.07
24	30.96	10.47	28.75	21.51	34.53	22.46
36	30.72	10.62	27.52	20.30	32.06	22.91

Notes: Median share of forecast error variance (%) due to the carbon policy surprise shock.

- **On impact:** strong for domestic turnover, wages, hours and internal prices; muted for non-domestic turnover and external prices
- **Longer horizons:** the contribution to non-domestic turnover and external prices grows (external prices: 6.68 to 22.91%); for wages and hours it falls

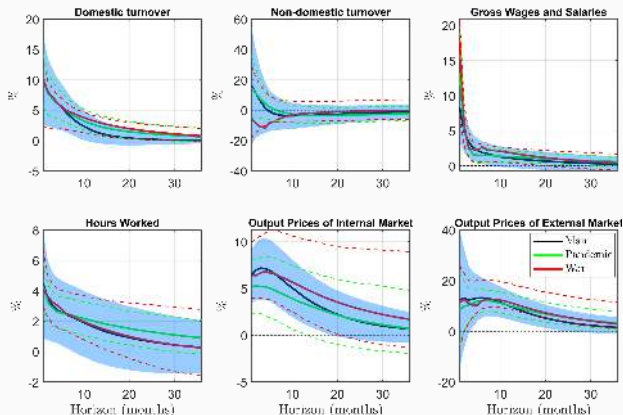
Historical decomposition: three episodes



Notes: Bars: median contribution of the shock; line: series (% dev.). Panels as in the IRFs.

- **Great Financial Crisis, 2008–09.** In early 2008 the shock accounts for about 25–30% of the variation in domestic turnover and internal prices, and more than 50% in some months for wages and hours. The contribution reverses sign by late 2008 and is no longer significant
- **Permits bought, not given free** to EU power plants. The shock accounts for about half of the change in gross wages around the decision; the effect on hours is not significant
- **Court ruling on free allocation, early 2016:** the contribution peaks; the paper links it to lower wholesale electricity prices, then lower output prices, turnover, hours and wages
- No significant contribution to non-domestic turnover

Robustness: the pandemic and the war



Notes: Benchmark IRFs (black, shaded) against the versions with the pandemic (green) and the war (red).

- Both events are added by enlarging the sample and with dummy variables
- Domestic turnover is slightly more persistent after month six; lower bands stay different from zero for more than two years, against about one year in the benchmark
- The war mainly affects non-domestic turnover, and the response is less significant than in the benchmark
- The pandemic pushes internal prices down, not external ones; the effect fades when the war is included
- Wages unchanged; hours more persistent with the pandemic

Robustness: identification and specification

- **Recursive (Cholesky) identification** instead of the proxy: wages and external prices become hump-shaped; other responses look quite similar after the first year
- **Exogenous terms**: real effective exchange rate added; Portuguese policy uncertainty index dropped; constant removed; linear trend added
- **Lags**: 3 and 12 instead of 6
- **Prior and hyperparameters**: Normal–Wishart, Normal–diffuse, diffuse with $\lambda_1 = 1000$, $\lambda_1 = 1$ and $\lambda_2 = 2$, grid-search optimum, identity S_0

Paper's assessment

The modifications suggest the results are robust to a substantial degree of change in specification.

Cholesky IRFs

Lags and REER

- **Interpretation, not test:** the channels (low-carbon investment, green-skill demand, compliance consultancy, limited export capacity) are offered as explanations; the paper does not test them directly
- **Uncertainty:** the bands shown are 68%, and the paper flags high uncertainty for non-domestic turnover
- **Identification:** relies on a correlation restriction between the shock and the surprise series; the recursive alternative changes the shape of some responses
- **Scope:** one country, aggregate energy-industry indices, sample 2005–2019; the pandemic and war enter as an extension, and the paper compares IRFs by visual inspection

Conclusion

- More stringent carbon standards have **short-term** effects on Portugal's energy sector: a notable positive effect on domestic turnover, less pronounced internationally
- Output prices rise at home and abroad, **more so externally**: asymmetries in how the new rules are absorbed
- The labour market responds positively: higher labour demand, wages and hours
- Unanticipated carbon policy changes contributed significantly to historical fluctuations, notably in the Great Financial Crisis, the permit-purchase rule and the 2013–2020 free-allocation ruling
- The paper's message: carbon regulation matters, and **not all of its effects are bad**

Thank you!

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Backup

Regulatory events behind the surprise series

#	Time	Event	Type
1	2005m6	Italy and Greece: Phase I national allocation plans (NAPs) approved	Free alloc.
2	2006m11	No double counting of Kyoto project reductions; decision on several NAPs	Intl. credit, free alloc.
3	2007m1	Phase II NAPs of Belgium and the Netherlands approved	Free alloc.
4	2009m9	Court judgment on NAP, Poland vs. Commission	Cap
5	2010m7	First step toward the 2013 cap; member states back auctioning rules	Cap, auction
6	2011m3	120 million allowances to be auctioned in 2012; Latvia judgment; free allocation to power sector	Auction, free alloc.
7	2011m11	International credits in phase three; Regulation 1210/2011 on volumes auctioned before 2013	Intl. credits
8	2013m2	Free allocation of 2013 aviation allowances postponed	Free alloc., auction
9	2013m4	European Parliament votes against back-loading	Auction
10	2013m9	Industrial free allocation for phase three finalized; aviation allowances update	Free alloc., auction
11	2014m3	First and second batches of international credit entitlement tables approved	Intl. credits
12	2016m4	Court judgment on free allocation in the EU ETS, 2013–2020	Free alloc.
13	2018m11	Updated information on exchange and international credit use	Intl. credits
14	2018m12	Poland's 2019 auctions to include allowances not used for power-sector modernization	Auction
15	2019m2	Delegated Decision on the carbon leakage list for 2021–2030	Free alloc.
16	2019m4	Iceland, Liechtenstein and Norway to start auctions on the common platform	Auction
17	2019m8	Commission amends the auctioning regulation for Phase 4	Auction

Data description and sources

Label	Description	Source
ζ_t	Carbon policy surprises in the Euro Area	Diego R Känzig (2023)
t_t	Index of domestic turnover in industry	INE/own
t_t^*	Index of non-domestic turnover in industry	INE/own
w_t	Index of gross wages and salaries in industry	INE/own
h_t	Index of hours worked in industry	INE/own
π_t	Index of output prices (internal)	INE/own
π_t^*	Index of output prices (external)	INE/own
Z_t	Brent crude price deflated by Portuguese headline CPI	FRED/own
epu_t	Economic Policy Uncertainty index for Portugal	Morão (2023)

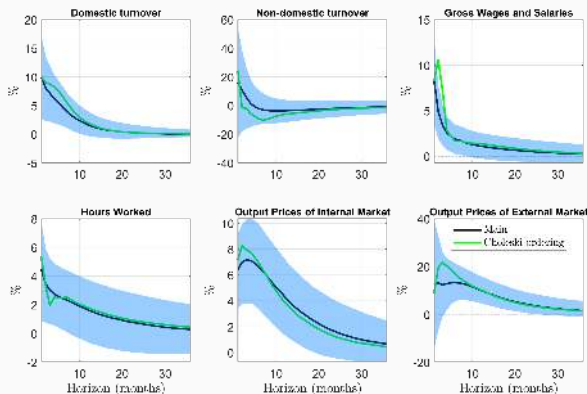
Notes: Monthly series, 2005m1–2019m12 in the main specification.

Hyperparameters

	Value	Description	Observation
ρ	1	autoregressive coefficients	used in all models
λ_1	0.1	overall tightness	1000 in one check, 1 in another
λ_3	1	lag decay	used in all models
λ_4	10^5	exogenous variable tightness	used in all models

Notes: A grid search for the hyperparameters is one of the robustness checks.

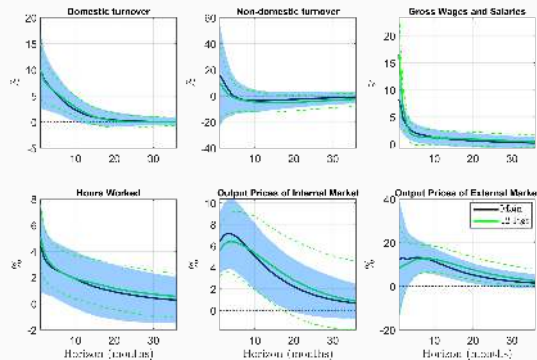
Recursive (Cholesky) identification versus the proxy



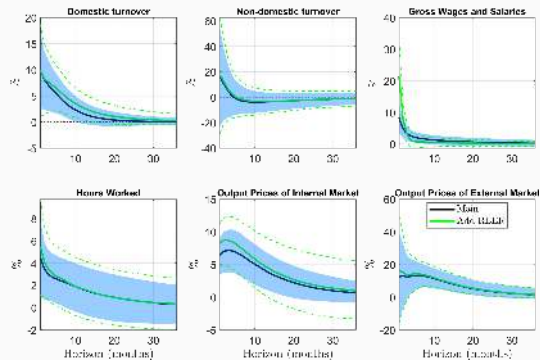
Notes: Benchmark (black, shaded bands) and recursive ordering (green).

The main difference is the hump-shaped responses of gross wages and external output prices under the recursive ordering.

Two further checks: 12 lags and REER as exogenous variable



Notes: BVAR(12)



Notes: Model with the REER as exogenous variable

The full set of figures is in the appendix of the paper.

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