Uncertainty in climate policy and the energy industry

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Climate policy uncertainty may matter for the energy industry

- Climate change and sustainability imperatives make **policy uncertainty** increasingly important
- Governments must craft climate policies that meet targets **without disrupting existing industries**
- The energy industry sits in the middle of these decisions, balancing economic benefits and climate goals
- The trade-off between environmental stewardship and economic stability shapes policy, yet remains **empirically underexplored**

Question
How does climate policy uncertainty (CPU) affect the energy industry? Do sectoral responses differ across turnover, labour and prices?

What the paper does

- **Portugal's energy industry**: new sectoral survey data, monthly, January 2005 to December 2022
- Six variables: **domestic and non-domestic turnover**, **gross wages**, **hours worked**, and **output prices** at home and abroad
- A **Bayesian structural VAR**; the CPU shock is identified with a **correlation restriction**, using a Portuguese CPU index (Morão 2025) as a proxy (Ludvigson et al. 2021)
- Impulse responses, variance decomposition and historical decomposition, then sensitivity checks

Why Portugal
A rapid transition towards renewables alongside traditional sources such as natural gas, and EU membership, so national initiatives interact with EU directives.

Preview of results

- **Turnover**: a CPU shock raises domestic turnover, strongly and persistently; the non-domestic response is positive but imprecise
- **Prices**: output prices rise at home and abroad, **more strongly in foreign markets**
- **Labour**: wages are unchanged; hours worked increase only marginally
- **History**: CPU shocks account for a sizeable share of past fluctuations; their contribution changes from dampening to positive over time
- The paper reports that the main finding holds across the sensitivity checks

Related literature

1. **CPU indices and their consequences**: Gavriilidis (2021) builds a news-based index and links CPU to lower CO_2 emissions with a recursive SVAR; Apergis et al. (2023) links CPU to travel demand
2. **Financial markets**: CPU and market volatility, in stock and bond markets (Yu et al. 2023; Lasisi et al. 2022), carbon markets (Wu et al. 2022) and oil (Salisu et al. 2023); since the Paris Agreement, CPU has played a bigger role in oil-market fear (Xiao and Liu 2022)
3. **Firm behaviour**: CPU raises corporate (green) innovation (Zhu et al. 2023; Huo et al. 2023) but may lower it (Mao and J. Huang 2022); it lowers investment (Gao and Zhang 2023; T. Huang and Sun 2023); firms adopt pollution-reducing technology (Wang 2022); carbon-intensive sectors lose market value (Khalil and Strobel 2023)

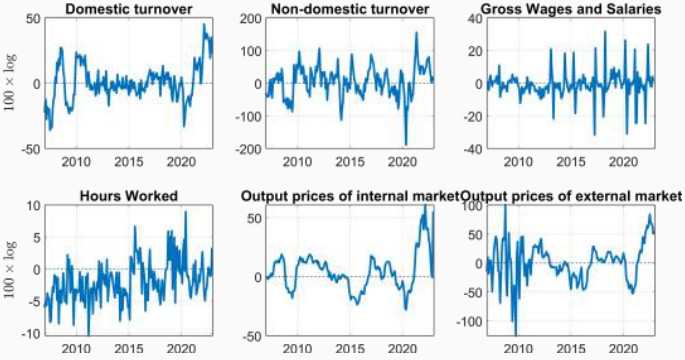
Contribution

- **Real-sector evidence**: how CPU shocks affect turnover, labour and prices in a single industry, complementing firm-level studies and financial-market studies
- **New data**: the Portuguese CPU index (Morão 2025) with novel Portuguese sectoral survey data
- **Identification**: the CPU index enters as a **proxy** for the structural shock (Ludvigson et al. 2021), not as a recursively ordered variable; the paper compares with the recursive alternative (Kilian et al. 2022)

Closest papers
Gavriilidis (2021) and Apergis et al. (2023) study consequences of CPU; Morão (2025) studies the macroeconomic effects of CPU in Portugal.

Data and Method

Data: six indices for Portugal's energy industry

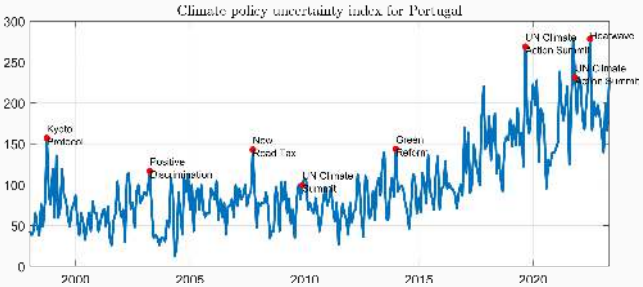


Notes: Baseline series in 100×log; panels in the order of the list at right.

- Monthly, January 2005 to December 2022
- **Domestic turnover** t_t: revenue from the industry in Portugal
- **Non-domestic turnover** t_t^*: exports and global transactions
- **Gross wages and salaries** w_t
- **Hours worked** h_t
- **Output prices**: home π_t and foreign π_t^* markets

Data sources

The shock proxy: a news-based CPU index for Portugal



Notes: Climate policy uncertainty index for Portugal, index points; dots mark events labelled in the figure.

- Built as in Baker et al. (2016): counts articles with at least one keyword from each of three groups, **climate**, **policy**, **uncertainty**
- Index developed in Morão (2025)
- Used as a **proxy**, not as an endogenous variable of the VAR

Keyword list

Model: a Bayesian structural VAR

Six endogenous variables, $y_t = [t_t,\ t_t^*,\ w_t,\ h_t,\ \pi_t,\ \pi_t^*]'$, and p lags:

$$y_t' \mathcal{D}_0 = \mathcal{C} + \mathcal{D}_1 y_{t-1}' + \cdots + \mathcal{D}_p y_{t-p}' + \eta_t', \qquad \eta_t \sim \mathcal{N}(0, I)$$

η_t: structural shocks; $\mathcal{D}_0$: contemporaneous interactions (invertible). Reduced-form innovations $\varepsilon_t' = \eta_t' \mathcal{D}_0^{-1}$.

- **Six lags**, a constant, and the Portuguese Economic Policy Uncertainty index (Morão 2024) as exogenous term; variables in log annual rates
- **Independent Normal–Wishart prior**, similar to the Minnesota prior (Litterman 1986) but not conditioning the prior for β on Σ
- Gibbs sampler (Dieppe et al. 2016): 5,000 iterations, the first 2,000 discarded
- Output: impulse responses (IRF), forecast error variance decomposition (FEVD), historical decomposition (HD)

Hyperparameters

Identification: a correlation restriction on the CPU shock

- Recursive identification rests on restrictive assumptions that may not match economic intuition (Kilian et al. 2022)
- Instead, following Ludvigson et al. (2021), the CPU shock $\eta_{1,t}$ must be correlated with the index S_t:

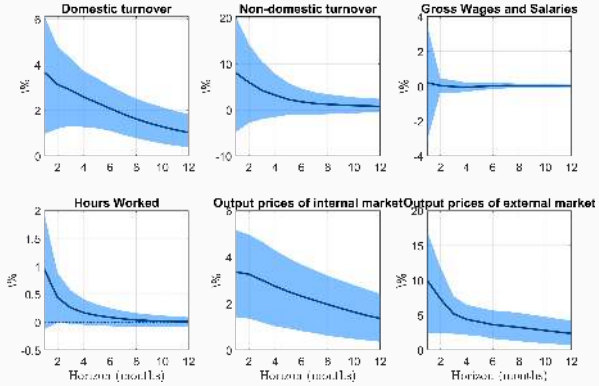
$$\rho_1 = \text{corr}(S_t, \eta_{1,t}) \geq \bar{c}$$

- S_t: the Portuguese CPU index; $\bar{c}$: a threshold correlation
- Ensures a strong link between the shock and the index while leaving the relations among the endogenous variables flexible
- Impulse responses are normalized to a **10% rise in foreign output prices on impact**; bands are 68% credible

Recursive alternative

Results

A CPU shock raises turnover and prices; wages do not move



Notes: Normalized to a 10% rise in foreign prices on impact. Line: posterior median; shaded: 68% credible bands.

- **Domestic turnover**: strong and persistent increase, about 3.6% on impact and still above zero after a year (read from the figure)
- **Non-domestic turnover**: positive but wide bands
- **Wages**: no response
- **Hours**: marginally significant increase
- **Prices**: both rise persistently; foreign is larger

Prices and turnover: the paper's reading

Turnover and labour

- Domestic turnover: firms may read uncertainty as foreshadowing favourable conditions for sustainability and invest in low-carbon technology
- Non-domestic: firms may already face global regulation, or wait and see
- Wages: firms seem to prioritize capital investment over labour costs
- Hours: a small uptick, possibly from adopting green technology or reconverting processes

Output prices

- Both rise: a response to higher carbon-reduction costs
- Foreign prices respond more: about 10% (normalized) against roughly 3–4% at home
- Possible reasons: higher climate awareness among foreign buyers, stricter foreign regulation, or amplification by other variables such as exchange-rate risk

CPU shocks raise domestic turnover and prices, and foreign prices are the most sensitive.

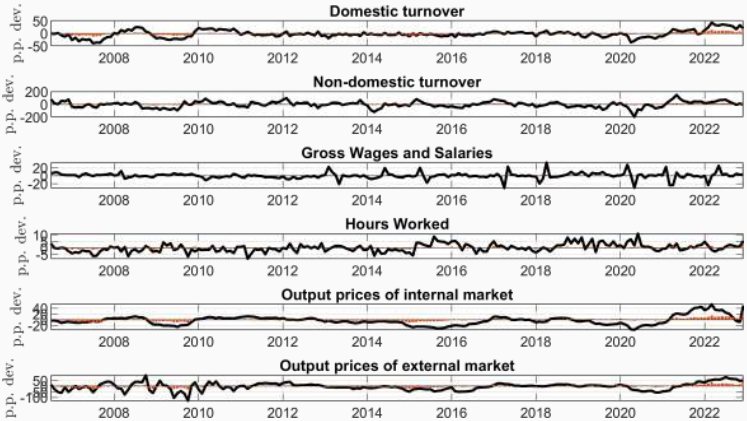
How much of the variation does the CPU shock explain?

Horizon (months)	t_t	t_t^*	w_t	h_t	π_t	π_t^*
1	29.20	12.80	9.83	16.66	35.90	27.38
6	36.35	13.39	10.00	16.19	35.12	29.90
12	35.18	13.82	10.00	16.10	34.39	29.04

Notes: Median share (%) of forecast error variance explained by the CPU shock.

- **Largest** for domestic turnover and home prices (about 29% and 36% at one month); foreign prices 27%
- **Smaller** for non-domestic turnover (12.8%), hours (16.7%) and wages (9.8%)
- Shares change little from one to twelve months; domestic turnover rises from 29% to 35%, which the paper reads as lagged adjustment

Historical decomposition: CPU shocks and past fluctuations



Notes: Bars: median contribution of the CPU shock; line: the series, in p.p. deviations.

- **Procyclical**: contributions fall when the series falls, rise when it rises
- **Domestic turnover**: about a third of the variation in 2007, 2009 and mid-2022 (paper)
- **Prices**: negative contributions in 2007 and 2009; minimal in 2010–2012
- **Non-domestic turnover**: modest, in line with the wide IRF bands

The CPU contribution changes sign over the sample

Early sample

- CPU shocks **dampened** domestic turnover and output prices
- The paper links the 2007 and 2009 price falls to events such as scrutiny of biofuel viability and the US policy shift
- During 2010–2012 the contribution is minimal, amid the Portuguese debt crisis

Later sample

- The negative contributions recede and turn **positive**; in the figure, clearest in 2021–22
- The paper attributes this to the rise of sustainability-focused firms and investment in low-carbon technology
- CPU is linked to global events such as COP26 and to domestic carbon and car tax changes

CPU has been a key driver of historical variations in the energy sector, and its sign has shifted.

Robustness: results hold in sign, with some loss of precision

- **Recursive (Cholesky) identification**: more optimistic and more persistent effects on domestic turnover and both prices; wages remain insignificant
- **Model specification**: real effective exchange rate added; exogenous variable dropped; 4, 1 and 12 lags; alternative priors and hyperparameters; identity S_0; linear trend; no constant; 5% correlation threshold
- **Pandemic and war** excluded: the domestic-turnover and home-price responses shrink in the paper's figure

Paper's assessment

The tests are consistent and the main finding remains unchanged. In the figures, the sign of the domestic-turnover and price responses is generally kept, but several variants have bands that include zero for home prices.

Cholesky | Pandemic, war | Lags | Priors | Exog., threshold

Caveats

- **Non-linearities**: the SVAR may not capture non-linear effects of global crises; the paper leaves this for future research
- **Imprecise responses**: non-domestic turnover has wide bands and hours worked is only marginally significant
- **Identification**: the recursive alternative gives more optimistic and persistent effects
- **Interpretation**: the channels behind the responses are offered as likely explanations (for example, investment in low-carbon technology or wait-and-see behaviour)
- **Scope**: one country; the paper expects the findings to apply most to countries with a mix of energy sources undergoing transitions, but size and mechanisms may vary with energy market liberalization and economic structure

Conclusion

1. CPU shocks have a **significant impact** on Portugal's energy industry; most sensitive are domestic turnover and output prices at home and abroad
2. Prices rise in both markets, **more so abroad**; wages are unchanged, hours worked rise only marginally
3. CPU shocks contributed to the ups and downs of the sector over time
4. Policy: **predictable climate policy** limits the negative effects of uncertainty
5. Next: non-linearities from global crises, other industries, other countries

Thank you!

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Backup

CPU index: keyword groups

Climate (C)

"carbon dioxide", "CO_2", "carbon emissions", "carbon neutrality", "carbon neutral", "CO_2 reduction", "carbon reduction", "greenhouse gases", "greenhouse effect", "global warming", "acid rain", "climate", "renewable energy", "green energy", "wind energy", "solar energy", "solar panel/s"

Policy (P)

"parliament", "government", "ministry of finance", "environmental fund", "European Commission", "deficit", "budget", "tax/es", "legislation", "standards", "normatives", "regulations", "rules", "laws"

Uncertainty (U)

"uncertain", "uncertainty", "instability", "unpredictability", "unstable", "indefiniteness", "insecurity", "doubt", "indecision", "risk/s"

An article counts if it contains at least one keyword from each group.

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Data description and sources

Label	Description	Source
S_t	Climate policy uncertainty in Portugal	Morão (2025)
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 (home)	INE/own
π_t^*	Index of output prices (foreign)	INE/own
epu_t	Economic policy uncertainty index for Portugal	Morão (2024)

Notes: Monthly series. Labels follow the definitions in the paper's text.

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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_2	0.5	cross-variable weighting	2 in one check
λ_3	1	lag decay	used in all models
λ_4	10^5	exogenous variable tightness	used in all models

Notes: Values commonly reported in the literature, as stated in the paper.

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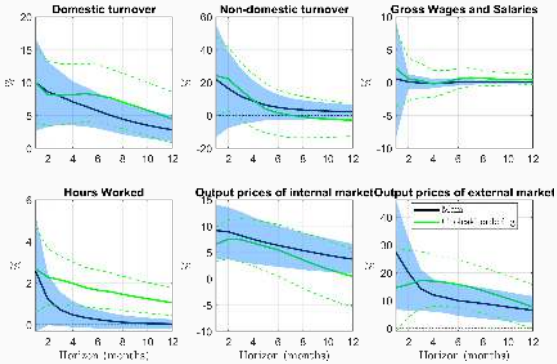
Recursive (Cholesky) identification versus the proxy



Notes: Main (black, shaded 68% bands) and recursive ordering (green). The figure is normalized differently from the baseline IRF figure (domestic turnover about 10% on impact).

The recursive model gives more persistent effects on domestic turnover and both prices; non-domestic turnover gains significance in the first months; wages remain insignificant.

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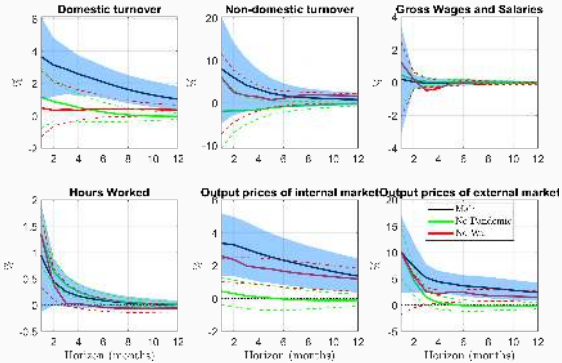
Excluding the pandemic or the war



Notes: Main (black, shaded 68% bands), without the pandemic (green) and without the war (red), as labelled in the figure.

In the figure, the domestic-turnover and home-price responses are visibly smaller when the pandemic is removed.

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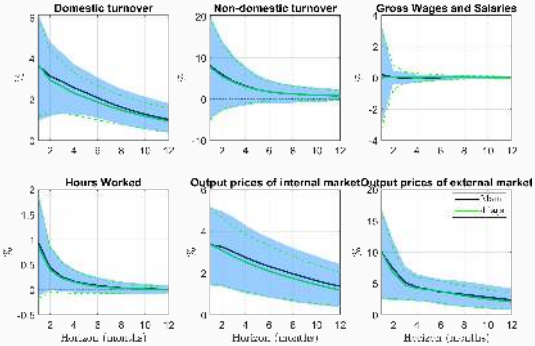
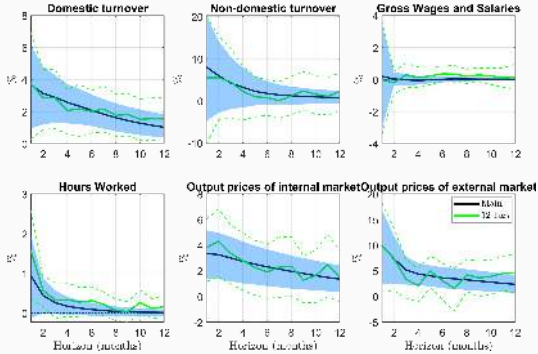
Lag length: 4 and 12 lags



Notes: BVAR(4), lag length chosen by AIC.



Notes: BVAR(12).

Main (black, shaded) against the alternative lag length (green). A BVAR(1) is also in the paper's appendix.

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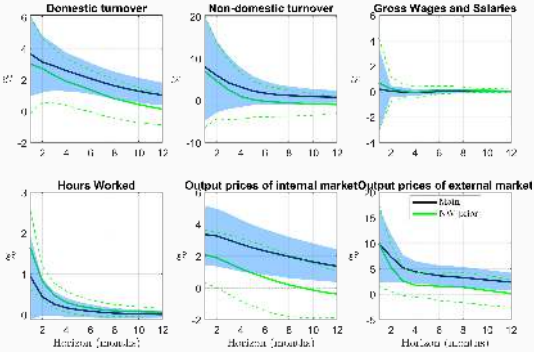
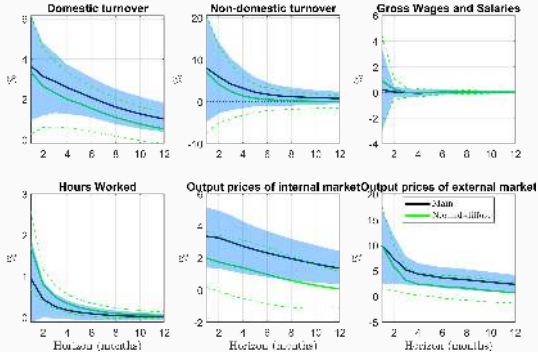
Alternative priors



Notes: Normal–Wishart prior.



Notes: Normal–diffuse prior.

Main (black, shaded) against the alternative prior (green). More prior variants are in the paper's appendix.

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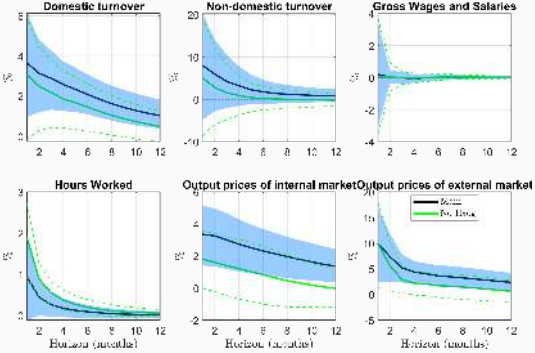
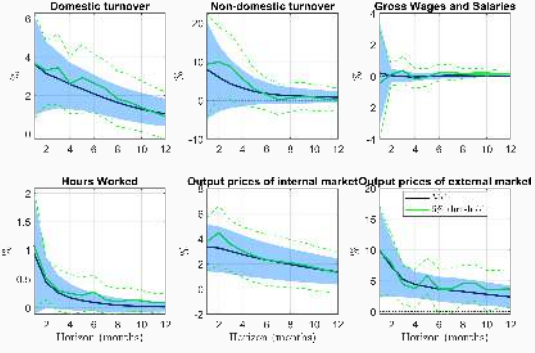
No exogenous variable and a 5% correlation threshold



Notes: Model excluding the exogenous variable.



Notes: Identification with a 5% correlation threshold.

Main (black, shaded) against the alternative (green).

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