

The macroeconomic effects of climate policy uncertainty: Evidence from Portugal

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October 2026

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Introduction

Climate policy is high on the agenda, but its uncertainty is little studied

- Climate policy has unprecedented prominence: domestic legislation, the Paris Agreement and national carbon pricing schemes, with **potentially far-reaching economic impacts**
- Yet the uncertainty about how these policies will be implemented, and what they will do, has remained **largely unexplored through a macroeconomic lens**
- Portugal is an **early adopter of green policies**, the setting of the paper

Question

How do shocks to Climate Policy Uncertainty (CPU) affect key macroeconomic variables?

This paper: a news-based CPU index feeds a Bayesian SVAR

Measurement

Textual analysis of Portuguese news sources: a **monthly CPU index** built from articles that mention climate, policy and uncertainty terms together

Model

Bayesian **structural VAR** with six monthly macro series, 1998m1–2022m12; the CPU shock is identified with a Cholesky decomposition

Asymmetries

Local projections of the CPU shock, split by **size** (small vs. large) and by **sign** (positive vs. benchmark)

Preview of results

- **Production and emissions:** higher CPU lowers industrial production and CO₂ emissions; both respond more strongly to positive and to large shocks
- **Labour market:** unemployment rises persistently; the rise is steeper after positive and after large shocks
- **Stock prices** respond positively despite the fall in production; the paper reads this as markets anticipating benefits for environmentally aligned sectors
- **Consumer prices** drift up, with wide credible bands; **policy uncertainty** dips first, then turns positive

The paper notes that the sign asymmetry is not severe enough to change the main interpretation.

Related literature

1. **Policy uncertainty and the economy:** the news-based approach of Baker et al. (2016), surveyed in Al-Thaqeb and Algharabali (2019); this literature mostly finds adverse effects of uncertainty shocks
2. **Asymmetric and financial-market effects of CPU:** asymmetric effects on green bond returns (Gyamerah et al. 2024), of uncertainty proxies (Kisswani and Elian 2021) and on stock returns (Batabyal and Killins 2021); country differences (Nusair et al. 2024). Mixed evidence: links to volatility (Lasisi et al. 2022; Salisu et al. 2023), but no significant effect on sustainable green asset returns (Akpa et al. 2023)
3. **Firms and Europe:** CPU and green innovation (Huo et al. 2023; Mao and J. Huang 2022), pollution-reducing technology (Wang 2022), investment (T. Huang and Sun 2023; Gao and Zhang 2023); the European setting in Pinar and Karahasan (2024), Basaglia et al. (2025) and Tedeschi et al. (2024)

- **A monthly CPU index for Portugal**, from news text, following Baker et al. (2016) and the CPU approach of Gavriilidis (2021) as adapted to Portugal by Morão (2025b)
- **Macroeconomic effects through several channels at once**: production, emissions, employment, prices, stock prices and policy uncertainty, in a European setting
- **Size and sign asymmetries** of the responses, studied across the main macroeconomic variables

Closest paper

Gavriilidis (2021) pioneered textual analysis of CPU and found a negative association between CPU and CO₂ emissions. This paper extends the evidence to macroeconomic effects in a European context.

Data and Method

Measuring CPU: articles that combine climate, policy and uncertainty terms

Climate (C)

CO₂, carbon emissions, greenhouse gases, global warming, climate change, renewable energy, ...

Policy (P)

parliament, government, ministry of finance, European Commission, budget, taxes, legislation, regulations, ...

Uncertainty (U)

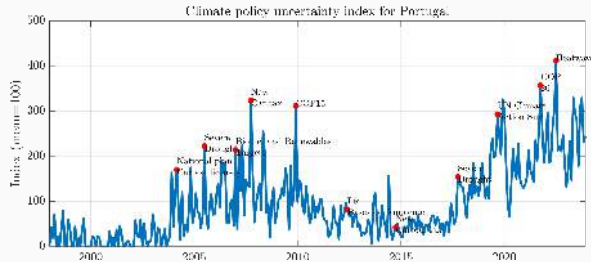
uncertain, uncertainty, instability, unpredictability, doubt, indecision, risk, ...

- An article counts only if it has terms from **all three** categories; monthly article frequencies are gathered for each news outlet
- Portuguese-language content with Portugal as the geographic focus
- Substantive news reporting only: 99–2000 words; no summaries, opinion pieces, interviews or headline-only stories

Search terms

News sources

The CPU index peaks at major domestic and global climate events

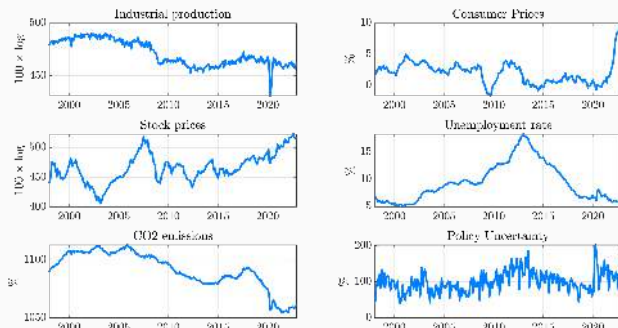


Notes: Climate policy uncertainty index for Portugal (mean = 100); dots mark the events discussed in the paper.

- Peaks coincide with, e.g., the national carbon licenses plan (2004), the 2005 drought, COP15 (2009), the UN Climate Action Summit (2019), COP26 (2021) and the heatwave
- The paper reports that the index aligns with the climate change news index of Engle et al. (2020) (COP15) and with water-related events in Morão (2023) (e.g. the 2005 drought)

Event list Climate awareness index

Data: six monthly macro series, 1998m1–2022m12



Notes: The macroeconomic data series in the baseline model, as plotted in the paper.

- **Industrial production**
- **Consumer prices:** headline inflation
- **Unemployment rate:** harmonized
- **Stock prices:** total share prices, all shares
- **CO₂ emissions**
- **Economic policy uncertainty (EPU)** for Portugal (Morão 2024)
- Variables enter in levels, not differences

Data sources

Model and identification: Bayesian VAR, Cholesky-identified CPU shock

Bayesian VAR with n endogenous variables y_t , m exogenous variables x_t and p lags:

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

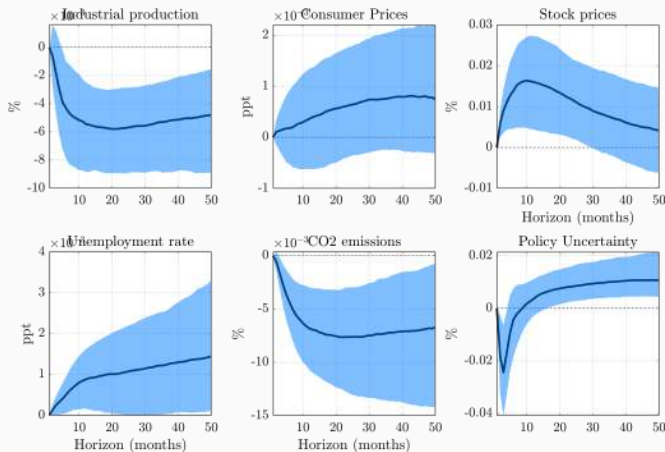
Structural shocks η_t from a Cholesky decomposition (Baker et al. 2016; Morão 2025a): $\varepsilon_t = \mathcal{D} \eta_t$

- Independent Normal–Wishart prior: $\beta \sim \mathcal{N}(\beta_0, \Omega_0)$ with $\beta_0 = 0$ and Ω_0 diagonal, from AR(1) residual variances (Litterman 1986); $\Sigma \sim \mathcal{IW}(S_0, \alpha_0)$ (Karlsson 2013)
- Gibbs sampler (Dieppe et al. 2016), BEAR 5.0 toolbox: 5,000 iterations, first 4,000 discarded
- Six lags and a constant; monthly data, 1998m1–2022m12
- The paper argues the SVAR identifies structural shocks without strong contemporaneous restrictions and lets the CPU index enter the model directly

Hyperparameters

Results

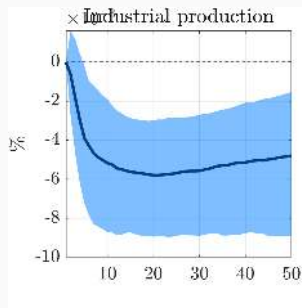
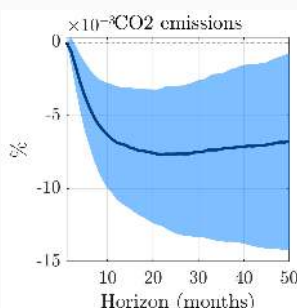
A CPU shock cuts production and emissions, lifts unemployment and stocks



Notes: Impulse responses to a CPU shock. Solid line: posterior median; shaded: 68% credible bands. Horizon in months.

- **Industrial production** falls and stays below zero over the horizon
- **CO₂ emissions** fall as well
- **Unemployment** rises steadily
- **Stock prices** rise
- **Consumer prices** drift up, but the bands are wide
- **EPU** first dips, then turns positive

Production and emissions: firms cut output first, then emissions

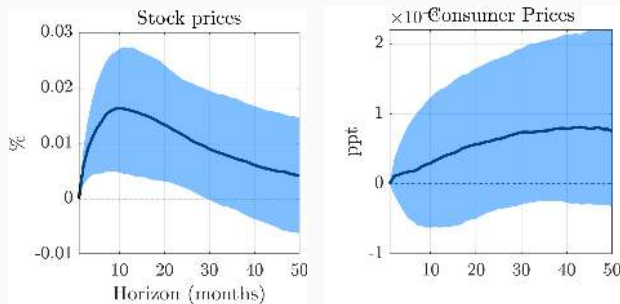


Notes: Industrial production and CO₂ emissions, from the baseline impulse responses; 68% credible bands.

- Both drop quickly in the first year
- Emissions keep falling until close to the second year, while the decline in production moderates earlier (paper's text)
- The paper reads this as a **two-stage adaptation**: firms first cut output, then change emissions intensity (cleaner energy, efficient equipment, product mix)

The primary channel runs through industrial production.

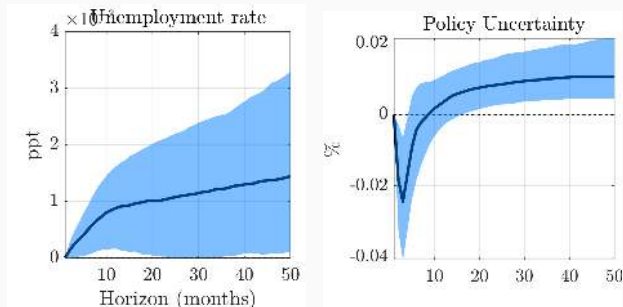
Stock prices rise; consumer prices drift up with wide bands



Notes: Stock prices and consumer prices, from the baseline impulse responses; 68% credible bands.

- **Stock prices:** a positive response that fades over time. The paper reads it as investors expecting gains in green-aligned sectors (Bouri et al. 2022), **but it may also be speculative behaviour**
- **Consumer prices:** a gradual rise; the credible bands are wide, so there is **some uncertainty** in the estimates
- The paper links the gradual rise to firms eventually passing costs on, in line with “wait-and-see” behaviour (Hoang 2022)

Unemployment rises persistently; policy uncertainty dips, then turns positive



Notes: Unemployment rate and economic policy uncertainty, from the baseline impulse responses; 68% credible bands.

- **Unemployment:** a persistent upward trend; the paper reads it as a longer-term, structural adjustment in industries exposed to regulatory change
- **EPU:** an initial negative spike, then a gradual return to positive territory
- The paper reads the dip as the confusion when legislation is proposed or debated, and the return as legislation moving through parliament

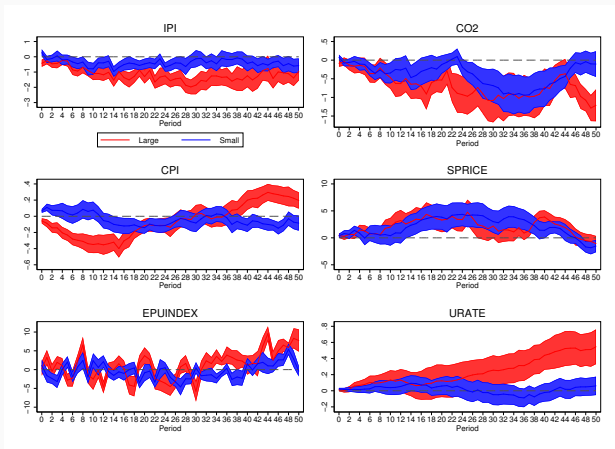
Asymmetries: local projections split the CPU shock by size and by sign

Local projections (Jordà 2005), implemented with Ugarte-Ruiz (2023), on the SVAR CPU shock η_t^{CPU} :

$$y_{t+h} = \alpha_h + \theta_h^{small} \eta_t^{CPU} \mathcal{I}(\text{small}) + \theta_h^{large} \eta_t^{CPU} \mathcal{I}(\text{large}) + X_t' \beta_h + \varepsilon_{t+h}$$

- **Size:** θ_h^{large} and θ_h^{small} are the dynamic effects of large and small shocks. Large shocks are those above the 90th percentile of the distribution, matching major events such as climate conferences or environmental disasters (paper)
- **Sign:** the effects of positive shocks are compared with those of the benchmark (all shocks) from the SVAR
- The paper judges that the larger credible bands of the positive and large-shock estimates justify keeping both signs in the baseline

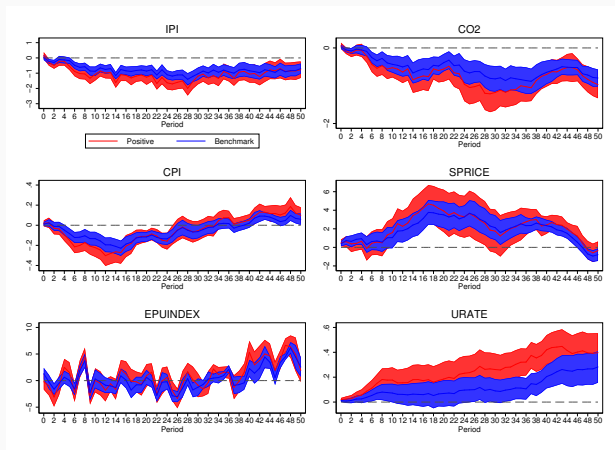
Large shocks have stronger effects, above all on unemployment



Notes: Large (red) and small (blue) CPU shock. Panels: IPI, CO₂, CPI, stock prices, EPU, unemployment rate (URATE).

- The responses mirror the baseline, with greater magnitude
- **Production:** large shocks cut output by about 2% at the peak (paper's text); **CO₂** falls more too
- **Consumer prices:** large shocks first lower prices, then raise them later; small shocks move them little
- **Stock prices:** similar for both sizes; large shocks look more volatile
- **Unemployment:** the most asymmetric; a significant rise after large shocks, only slight changes after small ones

Positive shocks cut production and raise unemployment more



Notes: Positive CPU shock (red) and benchmark (blue). Panels as in the size figure.

- Some sign asymmetry, but **not enough to change the main interpretation**
- **Production** and **CO₂**: larger declines after positive shocks (production: about 1.5% vs. roughly 1%, paper's text)
- **Consumer prices**: little asymmetry
- **Stock prices**: same sign, a bit more positive
- **Unemployment**: starts similar, then diverges; about 0.4 vs. 0.25 by period 50 (paper's text)
- **EPU**: slightly higher after period 30

Robustness and conclusion

Robustness: the paper finds its main conclusions hold across variants

- **Sample:** adding the COVID-19 pandemic period
- **Exogenous variable:** Global EPU as an alternative; no exogenous variable
- **Lags:** 3 and 12 instead of 6
- **Prior and hyperparameters:** Normal–Wishart, Normal–diffuse, diffuse with $\lambda_1 = 1000$, $\lambda_1 = 1$ with $\lambda_2 = 2$, grid-search optimum, identity S_0 , sum-of-coefficients and dummy prior (unit root or cointegration)

Paper's assessment

By visual inspection, the central conclusions remain: CPU shocks have a significant effect on the macroeconomy, although some estimates vary.

In the appendix figures, the consumer-price response is the one that changes most across variants.

Pandemic No exog. Lags Priors Hyperparameters S_0 , unit root

Limits: what the paper itself flags

- **Uncertainty:** the bands shown are 68% credible bands; for consumer prices the paper notes they are wide
- **Interpretation:** the explanations (costs passed on gradually, markets favouring green sectors, two-stage adaptation of firms) are the paper's readings of the responses; the paper adds that the stock response may also reflect speculative behaviour
- **Asymmetries:** positive- and large-shock estimates carry wider credible bands; the sign asymmetry does not change the main interpretation
- **Robustness:** assessed by visual inspection of impulse responses, and some variations in the estimates do occur

Conclusion: costs in production and jobs, optimism in stock markets

- The primary channel is **industrial production**, which falls; emissions fall too (two-stage adaptation, as the paper reads it)
- **Stock prices** rise: markets seem to expect gains for sectors that support stricter environmental rules
- **Unemployment** rises gradually and persistently; **consumer prices** show a modest but steady increase, with wide bands
- Effects differ by shock **sign and size**: positive and large shocks have deeper effects

Climate policy uncertainty raises costs through lower production and higher unemployment; the stock market's rise shows optimism about long-term sustainability.

Thank you! hmorao@phd.iseg.ulisboa.pt

Policy implications, as stated in the paper

1. Governments should establish **clear legislative timelines** for climate policies (specific carbon pricing and emissions standards), so firms can plan investment and adjust their workforces
2. Implement regulatory changes **in stages**, announcing detailed guidelines well in advance
3. **Targeted support** for the industries hit hardest: technology adoption incentives and workforce training
4. **Simplify approval processes** for green projects, to reduce uncertainty while keeping environmental standards
5. **Transparent monitoring frameworks**, so markets can anticipate and adapt to policy adjustments

Future research (paper)

How different economies manage the transition, and how to reduce legislative uncertainty while meeting environmental goals.

Backup

CPU index: search terms

Climate (C)

Carbon Dioxide, CO₂, Carbon Emissions, Carbon Neutrality, Carbon Neutral, CO₂ Reduction, Carbon Reduction, Greenhouse Gases, Greenhouse Effect, Global Warming, Acid Rain, Climate Change, Renewable Energy, Green Energy, Wind Energy, Solar Energy, Solar Panel/s

Policy (P)

Parliament, São Bento Palace, Government, Ministry of Finance, Environmental Fund, European Commission, Deficit, Budget, tax/es, Legislation, Reforms, Standards, normatives, regulations, rules, laws

Uncertainty (U)

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

Search run in Dow Jones Factiva on Portuguese-language content; the full query is in the paper's appendix. Articles must have 99–2000 words; summaries, calendars, corporate reports, rankings, routine financial updates, interviews, opinion pieces and headline-only stories are excluded.

CPU index: news sources

Name	Freq	Type	From	To
Jornal de Notícias	D	National	1998m1	2023m3
Correio da Manhã	D	National	2008m12	2023m3
Diário de Notícias	D	National	2010m5	2023m3
Público	D	National	2010m11	2023m3
Expresso	W	National	2013m9	2023m3
Jornal i	D	National	2013m12	2023m3
O Sol	W	National	2017m1	2023m3
Vida Económica	D	Business	1998m1	2023m3
Diário Económico	D	Business	1998m2	2016m5
Jornal de Negócios	D	Business	2011m10	2023m3

Name	Freq	Type	From	To
Dinheiro Vivo	W	Business	2014m4	2023m3
O Jornal Económico	W	Business	2017m7	2023m3
Açoriano Oriental	D	Regional	2010m6	2023m3
Jornal do Fundão	W	Regional	2011m7	2018m7
Observador		Online	2017m7	2023m3
ECO		Online	2019m2	2023m3
Executive Digest		Magazine	2019m11	2023m3
Reuters		News agency	1998m1	2023m3
Agência Lusa		News agency	2001m2	2023m3

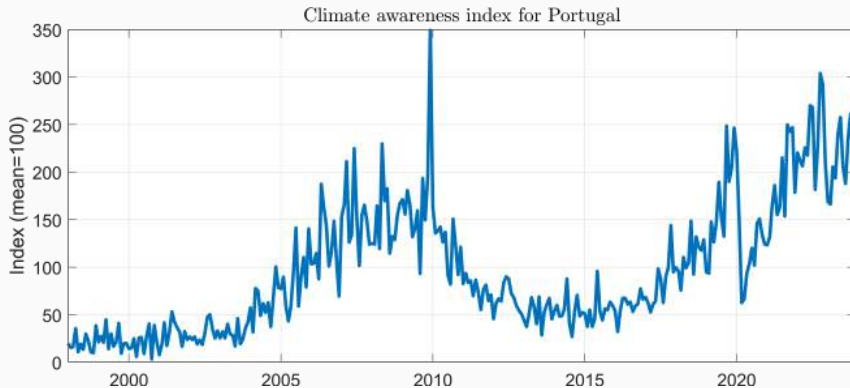
Notes: D = daily, W = weekly. Start and end of data collection for each source, as listed in the paper.

Major events highlighted by the CPU index

Year	Month	Event
2003	Dec	Proposal for carbon emission and vehicle taxes
2004	Mar	Initiation of national carbon licenses plan
2005	Jul	Severe drought
2007	Jan	Speech on new biofuels and renewables targets
2007	Oct	Road tax increase
2009	Dec	COP 15
2012	Jun	Implementation of “Lei de Bases do Ambiente”
2017	Nov	Severe drought
2019	Sep	UN Climate Action Summit
2021	Oct	COP 26 climate conference
2022	Jul	Heatwave

Notes: Table of major events in Portugal highlighted by the index, as in the paper.

A climate awareness index: drop the policy and uncertainty blocks



Notes: Climate awareness index, obtained by removing the Policy and Uncertainty blocks from the search.

Data description and sources

Label	Description	Source
y_t	Industrial production in Portugal	FRED
$co2_t$	CO ₂ emissions for Portugal	Own
π_t	Headline inflation rate for Portugal	FRED/own
u_t	Harmonized unemployment rate	FRED
s_t	Total share prices for all shares for Portugal	FRED
epu_t	Economic policy uncertainty index for Portugal	Morão (2024)

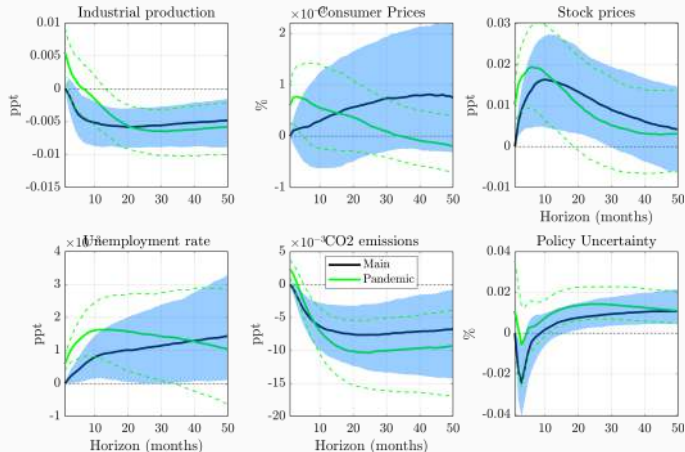
Notes: Monthly series, 1998m1–2022m12 in the main specification.

Hyperparameters of the prior

	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

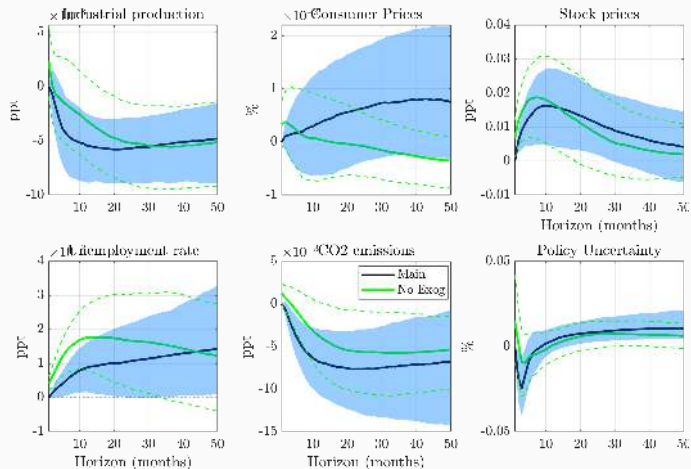
Notes: Hyperparameters set to values generally accepted in the literature (paper).

Robustness: adding the pandemic



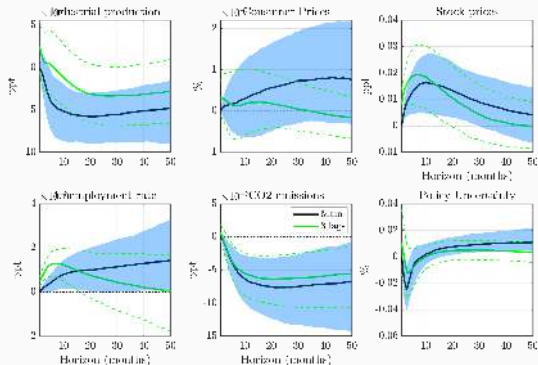
Notes: Baseline (black, shaded) and the model that adds the COVID-19 pandemic (green). Panels as in the baseline figure.

Robustness: no exogenous variable

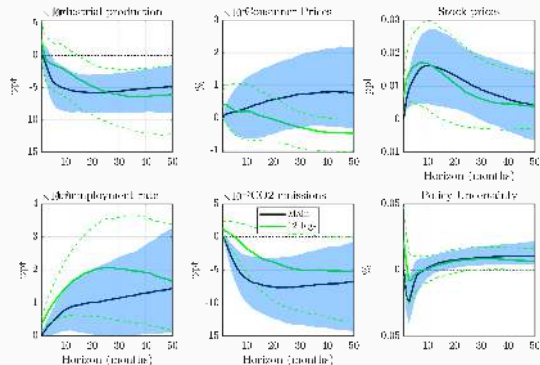


Notes: Baseline (black, shaded) and the model excluding the exogenous variable (green).

Robustness: 3 and 12 lags

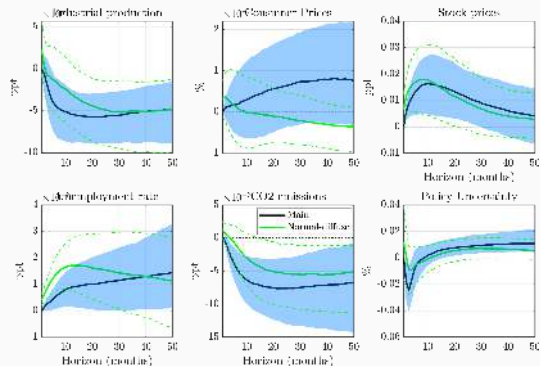
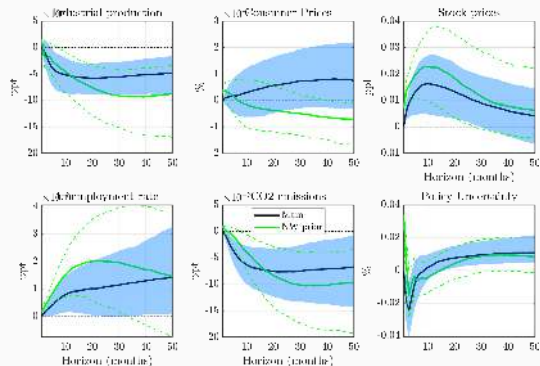


Notes: BVAR(3)

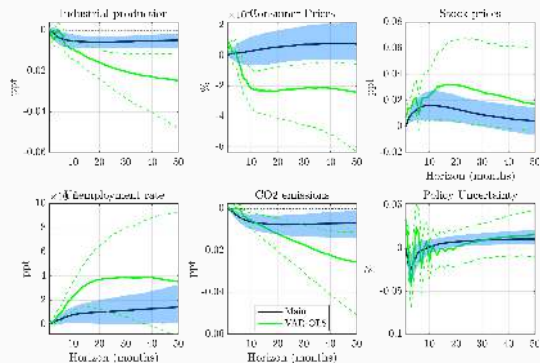


Notes: BVAR(12)

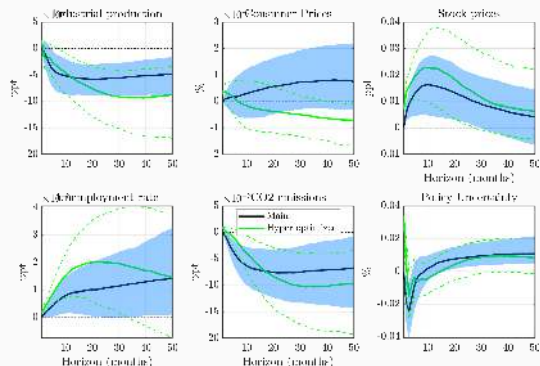
Robustness: alternative priors



Robustness: hyperparameters

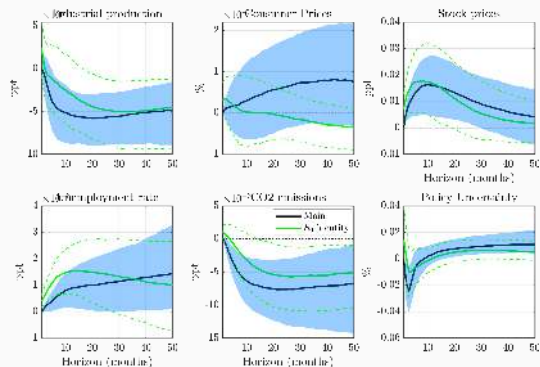


Notes: $\lambda_1 = 1$ and $\lambda_2 = 2$ (legend: VAR-OLS)

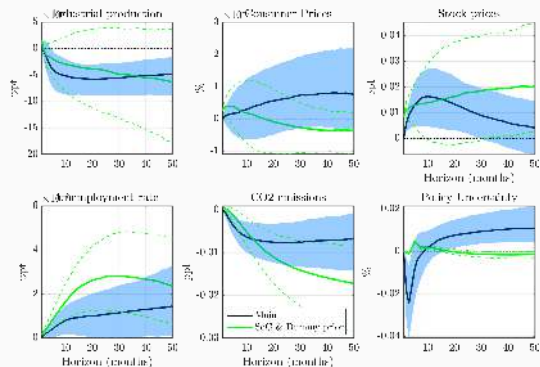


Notes: Hyperparameters optimized by grid search

Robustness: identity S_0 and sum-of-coefficients prior



Notes: S_0 identity matrix



Notes: Sum-of-coefficients and dummy prior (unit root or cointegration)

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