

Weather Shocks and Sectoral Dynamics in European Economies

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Motivation

- What are the macroeconomic impacts of weather shocks?
- Are effects confined to **directly exposed** sectors, or do **indirect spillovers** propagate through the economy?
- Does the **type of shock** matter for the sign, magnitude, and persistence of the response?

We address these questions by proposing a **novel measure of country-level exposure to abnormal weather** and studying the effects of **cold, heat, drought, precipitation, and wind** shocks in a Bayesian VAR framework.

What we do

- **New measurement:** country-level exposure to *abnormal* weather using daily grid-cell data, aggregated with economic-activity weights
- **Scope:** Germany, France, and Italy (largest European economies)
- **Outcomes:** sectoral output and prices (energy, construction, manufacturing, services)
- **Why this matters:**
 - existing evidence largely focuses on temperature; composite indices are increasingly used (Kim et al., 2025)
 - but composite measures can mask heterogeneity and transmission channels across shocks and sectors
- **Policy relevance:** accurate exposure measurement enables sector-specific adaptation by pinpointing the most exposed sectors and channels.

Preview of main findings

- Abnormal weather has **significant and heterogeneous** effects, operating through **direct** and **indirect** channels
- **Construction (most exposed)**: cold and wind reduce activity; heat has a *latitude effect*-positive in colder Germany, negative in warmer Italy
- **Energy (demand & supply channels)**: cold shocks raise heating demand, while wind shocks affect the supply side by lowering electricity generation costs (and energy prices).
- **Manufacturing (mainly indirect)**: responds through spillovers, especially via weather-driven energy price fluctuations
- **Services**: first evidence for Europe-overall limited effects, but some sub-sectors react to heat; responses line up with construction, suggesting possible spillovers

Related literature and contribution

- **Climate vs. weather; abnormal vs. disasters.** Climate (IAMs) (Hassler & Krusell, 2018; Nordhaus, 1993); weather fluctuations (Dell et al., 2012; Hsiang, 2016). Natural disasters: (Felbermayr & Gröschl, 2014; Ferriani et al., 2024; Kruttli et al., 2023; Strobl, 2011).
- **Empirical approaches.** Panels (rich geography): Billio et al. (2020), Bloesch and Gourio (2015), Kotz et al. (2022), Starr (2000), and Wilson (2019). SVARs (rich dynamics): (Ciccarelli et al., 2023; Kim et al., 2025).
- **Sectors and channels.** Agriculture: (Ciscar et al., 2011; Gallic & Vermandel, 2020); broader sectors/channels: (Donadelli et al., 2017; Graff Zivin & Neidell, 2014; Roth Tran, 2022). Demand vs supply: (Auffhammer & Mansur, 2014; Burke et al., 2005; Ciccarelli & Marotta, 2021; Deryugina & Hsiang, 2014).
- **Our contribution.** Develop activity-weighted, grid-level *country exposure* indices for Europe and trace dynamic effects of *cold, heat, drought, precipitation, wind* on sectoral output and prices (incl. first evidence on services), and show how composite indices can mask cross-sector and cross-country heterogeneity.

Measuring exposure to abnormal weather: intuition

- **Goal:** build country-level indices that capture *economically relevant* abnormal weather and are comparable across countries and shock types: **cold, heat, drought, precipitation, wind**.
- **Grid-level first:** national averages can wash out relevant shocks → compute anomalies locally to avoid averaging offsetting regional realizations.
- **Seasonal reference:** “abnormal” should mean unusual *for that time of year*; also get seasonal adjustment.
- **Large deviations:** focus on threshold exceedances to capture unanticipated episodes (and their within-month accumulation).
- **Economic exposure:** aggregate with activity weights (e.g., night lights) → shocks in key regions matter more ([Gortan et al., 2024](#)).
- **Standardize by month:** scale by month-specific volatility so a 1sd shock has a similar interpretation (rarity/intensity) across countries and weather dimensions.

Weather data: how are the shocks built?

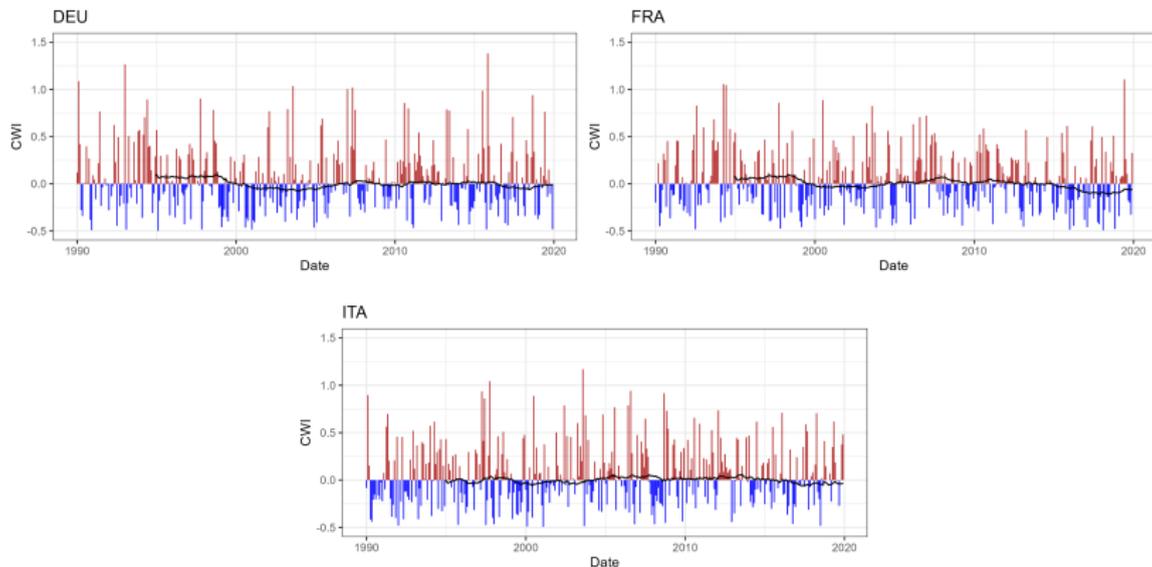
- For each shock (cold, heat, drought, precipitation, wind), we:¹
 1. detrend the daily series at the grid-cell level,
 2. compute calendar-month-specific percentile thresholds at each grid cell,
 3. sum threshold-exceeding daily values within the month,
 4. aggregate across grid cells using economic-activity weights,
 5. standardize using month-specific standard deviations
- This preserves spatial heterogeneity, mitigates aggregation bias, and makes shocks directly comparable across countries and weather dimensions

$$WM_{m,y}^C = \frac{\sum_c \omega_c \sum_{d=1}^{D_m} W_{c,d} \mathbf{1}\{W_{c,d} \geq q_{c,m}\}}{\sigma_m^C}$$

Composite weather index (CWI) = average of the standardized components (similar to ACI for North America)

¹Temperatures, precipitation, wind: ERA5 reanalysis (Hersbach et al., 2020). Drought: SPEIbase v2.9 (SPEI3) (BeguerÁa et al., 2023). Borders: GADM0. Economic weights: night-time lights (Li et al., 2020). ▶

Weather data: Composite Weather Index (CWI)



See components

Response variables: sectoral and macro data

- Monthly sample: January 1990 to December 2019
- Output: manufacturing (C), energy (D), construction (F), and services G-H-I-J-L-N (services output only available monthly for France)
- Prices: producer prices for manufacturing and energy; HICP energy and HICP services
- Macro controls: unemployment rate and 3-month Euribor

Section

C	<i>MANUFACTURING</i>
D	<i>ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY</i>
F	<i>CONSTRUCTION</i>
G	<i>WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES</i>
H	<i>TRANSPORTATION AND STORAGE</i>
I	<i>ACCOMMODATION AND FOOD SERVICE ACTIVITIES</i>
J	<i>INFORMATION AND COMMUNICATION</i>
L	<i>REAL ESTATE ACTIVITIES</i>
N	<i>ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES</i>

Econometric approach

- Baseline model: Bayesian SVAR for each country,

$$\mathbf{B}_0 \mathbf{y}_t = \mathbf{B}_1 \mathbf{y}_{t-1} + \cdots + \mathbf{B}_p \mathbf{y}_{t-p} + \mathbf{w}_t,$$

where \mathbf{y}_t contains weather, sectoral output, producer prices, consumer prices, unemployment and the short-term interest rate

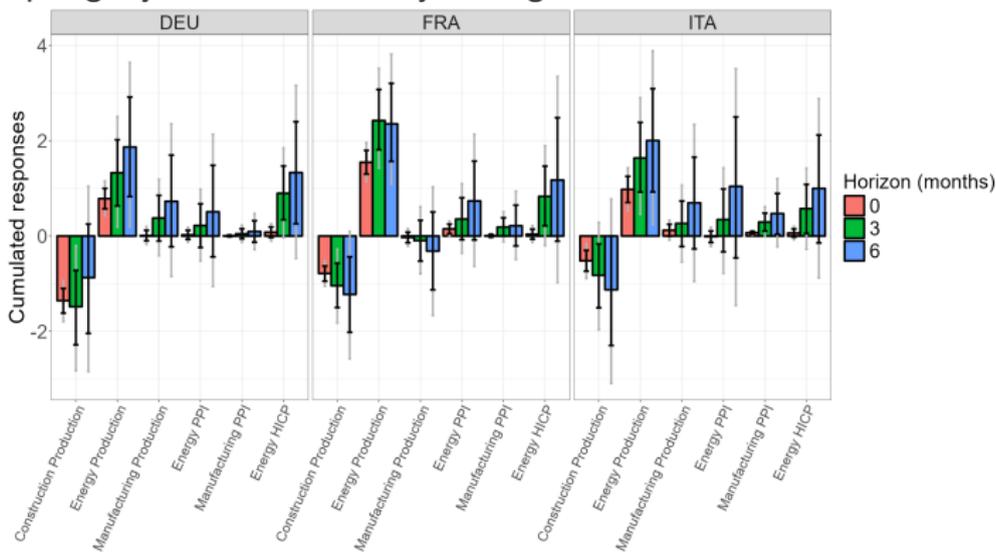
- Bayesian estimation with Minnesota, sum-of-coefficients and dummy-initial-observation priors ([Giannone et al., 2015](#))
- Recursive identification: the weather variable is ordered first, so macro variables do not affect weather *within the same month*
- Local Projections are used to study non-linearities by season and by business-cycle regime

Reading the results

- We report **impact** responses and cumulative effects at **3 and 6 months**, and then selected full IRFs when useful to isolate channels
- Responses are shown for a **1 standard deviation weather shock**
- Output and price variables are expressed in **year-on-year growth rates**, so IRFs measure faster or slower growth relative to the counterfactual path
- Comparing **individual shocks** is crucial, because the composite CWI can hide offsetting effects (as shown later)

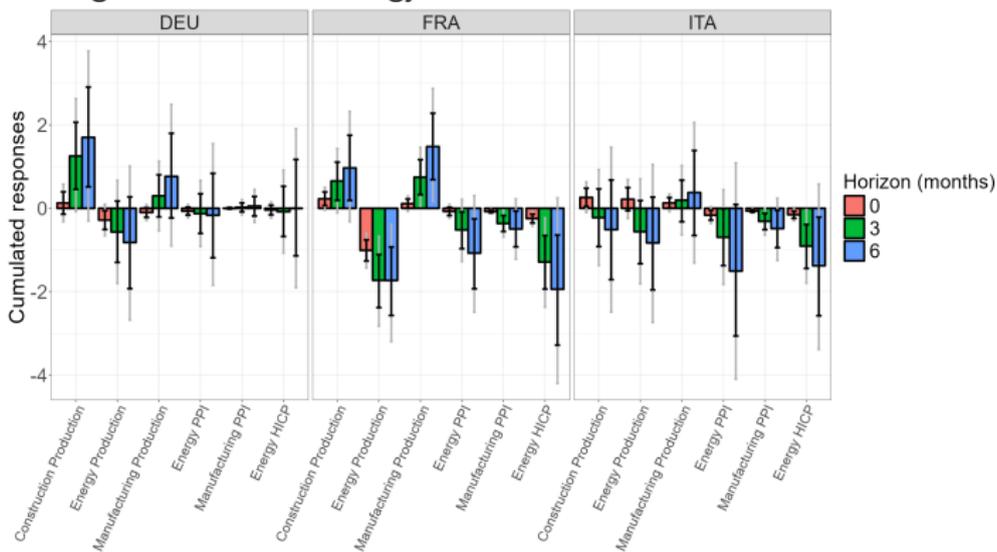
Results: Cold shock

- **Construction** falls in all countries; the contraction is stronger where cold conditions are more binding for outdoor activity
- **Energy** production rises persistently and consumer energy prices increase with a lag: a heating-demand channel [See full energy IRFs](#)
- **Manufacturing** output is largely unaffected, while producer prices edge up slightly but remain mostly not significant



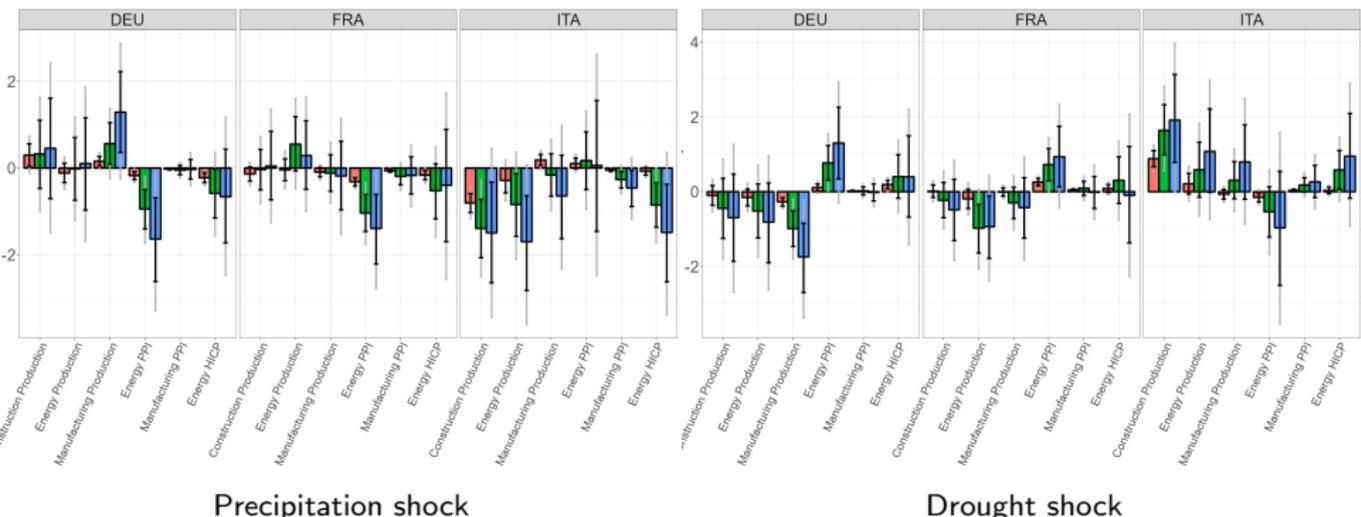
Results: Heat shock

- **Construction** benefits most in colder Germany, rises only mildly in France, and is not statistically significant for Italy
- **Energy** production and prices move opposite to cold shocks because European cooling demand is limited
- **Manufacturing** tends to increase with a lag (significant for France), hinting at an indirect energy-cost channel [See full energy IRFs](#)



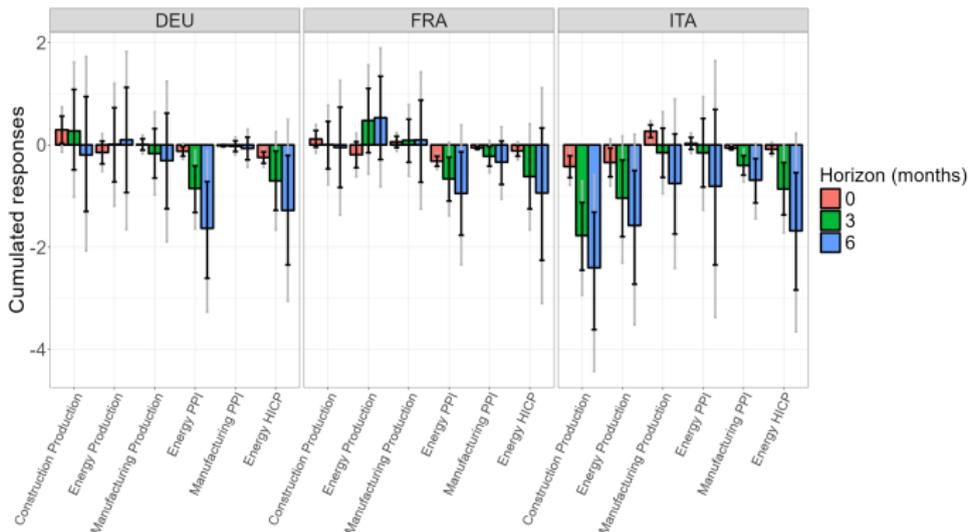
Results: Precipitation and drought shocks

- **Energy:** Italy precipitation-sensitive (hydropower exposure), France drought can lower energy output
- **Manufacturing:** Germany rises after precipitation shocks and falls after drought shocks; Italy shows the opposite pattern (less precisely estimated); France is the most resilient (Billio et al., 2020; Olper et al., 2021).



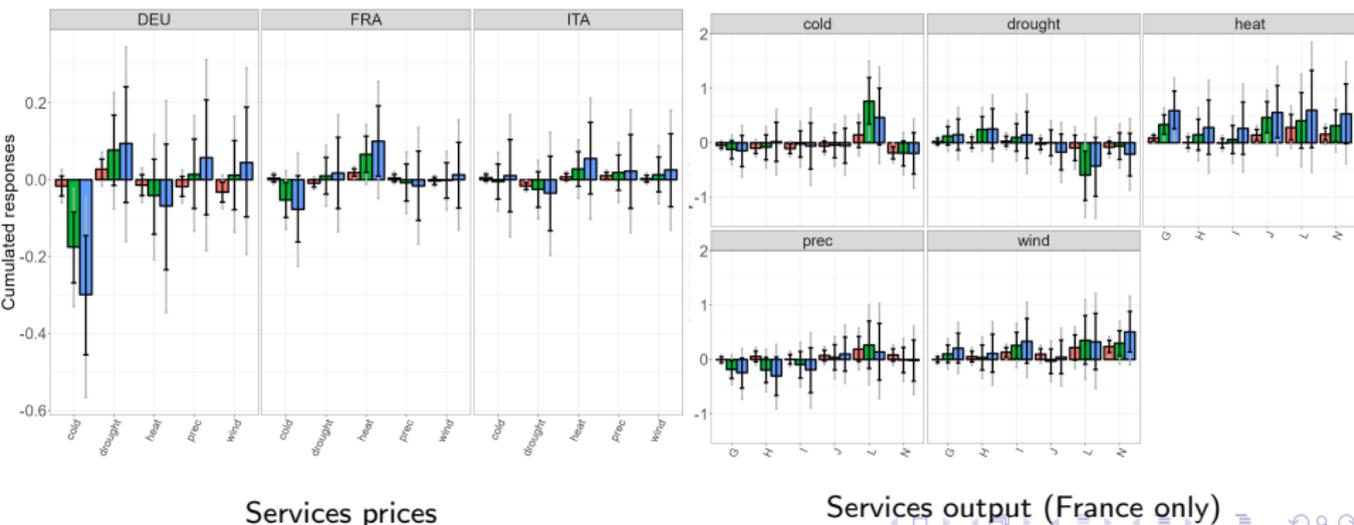
Results: Wind shock

- **Construction:** large negative response in Italy (about -2% cumulated within 6 months); no significant response in Germany/France
- **Energy prices:** fall for both producers and consumers across countries, consistent with higher wind generation lowering marginal electricity prices. Wind power shares: **21.3%** (DEU), **8.0%** (FRA), **7.2%** (ITA) (IEA, 2022)



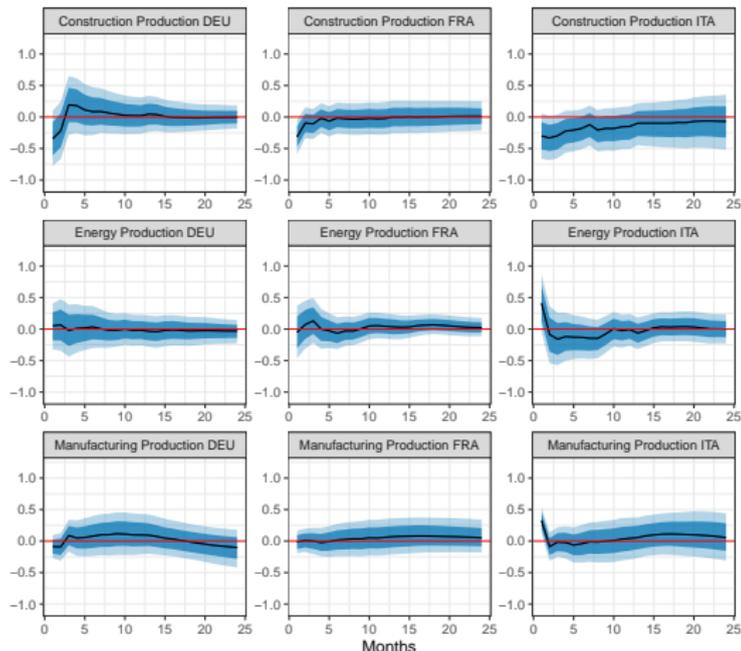
Results: Services inflation and output

- First evidence on services in European economies in this framework
- Service prices react mildly on average, but when significant they move with construction
- In France, output responses are limited overall, but heat shocks significantly affect several sub-sectors (G, J, L and N)
- \Rightarrow consistent with spillovers linked to construction activity



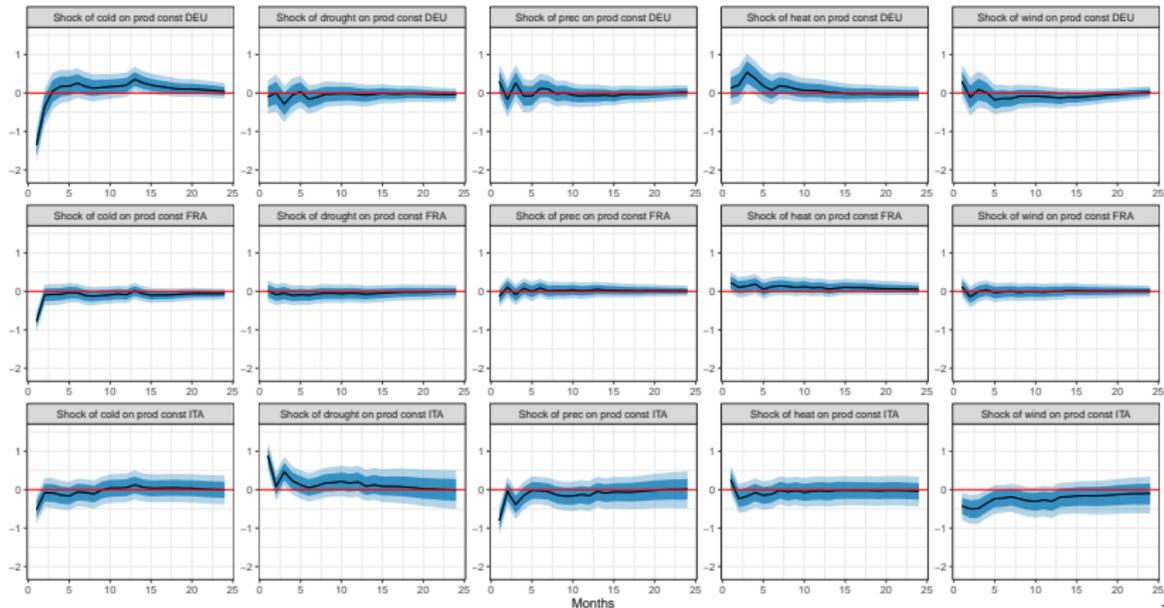
Results: What do we learn from the composite CWI?

- Construction declines under the composite index, but the drivers differ across countries (Italy largely wind/precipitation-driven; France mainly cold-driven; Germany a mix of cold and heat effects)
- Energy and manufacturing responses become harder to interpret because weather-specific effects partly offset each other



Results: Construction is the most exposed sector

- Cold shocks reduce construction on impact in all three countries
- Italy is the only country with significant responses to all shocks on impact: cold, precipitation and wind are negative; drought and heat are positive
- Wind effects are persistent (at least a few months), consistent with project delays in outdoor activity



Sensitivity / robustness checks

- **Falsification test:** randomise the timing of weather shocks Fig
- **Accumulation effects:** shocks based on # of threshold-exceeding days Fig
- **Country-level construction:** aggregate first, then threshold/standardise \implies attenuation bias Fig
- **Different thresholds:** 99th percentile (vs 95th) Fig
- **Exclude disaster months:** set shocks to zero in EM-DAT disaster months Fig

Conclusions

- **Measurement contribution:** country-level indices of *abnormal weather exposure* from daily grid data, weighted by economic activity
- **Evidence (B-SVAR):** Germany, France, and Italy show sizable and heterogeneous short- to medium-run effects of **five shocks** (cold, heat, drought, precipitation, wind) on sectoral output and prices
- **Main mechanisms:**
 - **Construction:** directly exposed; cold and wind reduce activity; heat boosts construction in colder Germany but not in warmer Italy (*latitude effect*)
 - **Energy:** demand and supply channels-cold raises heating demand; wind lowers generation costs and energy prices
 - **Manufacturing:** mainly indirect effects through energy input costs
- **Composite indices:** aggregate measures (e.g., ACI [Kim et al., 2025](#)) can mask mechanisms by conflating offsetting weather components
- **Policy implications:** improving resilience requires accurate exposure measurement and *sector-specific* adaptation

Download the weather shock indices

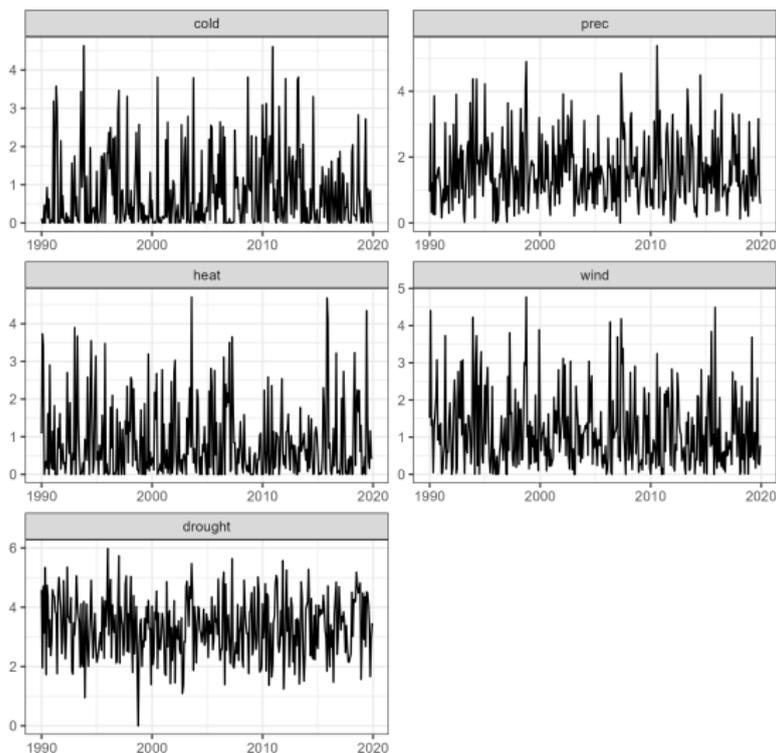
Currently available for DEU, ESP, FRA, GBR, and ITA



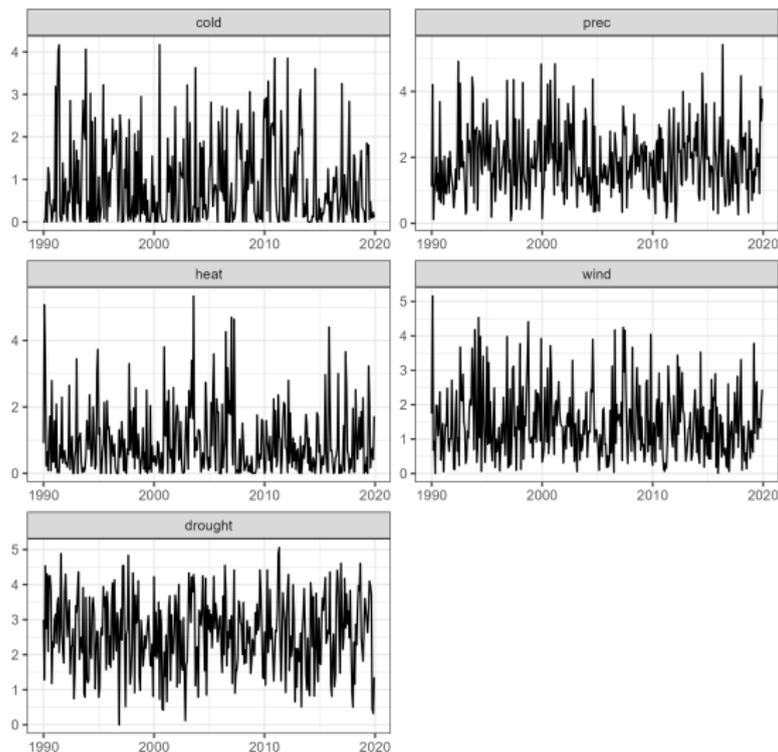
Scan to download the dataset (or visit):

<https://colombodaniele.github.io//paper/ColomboFerrara2025>

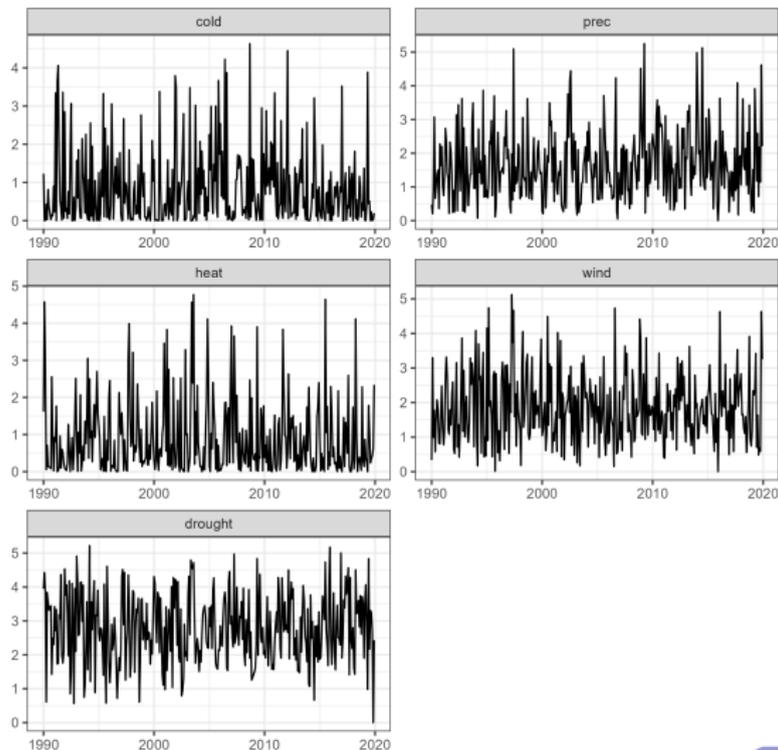
Additional material: Weather components for Germany



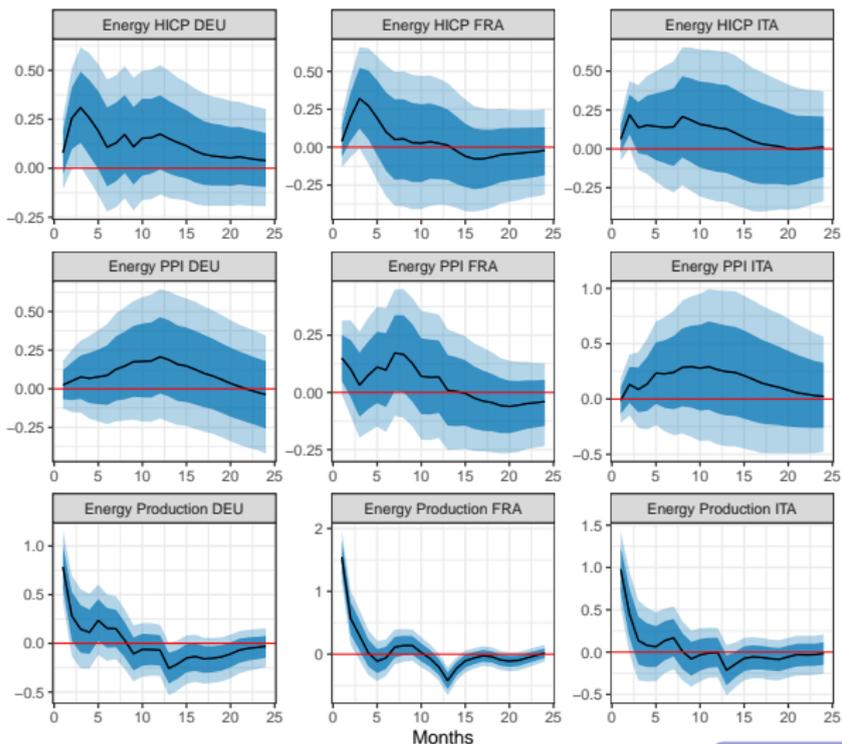
Additional material: Weather components for France



Additional material: Weather components for Italy

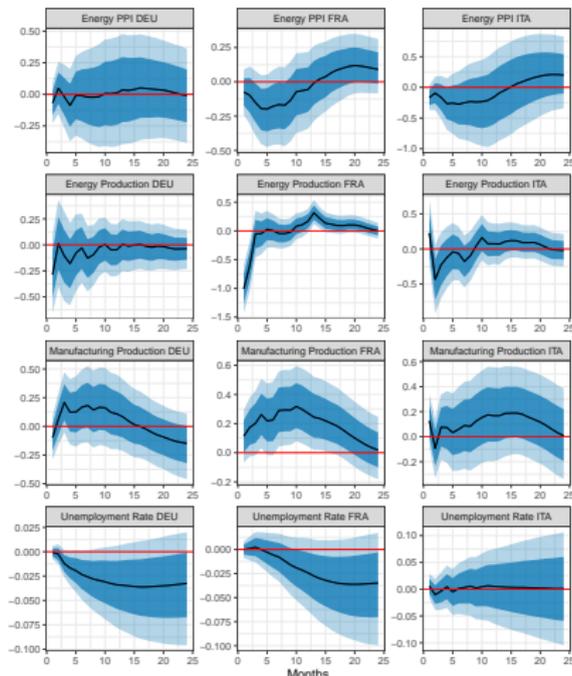


Cold shock: energy output and prices (full IRFs)

[Back to Cold shock slide](#)

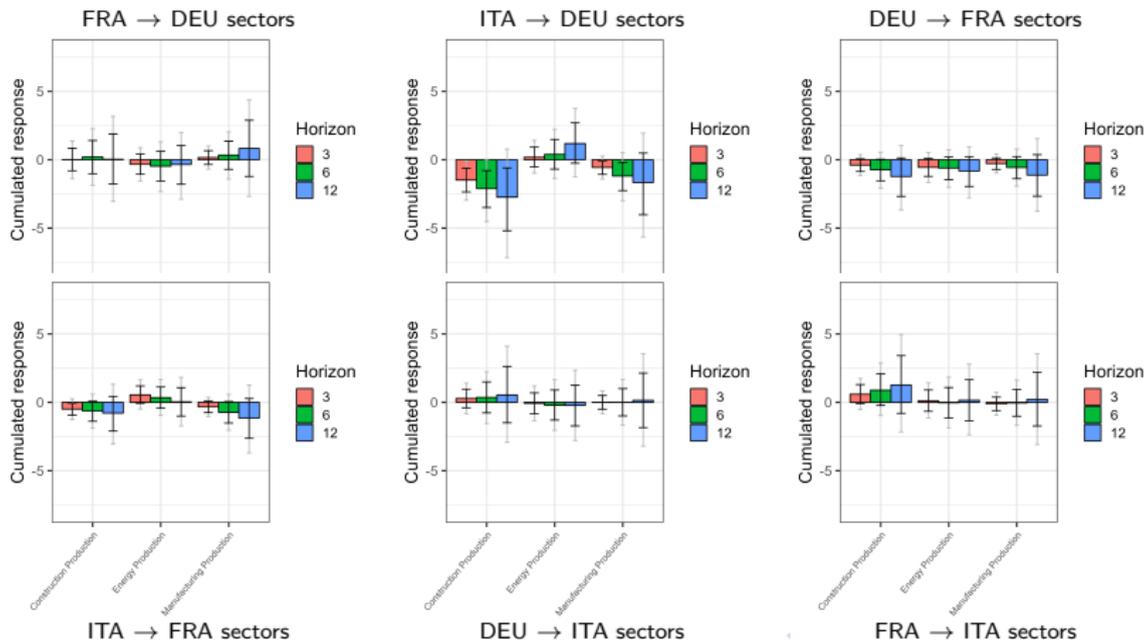
Heat shock and the manufacturing channel (full IRFs)

- Heat shocks reduce heating demand (reduction in production and prices)
- Energy prices for producers drop, leading to lower input costs for manufacturing and an increase in manufacturing output.

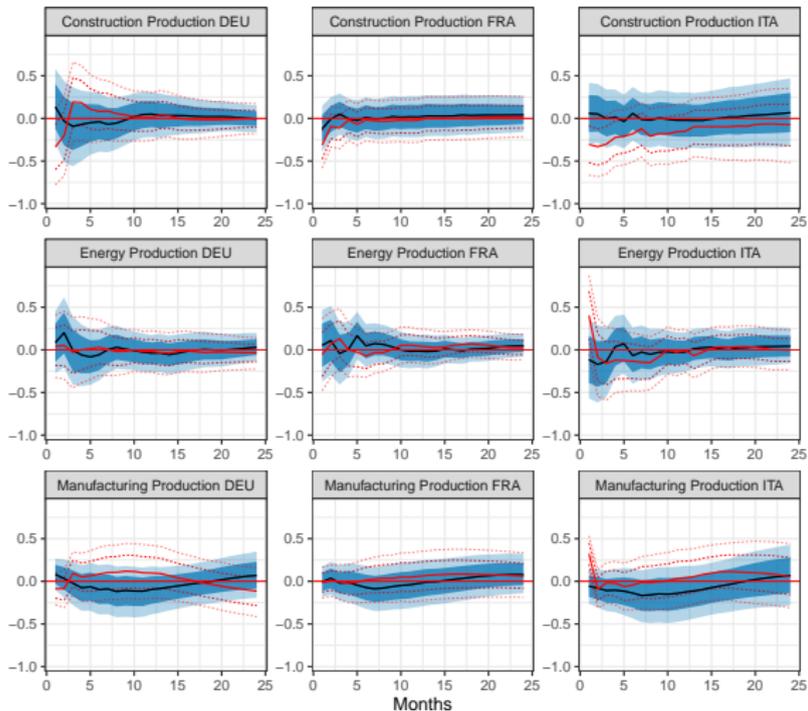


Cross-country spillovers

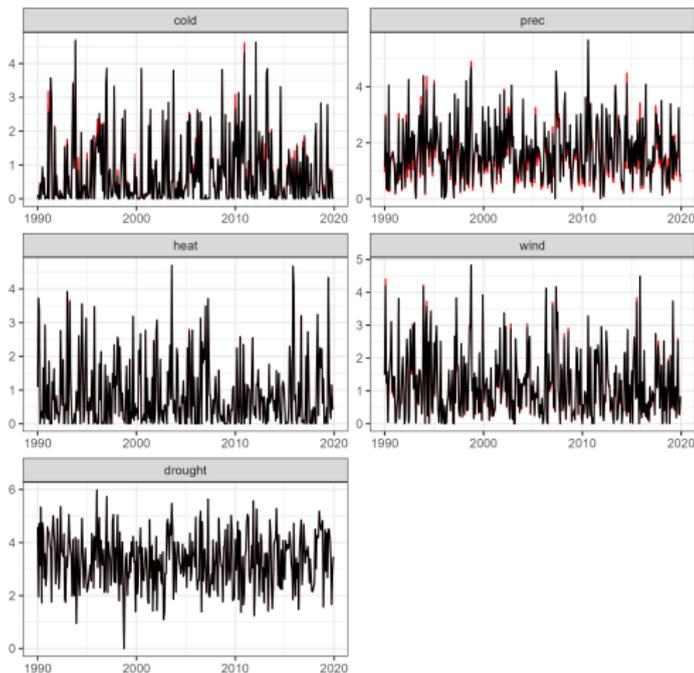
- Separate VARs may miss spillovers if shocks are correlated across countries
- Covariances are small: DEU→FRA: 0.09, DEU→ITA: 0.04, FRA→ITA: 0.06
- Check: use residual foreign shock orthogonal to domestic
- Result: responses are statistically insignificant



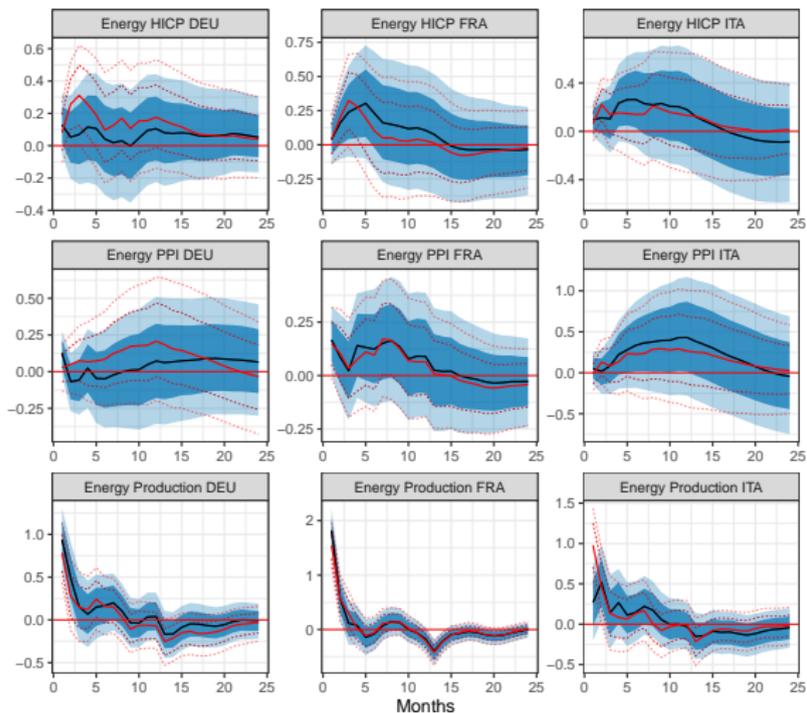
Sensitivity: Randomised shocks (falsification)

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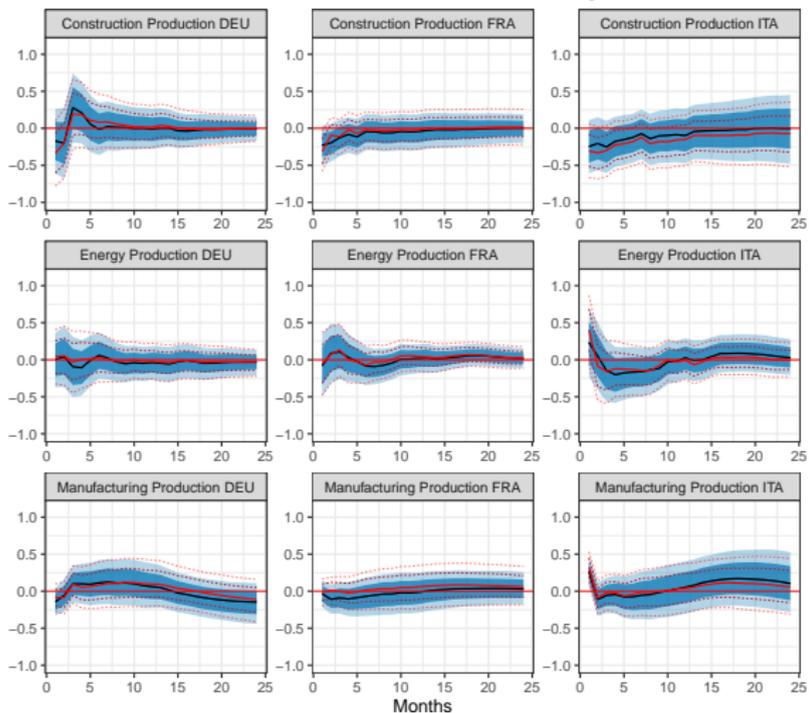
Sensitivity: Accumulation effects (# threshold-exceeding days)



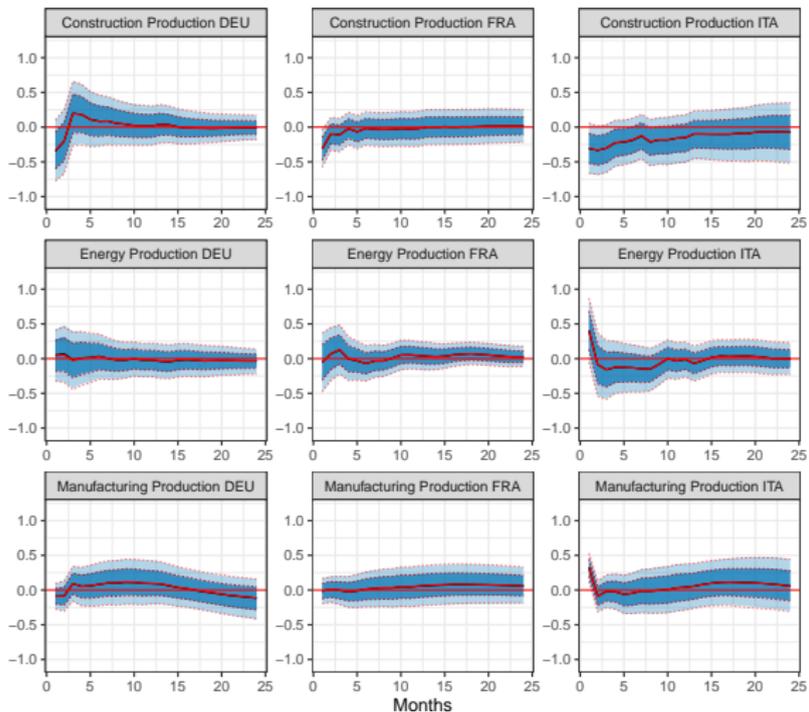
Sensitivity: Construct shocks at the country level first

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Sensitivity: Alternative threshold (99th percentile)

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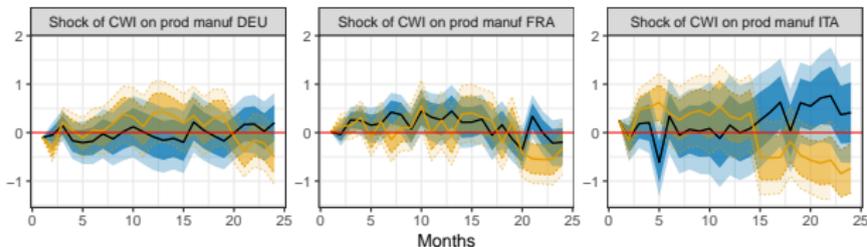
Sensitivity: Excluding disaster months (EM-DAT)

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Results: Non-linearities

- No strong **seasonal non-linearity** once shocks are defined relative to month-specific thresholds
- **Business-cycle** (ESI) asymmetry is only partial: Germany reacts more in low-growth regimes, Italy more in high-growth regimes, while France remains muted

Seasonality



Business cycle regime

