Cross-Country Heterogeneity, Shock Propagation, and Monetary Policy in the Euro Area

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Shock Propagation across the Euro Area and Monetary Policy Tradeoffs

- **Euro Area:** Segmented labor/resource markets + Integrated product markets
  - countries have different shock incidences and adjustment mechanisms ...
  - ... but they compete on the same product markets
- **Two questions** for policymakers: ↗ aggregate inflation-output tradeoff? ↘ shock incidence across countries?
- **A new framework:** Input-Output + Factor Market Networks
  - input-output: Leontief inverse = shock exposure, buyer-supplier interactions
  - factor markets: GE multiplier = demand/supply adjustment margins, cross-market interaction
- **Contributions:** theory and measurement
  - theory: which features of local factor markets matter for shock propagation and how
  - measurement: build Euro-Area wide dataset and calibrate quantitative model
- **Portable toolkit:** cross-country monetary transmission, spending multipliers, supply shocks

Today's Application: Energy Price Shocks

- **Apply Factor Market Network** toolkit to calibrated euro area model
  - factor market segmentation: country-specific labor, capital, and natural resources
    - measure labor market adjustment (wage rigidity, occupational composition)
    - measure scalability of energy resources, document some resources are not traded
    - document limited cross-country asset ownership
  - product market integration: within-country IO network + trade linkages = World IO network
    - allow for product-market competition within industries across countries
- **Quantification:** energy price shocks $\rightarrow$ cross-country heterogeneity and policy tradeoffs
  - document fact 1: different gas electrifiability across country-industry pairs
  - document fact 2: different supply elasticity of clean energy across countries
- **Insight:** heterogeneous adjustment margins fundamental for shock propagation
  - aggregate inflation-output tradeoff: substitution through the factor network dampens shocks
  - dispersion in incidence governed by scalability of resources households and firms can flee to

Outline

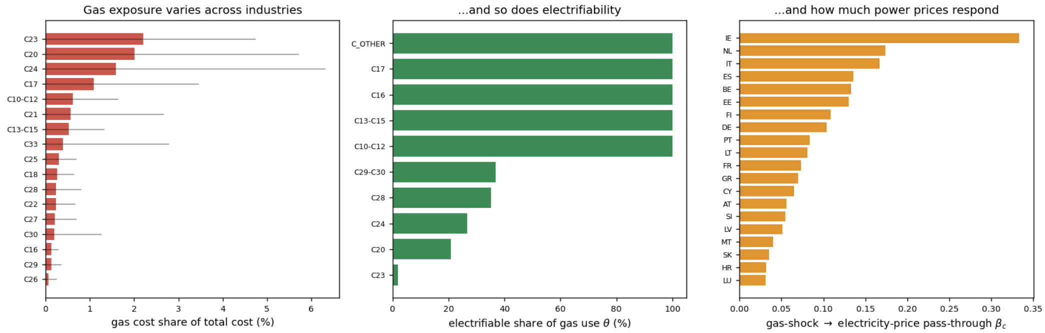
Energy Shocks and EA Heterogeneity: Stylized Facts

Cross-Country Interactions and Aggregate Dynamics: A New Analytical Framework

Energy Shock Propagation in a Calibrated Model of the Euro Area

Takeaways

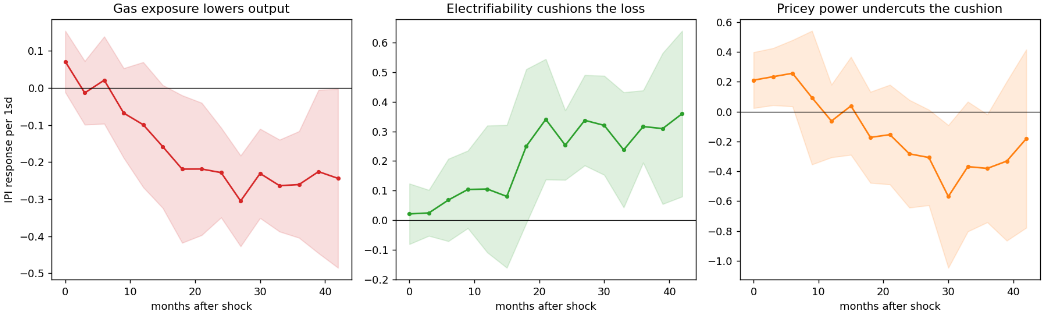
Gas Exposure, Substitutability, and Supply of Alternatives: Heterogeneity



Three dimensions of heterogeneity:

- **Gas share** of total cost, by industry (bars = cross-country mean, whiskers = spread)
- **Electrifiable share** of gas use, by industry
- **Supply of alternatives:** pass-through gas-shock → electricity-price, by country

Gas Exposure, Substitutability, and Supply of Alternatives: Implications



z_t = Alessandri-Gazzani (2025) gas shock;
e_{ci} = gas exposure; e^{es}=electrifiable share; e^{pr}= electricity price pass-through by country

$$100 \cdot \Delta_h \log Y_{c,i,t} = \alpha_{ci} + \delta_{ct} + \gamma_L\, z_t e_{ci} + \gamma_E\, z_t e^{\mathrm{es}}_{ci} + \gamma_P\, z_t e^{\mathrm{pr}}_{ci} + \varepsilon_{c,i,t}$$

- **Exposure hurts**, persists to 3.5 yrs.
- **Electrifiability helps**: substitutable gas hurts less than non-substitutable uses
- **Electricity price increase offsets** the benefits

Outline

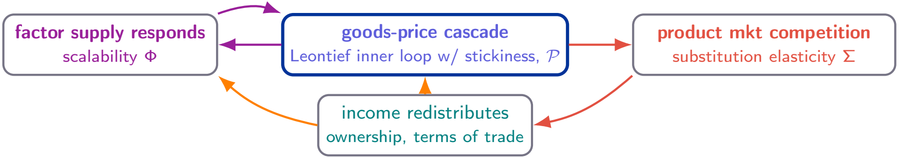
Model Environment

- **Industries** $(i \in \mathcal{N})$
  - CRS production, use labor, nat resources (oil, gas, coal), semi-fixed assets, intermediates
  - face Calvo nominal rigidities on labour and product markets
- **Labour and non-labour factors** $(f \in \mathcal{F})$
  - intensive margin hours and utilization choice
  - extensive margin industry/occupation choice
- **Representative household** in each country
  - owns local labor + local/foreign non-labor factors, and industries
  - allocates consumption expenditure across goods and over time
- **Central Bank** sets nominal interest rate for the euro area
  - simplification today: one world currency area
  - work in progress: multiple currency areas

Modeling Country-Industry Interactions

- **Input-output**: fixed point in goods prices, given factor prices (Leontief inverse)
  - limitation: no feedback loops between factor costs, demand, goods prices

- **A larger loop** the Leontief cascade is part of:
  - goods prices, factor demands, factor prices, and household incomes are solved together



- **General Equilibrium Multiplier** describes propagation across factor markets
  - demand for $f \uparrow \implies p \uparrow$ for industries using $f \implies$ substitute away from $f \implies$ demand $\downarrow$, etc.
  - sums ∞ rounds of cross-market feedback – like Leontief inverse sums ∞ supply-chain rounds

$$\mathcal{M} \equiv (I + \Sigma\mathcal{P}\Phi)^{-1} = \underbrace{I}_{\text{direct effect}} - \underbrace{\Sigma\mathcal{P}\Phi}_{\text{1st-round GE}} + \ldots$$

Aggregate Inflation-Output Tradeoff and Cross-Country Incidence

$$\begin{cases} \boldsymbol{\pi} - \rho \mathbb{E} \boldsymbol{\pi}_{t+1} = \boldsymbol{\kappa} \tilde{y} - \mathcal{V}_a \boldsymbol{a} - \mathcal{V} \left(\boldsymbol{p}_{t-1} + \rho \mathbb{E} \boldsymbol{\pi}_{t+1} \right) & \text{Phillips curves by industry} \\ \bar{y}_{t+1} - y_t = \frac{1}{\gamma} \left(i_{t+1} - \mathbb{E} \hat{\pi}_{t+1} \right) + \mathcal{E}_Y & \text{Euler equation (aggregate)} \\ i_{t+1} = r^* + \phi_\pi \pi_t + \phi_y y_t & \text{Taylor rule} \end{cases}$$

- **Relative employment:** countries with scalable resources sap demand from competitors
  - monetary expansion: price of non-scalable/flex-priced resources $\uparrow \longrightarrow$ employment $\downarrow$
  - productivity gain: employment $\uparrow$ for complements and $\downarrow$ for substitutes; stronger for scalable f

$$\ell = \mathcal{M} \left[1 \bar{y} + \left(\Sigma \mathcal{P} - I_a \right) \boldsymbol{a} - \Sigma \left(I - \mathcal{V} \right) \left(\boldsymbol{p}_{t-1} + \mathbb{E} \boldsymbol{\pi}_{t+1} \right) \right]$$

- **Inflation-Output tradeoff:** substitute to sticky-price/scalable resources $\rightarrow$ muted inflation
  - flatter aggregate slope (monetary non-neutrality $\uparrow$)
  - inflation-output tradeoff improves $\Longleftrightarrow$ productivity shocks shift ℓ toward scalable resources

$$\bar{\pi}_t - \rho \mathbb{E} \bar{\pi}_{t+1} = \bar{\kappa} \tilde{y} + Cov \left(\bar{\boldsymbol{\kappa}}, \mathcal{M} \left(\Sigma \mathcal{P} - I_a \right) \right) \boldsymbol{a} - \bar{\mathcal{V}} \left(\boldsymbol{p}_{t-1} + \rho \mathbb{E} \boldsymbol{\pi}_{t+1} \right)$$

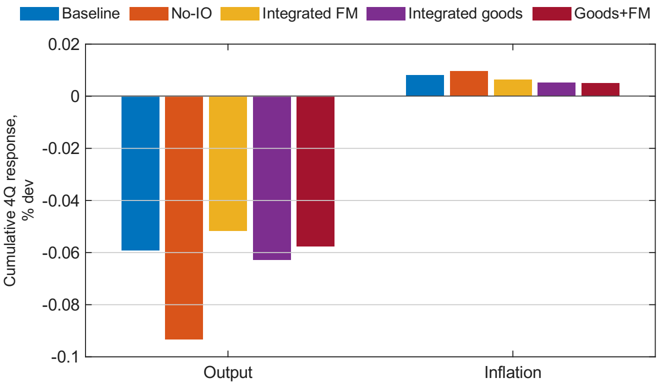
Outline

Model Calibration: Overview and Data Sources

- **Baseline calibration:** EA 20 + Hormuz-exposed block, Hormuz-not-exposed, ROW
  - one-household, one L, one K, 3 fossil and one clean energy resource per country
  - countries have different supply elasticity (= scalability) of clean energy
  - different share of electrifiable gas across country-industry pairs
- **Monetary policy:** targets CPI inflation ($\phi_\pi = 1.7$, $\phi_y = 0.3$, $\rho_i = 0.2$)
- **Shock:** reduction in world endowment of gas that generates a price increase by about 50%

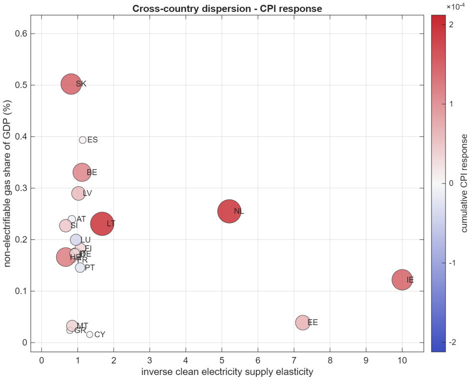
  background calibration
- **Data sources:** Eurostat FIGARO, Exiobase, EU-Klems, PRISMA, Wage Dynamics Network

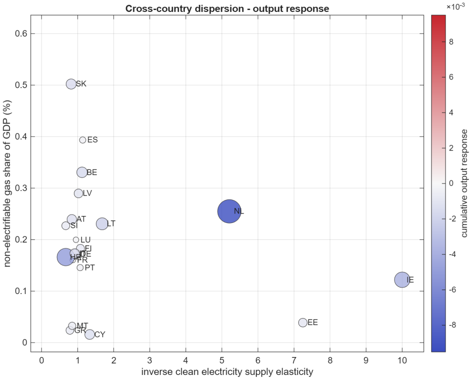
What Mechanisms Matter: Production Network and Factor Markets



- Removing the non-energy production network (No-IO, energy links kept): output loss deepens by 45% and cumulative inflation rises by 22% — the network *absorbs* the shock through input substitution
- Integrated EA factor markets (pooled labour + capital): output loss −22%, CPI peak −35% — factor mobility dampens the impact

Exposure vs Incidence: Locked-In Gas and Clean-Electricity Scalability





- x-axis: how hard it is to scale clean electricity
- y-axis: non-electrifiable gas share of GDP
- Expenditure shares are not the whole story: matters whether you can flee gas *and* scale the alternative

Outline

A New Analytical Framework, A New Versatile Toolbox

- **New Analytical Framework:** the Factor Market Network allows to
  - study supply-side channels of amplification or dampening of shocks to EA aggregate outcomes
  - translate heterogeneous shock exposure into cross-country incidence
- **New Versatile Toolbox**: can be applied at different levels of granularity
  - today: across EA countries
  - intra-EA countries, across households (provide $\neq$ labour services and own $\neq$ types of capital)
  - use whole 54-country $\times$ 75-industries $\times$ 3-primary factors network, or shrink it
  - tailor to climate shocks, defence spending allocation, AI and labour market, trade shocks
  - open-economy, two-currency union version on its way
- **Quantitative/empirical result**: exposure through expenditure shares is not the whole story
  - oil/gas shocks bite less if you can substitute away AND scalable alternatives are available
  - the intermediates network absorbs the shock through input substitution

Thank you!

Model Calibration: Elasticities and Nominal Rigidities

Substitution elasticities σ (CES, quarterly)

Margin	Value
Intermediates / Armington	
Same-country, cross-industry	0.30
Cross-country, cross-industry	0.25
Armington, same good cross-origin	1.5
Energy (= gas & electricity)	
Energy inputs vs. non-energy inputs & factors	0.02
Oil/coal vs. other industries	0.10
Crude oil $\rightarrow$ refining	0.05
Gas $\rightarrow$ distribution	0.05
Gas/coal $\rightarrow$ brown electricity	0.20
Gas retailer split (escapable / locked)	
Escapable gas $\leftrightarrow$ electricity	5.0
Escapable gas $\leftrightarrow$ other gas inputs	0.20
Locked gas $\leftrightarrow$ all inputs	0.01
Brown $\leftrightarrow$ clean electricity (same country)	10
Household gas $\leftrightarrow$ electricity (same country)	5.0
Household consumption	
Within / across / energy vs. rest	1.0 / 0.75 / 0.20
Investment composition	
Within / across / energy	0.25 / 0.20 / 0.20
Government composition]	
Within / across / energy	0.10 / 0.10 / 0.10
Final-use Armington, non-energy (C/I/G)	5.0

Factors	Value
Labor types, within country (SR)	0.50
Labor types, cross-country	0
Capital kinds, within / cross	0.5 / 0
Labor $\leftrightarrow$ capital	0.5
Capital $\leftrightarrow$ intermediates	0.3
Labor $\leftrightarrow$ intermediates	0.20
Resource $\leftrightarrow$ L/K/intermediates	0.10

Factor supply curvature $1/\varphi$ (inverse Frisch)

Factor	Value
Labor (occupation, country-collapsed median)	3.3
range across occupations	2.0–5.0
Semi-fixed assets, country-collapsed median	8.5
machines/equip./transport/telecom	6
software / R&D	4
cultivated biological assets	9
non-residential structures	10
dwellings	12
IP products & mineral rights	12
Natural resources (scarcity rent)	20

Nominal rigidities (Calvo reset slope $\Delta = \frac{(1-\theta)(1-\rho\theta)}{1-\rho\theta(1-\theta)}$)

Price/wage	Value (duration)
Wages Δ_L (ISCO)	0.026 (0.149)
Fixed-asset rents Δ_F, median	0.14
structures/land-like	0.065 (12mo)
equipment/intangibles	0.236 (6mo)
computing	0.626 (3mo)
Producer prices Δ_I (PPI, median)	0.38
Retail/household Δ_H (COICOP, median)	0.46
Investment retailers Δ_K (equip. PPI)	0.313
Resource spot prices Δ_R	0.99
Government deflator Δ_G	0.065 (12mo)
Gas supply shock persistence ρ	0.90

Calibrating the gas supply shock

Design. The shock is applied to `RGAS` only, as an effective supply shock, i.e., a shift in usable gas availability at the resource-market node. There is no oil leg.

Mapping to the model shock. The gas shock is sized as follows:

$$\text{deliverability loss} = 0.4187, \qquad \text{weight in world gas supply} = 0.20,$$
$$\text{world effective gas supply loss} = 0.20 \times 0.4187 = 0.0837, \quad a^R_{\mathbf{gas},1} = \log(0.9163) = -0.0875.$$

Dynamic path and policy environment. The gas supply state follows

$$a^R_t = 0.90^{\,t-1} a^R_1,$$

implemented as an MIT shock. Monetary policy follows an EA consumption-CPI-inflation targeting rule with a natural-output-gap response:

$$i_t = 0.2\, i_{t-1} + 0.8 \left(1.2\, \pi^{CPI,EA}_t + 0.33\, \tilde{y}_t\right),$$

where $\tilde{y}_t$ is the world natural-output gap.

back to calibration