Gas Prices and the Macroeconomy

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Introduction

Natural gas is a key energy source

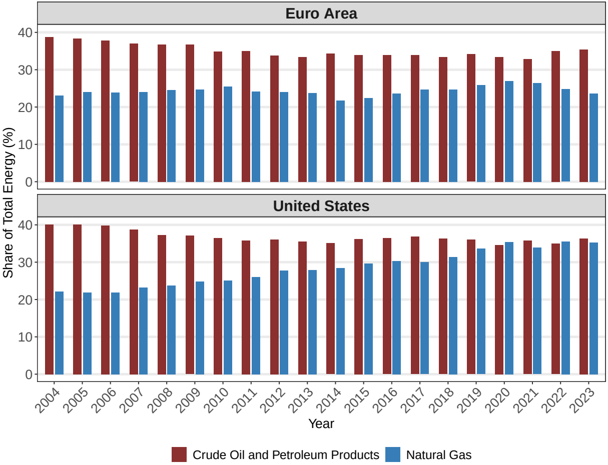


Figure: Natural gas and oil as a share of total energy supplied

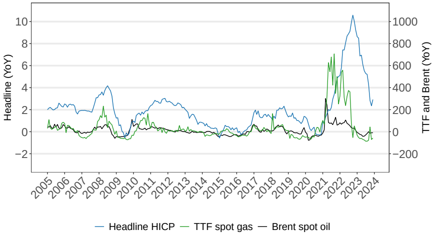
Unprecedented natural gas shocks

Recent disruptions in the gas market have sparked renewed interest in the question of how energy prices affect the macroeconomy

Figure: Nord Stream Sabotage, September 2022.
Source: *Reuters*

Figure: Attacks on gas pipelines in Iran, February 2024.
Source: *Fars News*

Surge in gas and energy prices and global rise in inflation



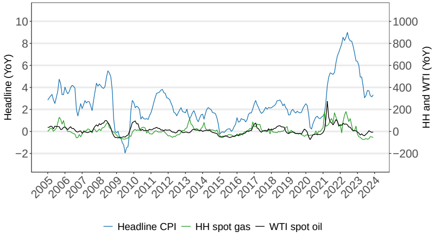


Figure: Top panel: EA. Bottom panel: US.

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Key challenge: gas prices are endogenous ⇒ construct instruments for gas demand and supply

Outline and Main Findings

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Main findings

- **Gas demand more rigid** than gas supply in both regions: supply shocks account for a larger share of price fluctuations.
- Supply shocks are amplified via **expectations and uncertainty**.
- **Inflationary effects are sizable** in the Euro Area, while real-activity impacts are limited on aggregate but display strong sectoral heterogeneity.
- Gas price shocks **increase CO_2 emissions** in the short to medium run due to substitution toward more carbon-intensive fuels.

Related Literature

- **Temperatures and gas prices.** Mu (2007), Nick and Thoenes (2014), and Wang et al. (2019) Dubin and Gamponia (2007), Chen et al. (2023), and Baumeister and Hamilton (2024)
- **Event studies on gas news.** Gay et al. (2009), Bjursell et al. (2010), Halova et al. (2014), and Prokopczuk et al. (2021) Bartelet and Mulder (2020) and Goodell et al. (2023, 2024)
- **Elasticities of gas demand and supply.** Wiggins and Etienne (2017), Hou and Nguyen (2018), Nguyen and Okimoto (2019), and Rubaszek and Uddin (2020) Rubaszek et al. (2021), Casoli et al. (2024), and Farag (2024)
- **Macroeconomic effects of oil price shocks.** Hamilton (2003), Kilian (2009), Caldara et al. (2019), Zhou (2020), Känzig (2021), and Baumeister and Hamilton (2023)
- **Macroeconomic effects of gas shocks.** Albrizio et al. (2023), Moll et al. (2023), Bachmann et al. (2024), and Di Bella et al. (2024) Adolfsen et al. (2024), Alessandri and Gazzani (2025), and Boeck and Zörner (2025)
- **Energy pass-through.** Gao et al. (2014), López (2018), Känzig (2021), Kilian and Zhou (2022), Joussier et al. (2023), Adolfsen et al. (2024), and Boeck and Zörner (2025)

Gas markets

Euro Area and United States Gas Markets

1. **Demand composition** Energy mix Composition of demand
   Natural gas accounts for about 1/4 of all energy supplied in both regions, mainly for power generation, heating, and industry. Heating demand large ($\approx 1/3$ of total) and highly temperature-sensitive.

Euro Area and United States Gas Markets

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   - **Euro Area:** 90% import-dependent by 2019. Reliance on a few key suppliers makes prices highly sensitive to realized or expected disruptions.
   - **United States:** World's largest producer, with output growth driven by shale extraction. Exports LNG mainly to Europe and Asia. Prices less volatile but react to domestic disruptions.

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   $\Rightarrow$ Disruptions can be exploited via HF identification to study the effects of gas supply price shocks

EA and US Gas Markets (II)

3. **Integration** Unlike oil, the global gas market remains fragmented due to supply-side constraints and limited fungibility (e.g., reliance on pipelines, infrastructure capacity). Despite growing LNG trade, regional price differences persist. *In August 2022, EA gas prices surged 14-fold, while US prices remained much lower (IMF Blog, 2023)*

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4. **Market Development** The US gas market is more mature, with HH as the benchmark since the 1990s. In Europe, a unified market is more recent, but the TTF has emerged as the reference price (Heather, 2021) TTF as European benchmark

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   ⇒ TTF (EA) and HH (US) are the relevant prices to look at

Identification

Gas demand shock

- Residential and commercial sectors consume over 45% (EA) 35% (US) of natural gas, mainly for heating.
- **Exogenous variation:** unexpected demand of gas for heating due to anomalous temperatures.
- Unlike average seasonal temperature fluctuations, a large deviation from the average is not anticipated by economic agents.
- Can construct a *temperature proxy* that is inversely correlated with the price of natural gas, and can be used as an instrument for gas-specific demand.

Constructing an instrument for gas demand

Data:

- ERA5 grid-level temperature data
- GADM spatial data
- Gridded population (Doxsey-Whitfield et al., 2015) to proxy economic activity

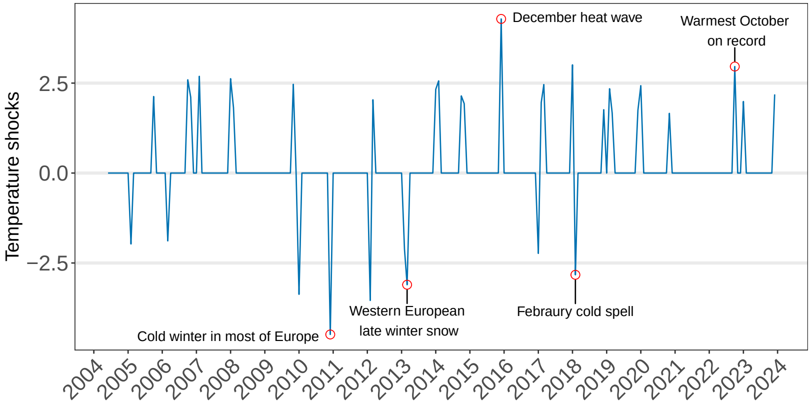
Daily temperature series: grid-level daily temperatures aggregated at the country level, weighting each grid by economic activity. European temperature series obtained by averaging each country weighting by gas consumption

Temperature proxy:

1. Take deviations from average temperatures by subtracting to daily average temperatures of each calendar day the mean monthly average temperature (across all years in the sample)
2. Aggregate to monthly by taking averages across time
3. Threshold the series (below 1sd) to reduce noise
4. Exclude summer months (April to September) due to ambiguous correlation. This improves instrument relevance but does not materially affect results (further discussed in sensitivity analysis)

Gas demand shock

Deviations from *normal* temperatures impact heating demand, which, in turn, influences gas prices. US demand instrument



Constructing an instrument for gas supply

Exogenous variation:

High-frequency approach, intra-day variation in gas prices following market-relevant news

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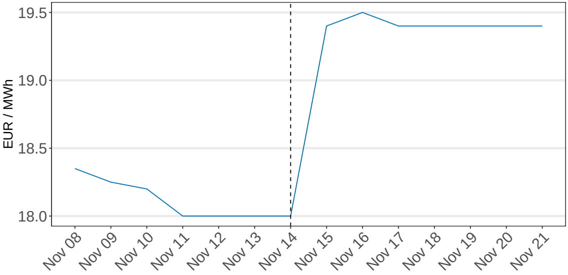
Constructing the gas supply surprises:

1. Compute gas supply surprises:

$$GasSurprise_d^h = F_d^h - F_{d-1}^h$$

   where F_d^h is the log settlement price of the h-months ahead gas futures contract at date d
2. Take the first principal component of the gas surprises spanning the first year of the gas futures term structure
3. Aggregate to monthly by summing daily surprises

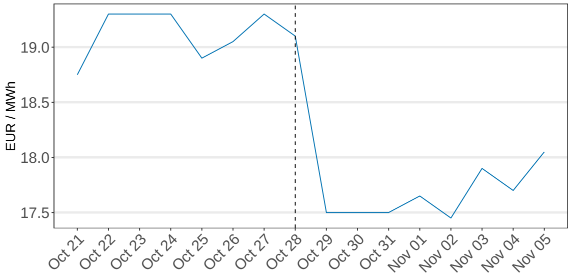
News example #1: Unexpected supply drop from Norway



Drop in Langeled flows, **2010M11**

- On November 15, 2010, Norwegian gas flows through the Langeled pipeline experienced an unexpected drop due to unforeseen technical issues
- The TTF spot price rose by about 8%

News example #2: UK expands LNG capacity



UK expands LNG capacity, **2010M10**

- On October 28, 2010, National Grid announced LNG capacity expansion at the Isle of Grain
- The TTF spot price fell by about 9%

Gas supply news

Gas supply shock

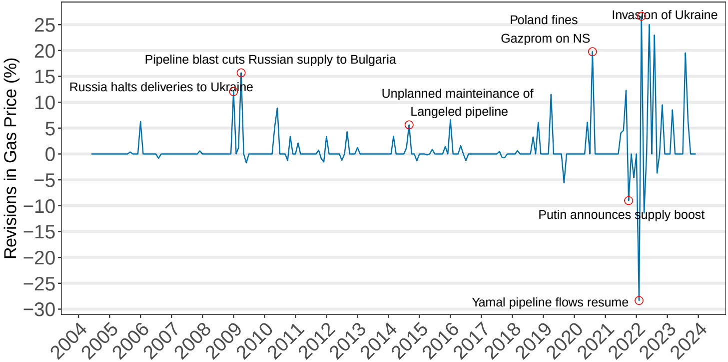


Figure: Gas price surprises series constructed from changes in gas futures prices around announcements (principal component spanning first year of TTF gas futures term structure).

- Similarly, construct a surprises series for the US US surprises series

Assessing the instruments: correlation with other shocks

Source	Shock	Europe supply		Europe demand		US supply		US demand		n
		ρ	p-value	ρ	p-value	ρ	p-value	ρ	p-value	
Kilian (2009)**	Oil supply	-0.02	0.79	-0.01	0.87	0.04	0.56	0.04	0.52	240
Kilian (2009)**	Aggregate demand	-0.07	0.31	0.01	0.83	0.02	0.77	-0.07	0.29	240
Kilian (2009)**	Oil-specific demand	0.05	0.42	-0.08	0.25	0.01	0.84	-0.05	0.44	240
Baumeister and Hamilton (2019)*	Oil supply	-0.06	0.36	0.03	0.67	-0.04	0.57	0.02	0.73	240
Baumeister and Hamilton (2019)*	Oil demand	0.00	0.99	-0.05	0.45	0.09	0.16	-0.04	0.51	240
Känzig (2021)**	Oil supply expectations	-0.08	0.20	-0.03	0.70	0.02	0.82	0.12	0.07	240
Caldara et al. (2019)*	CCI oil supply	0.02	0.77	0.01	0.87	0.01	0.87	0.01	0.88	144
Miranda-Agrippino and Nenova (2022)	Target monetary policy (EA)	0.07	0.33	0.03	0.63	-0.05	0.51	0.02	0.73	207
Jarociński and Karadi (2020)	Information median monetary policy (EA)	-0.01	0.89	0.07	0.30	0.02	0.70	0.08	0.24	234
Gertler and Karadi (2015)	FF4 monetary policy (US)	-0.13	0.20	-0.14	0.15	-0.01	0.97	0.02	0.87	102
Miranda-Agrippino and Nenova (2022)	Target monetary policy (US)	0.02	0.74	-0.02	0.75	0.01	0.88	0.02	0.82	186
Bloom (2009)**	VXO-VIX	-0.03	0.70	0.03	0.60	0.00	0.99	0.06	0.38	240
Gilchrist and Zakrajšek (2012)*	Corporate credit spread index	0.05	0.49	-0.05	0.43	-0.04	0.60	-0.06	0.33	240
Caldara and Iacoviello (2022)*	Geopolitical risk index	0.05	0.40	0.05	0.46	0.04	0.51	0.06	0.38	240

Table: Correlation with other shocks

- The supply instrument is informationally-robust when controlling for these and other potential confounding factors
  Info-robust
- Show that shock is not predictable via Granger's tests

* Extended by the original authors wrt the original paper sample.

** Extended by us.

Estimation

Econometric Framework and Identification

- Structural VAR

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

  where $\mathbf{y}_t$ $(K \times 1)$ includes gas-market, macro, and control variables

- Estimate the reduced-form representation

$$\begin{aligned}\mathbf{y}_t &= \mathbf{B}_0^{-1}\mathbf{B}_1\mathbf{y}_{t-1} + \cdots + \mathbf{B}_0^{-1}\mathbf{B}_p\mathbf{y}_{t-p} + \mathbf{B}_0^{-1}\mathbf{w}_t \\ &= \mathbf{A}_1\mathbf{y}_{t-1} + \cdots + \mathbf{A}_p\mathbf{y}_{t-p} + \mathbf{u}_t,\end{aligned}$$

- Use external instruments (*proxy-VAR*) to identify relevant columns of $\mathbf{B}_0^{-1}$

$$\mathbb{E}[z_t w_{1,t}] \neq 0$$

$$\mathbb{E}[z_t \mathbf{w}_{2:K,t}] = \mathbf{0}$$

Estimating demand and supply elasticities

Consider dynamic demand and supply equations of the form:

$$q_t^d = \alpha_{qp}^d p_t + \mathbf{x}'\boldsymbol{\beta}_d + w_t^d,$$
$$q_t^s = \alpha_{qp}^s p_t + \mathbf{x}'\boldsymbol{\beta}_s + w_t^s,$$

As shown by Baumeister and Hamilton (2024), the elasticities α_{qp}^d and α_{qp}^s-interpreted as the change in demand and supply quantities following a 1% increase in the price of natural gas, *holding all other variables constant*-are elements of the matrix $\mathbf{B}_0$, not of $\mathbf{B}_0^{-1}$.

Nevertheless, they can still be recovered even when only a single column of $\mathbf{B}_0^{-1}$ is identified:

$$\mathbf{b}_{0,j}' = \left[(\mathbf{B}_0^{-1})_{:,j}\right]' \boldsymbol{\Sigma_u}^{-1}$$

Bayesian Estimation

- Bayesian VAR with Minnesota (Doan et al., 1984), sum-of-coefficients (Sims & Zha, 1998; Robertson & Tallman, 1999), and dummy-initial-observation (Sims, 1993) priors.
- Following Kadiyala and Karlsson (1997), we specify conjugate prior distributions and implement them via dummy observations (Bańbura et al., 2007):

$$\mathrm{vec}(\beta) \mid \Psi \sim \mathcal{N}(\mathrm{vec}(\beta_0), \Psi \otimes \Omega_0) \quad \text{and} \quad \Psi \sim \mathcal{IW}(S_0, \alpha_0)$$

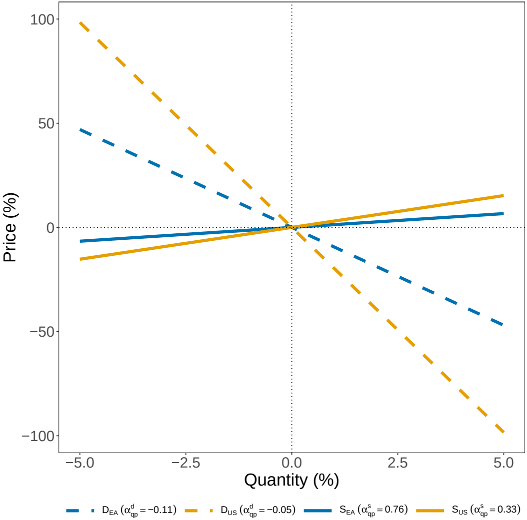
- The informativeness of the priors is determined using the hierarchical approach of Giannone et al. (2015), which selects the hyperparameters by maximizing the marginal likelihood of the data.

Results

Main Results

1. **Estimates of demand and supply elasticities** for natural gas in both EA and US.
2. **Historical decomposition** of the real price of natural gas: identified demand and supply shocks account for much of the observed variation.
3. **Propagation of shocks** via impulse response functions in both EA and US.
4. **EA supply shocks focus**: sectoral analysis of price and quantity responses, and historical decomposition of inflation.
5. Historical decomposition of **headline inflation**: gas supply shocks one of the main drivers of inflation surge in the EA.

Estimated short-run gas demand and supply curves



- **Euro Area**: Demand elasticity $= -0.11$, Supply elasticity $= 0.76$
- **United States**: Demand elasticity $= -0.05$, Supply elasticity $= 0.33$

FEVD of gas price by shock type

Region	Shock	$h = 1$	$h = 6$	$h = 12$	$h = 18$	$h = 24$
Euro Area	Gas supply	46.8	38.5	36.0	34.5	33.2
	Gas demand	19.0	19.1	23.4	24.2	24.2
United States	Gas supply	68.6	32.5	23.3	21.1	19.8
	Gas demand	14.5	23.3	22.9	21.8	22.2

Note: Forecast error variance decomposition of gas prices. Values represent percentage contributions of identified supply and demand shocks.

As demand is more rigid, supply shocks explain a larger share of variation in gas prices, and vice versa.

Gas shocks contribution to real gas price series

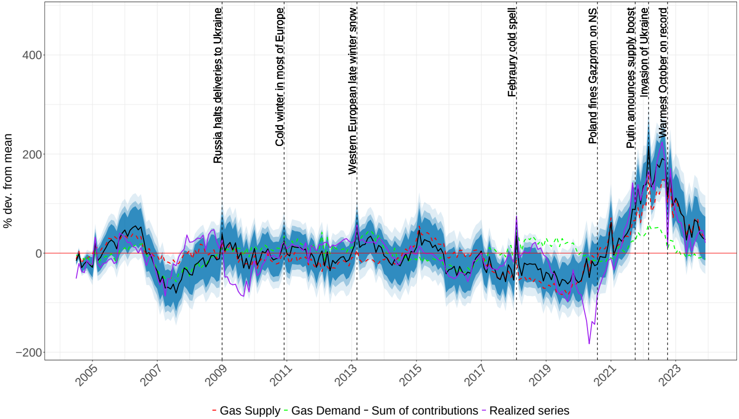


Figure: EA: Historical decomposition of the real price of gas.
2009M1 Russian halt of all gas deliveries to Ukraine; **2010M12** abnormally cold winter in Europe; **2013M3** late snow in Western Europe; **2018M2** cold spell; **2020M8** Poland fines Gazprom; **2021M10** Putin announces gas supply increases; **2022M3** supply fears following the invasion of Ukraine; Warmest October on record in **2022M10**.

HD gas price US

Baseline specification

Main specification includes eight variables. IRFs normalized to one-time 10% increase in gas price

Gas market variables:

- Gas Price (real spot gas price)
- Gas Quantity Supplied (domestic production + net imports)
- Gas Quantity Demanded (domestic consumption + exports)
- Gas Inventories

Macro transmission:

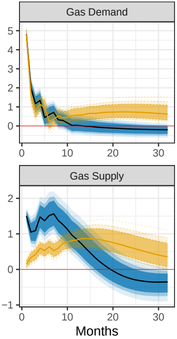
- Headline Inflation
- Industrial Production

Other relevant variables:

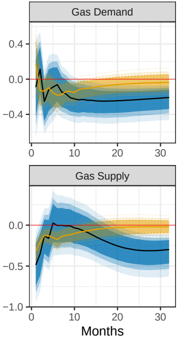
- Financial Volatility
- Oil Price

Joint baseline responses

Responses of quantities supplied and demanded



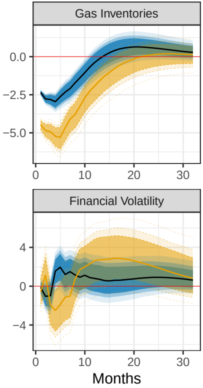
Gas Demand Shock



Gas Supply Shock

- Since demand more rigid, 0.5% decrease in Q supplied enough to trigger 10% increase in price (wrt 5% increase in Q demanded)
- Different timing of **supply adjustment** (slower in US) explained by imports vs domestic production Drivers of supply responses
- Faster **demand adjustment** in US due to different Composition of demand and Interfuel substitution

Inventories, volatility, and uncertainty channel



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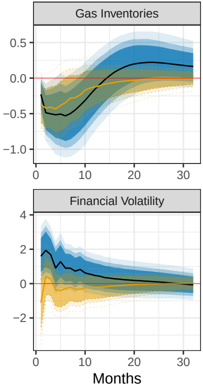
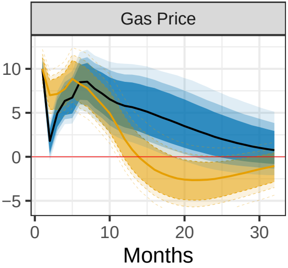


Gas Supply Shock

- Evidence points to precautionary demand mechanism in the EA (Kilian & Murphy, 2014; Känzig, 2021) Only expected events

Gas price shock persistence



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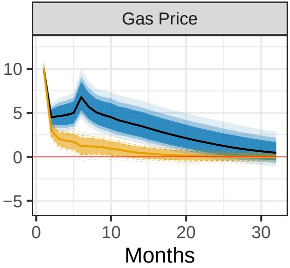
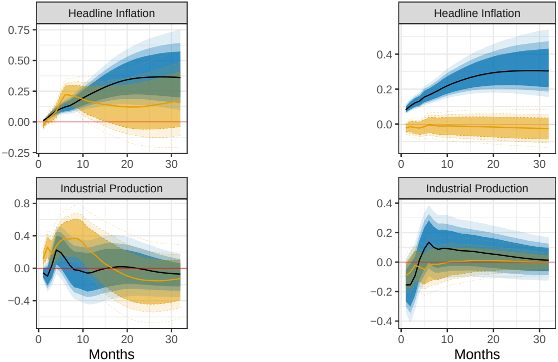


Gas Supply Shock

- Persistence reflects adjustments in inventories and demand to offset the shocks
- **EA more vulnerable to supply shocks**: Inventories remain unresponsive due to precautionary demand under heightened uncertainty, while slow demand adjustment limits the system's capacity to absorb shocks

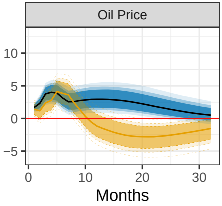
Macroeconomic impact



Gas Demand Shock　　　　Gas Supply Shock

- In EA both shocks largely inflationary, with limited real effects (though more pronounced in Germany)
- Large portion of costs passed downstream PPI, and 1-to-1 pass-through to electricity prices (more in following slides)
- In US only modest effect of demand shocks. Real effect due to production in energy sector

Gas and oil markets interrelation



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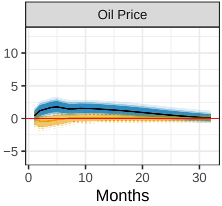

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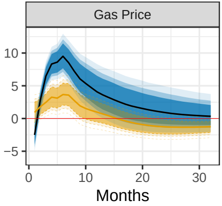
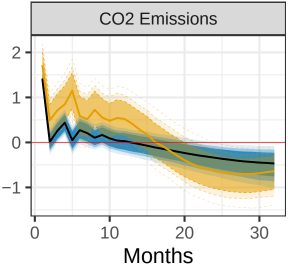


Oil supply shock

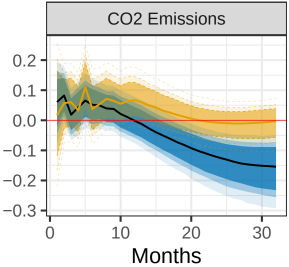
(Identified as in Känzig (2021))

- Gas and oil are imperfect substitutes
- Increasing LNG trade but constrained US export capacity (Albrizio et al., 2023) has led to higher integration in European and Asian markets
  $\Rightarrow$ EA shocks impact global oil more than US shocks

Environmental impact of gas price shocks



Gas Demand Shock



Gas Supply Shock

Figure: CO_2 emissions

- **Demand shocks** increase emissions on impact by $\approx 1.5\%$: more carbon-intensive fuels are burned to satisfy demand.
- **Supply shocks** increase up to 0.1% in both EA and US: gas becomes more expensive and is substituted by higher-emission fuels.

Interfuel substitution

Transmission to broader energy prices (EA)

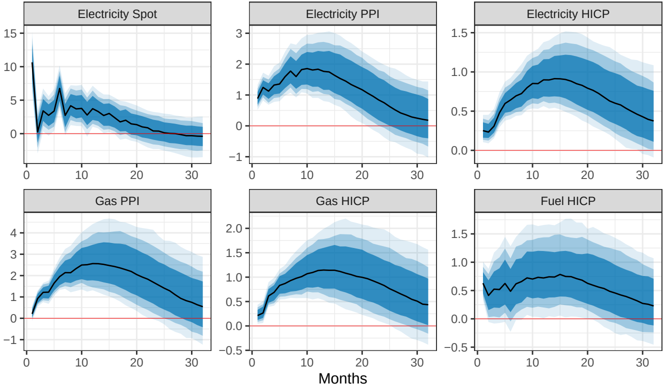


Figure: Energy prices responses to a gas supply shock

- 1-to-1 pass-through to electricity spot (marginal pricing)
- Firms face stronger price hikes than consumers (PPI response larger than HICP)
- Fuel consumer prices adjust quickly to spot market changes, while gas and power prices respond more slowly due to long-term contracts and regulation

Gas pass-through to consumer prices (EA)

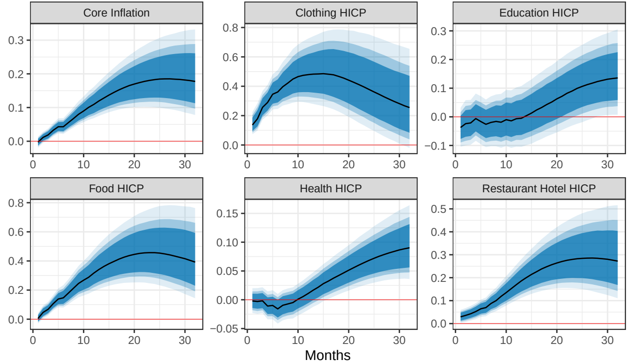


Figure: Core and HICP 2-digit sectors responses to a gas supply shock

- Gas shocks feed into core inflation
- Goods inflation (food, clothing) tends to be stronger and more persistent than services (education, healthcare)

⇒ Direct effects in sectors where energy constitutes a significant cost factor (clothing, transport) vs lagged effects in sectors impacted indirectly

Gas effects on sectoral output (EA)

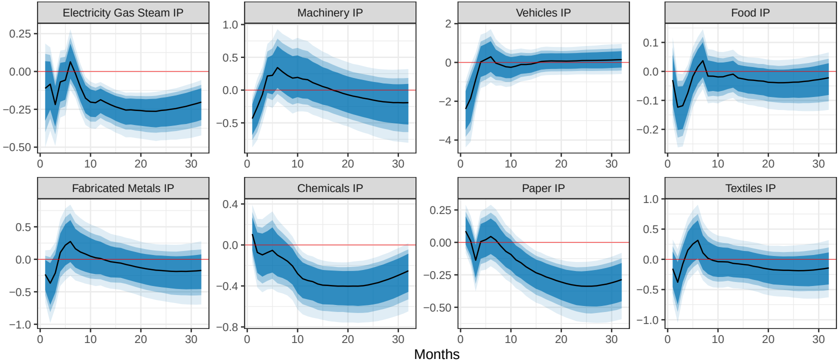
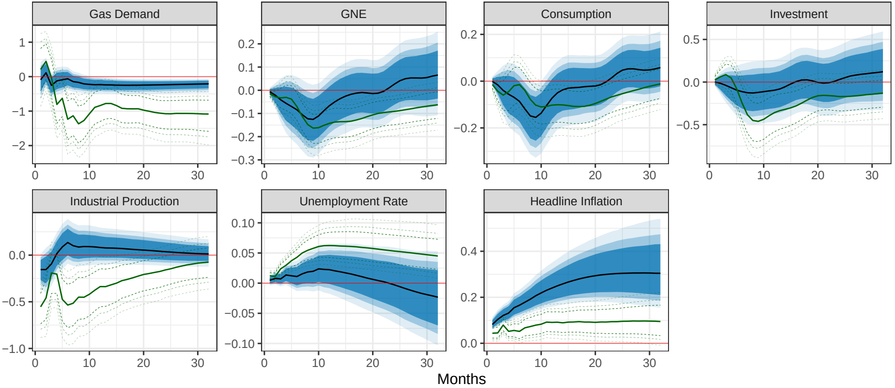


Figure: Responses of IP sectors (by value added) to a gas supply shock

- No aggregate effect but sectoral heterogeneity: strongest impact on gas-intensive sectors (e.g., chemicals, paper)
- Output U-shaped, inflation inverted U-shaped, and sectoral heterogeneity: cost-push shocks (Davis & Haltiwanger, 2001)

Aggregate demand channel (EA)

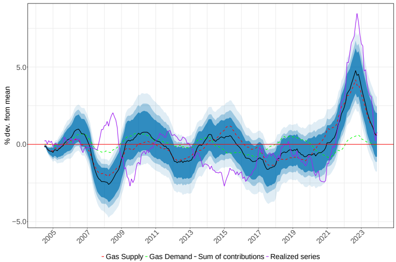
Augment baseline specification with national expenditure variables and unemployment:



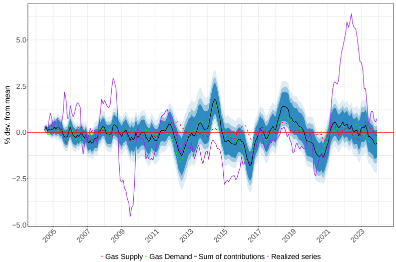
- For Germany (elasticity of demand: -0.2) evidence of **knock-on effects** via AD. When reduction in gas consumption reflects a decline in real income, reduction in overall spending, leading to significant output losses (Auclert et al., 2023).
- EA responses similar in direction but more muted: short-lived effect and not sufficiently pronounced to trigger broader cascading dynamics

Back to macroeconomic impact

Contribution of gas price shocks to the inflation surge



Euro Area



United States

Figure: Historical decomposition of headline inflation

- **EA:** Inflation surge largely driven by gas (supply) shocks
- **US:** Oil price shocks (linked to global supply imbalances and heightened geopolitical uncertainty) more important driver Contribution of oil shocks

Robustness

- **Identification**:
  - Background noise and placebo Details on noise and placebo
  - Informationally robust instrument Info robust IRFs
  - Identification as in Kilian (2024) Kilian's aggregation
  - Granger tests on instrument Granger's tests
  - Demand instrument including summer months Demand with summer IRFs
  - Mertens and Ravn (2013)'s procedure Orthogonalising the structural shocks

- **Estimation**:
  - Extended sample for US (HH starts in 1997) US extended IRFs
  - Estimation via internal instrument strategy Internal instruments
  - Estimation by VAR-OLS Frequentist VAR IRFs
  - Estimation by LP-IV LP-IV

$\Longrightarrow$ Results are robust

Conclusions

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- Found that gas shocks have significant macroeconomic effects, with notable regional differences
- Results show that expectation-driven mechanism amplifies inflationary pressures in EA via precautionary demand and heightened uncertainty
- Aggregate real effects are limited, though in the EA significant sectoral heterogeneity and larger impact on Germany
- Gas supply shocks increase CO_2 emissions in the short to medium run, due to substitution toward more carbon-intensive fuels.
- Gas one of the main drivers of the post-pandemic inflation surge in the EA

Concluding Remarks: Policy Implications

- Strengthening energy security and increasing flexibility of energy use remains a key priority (also wrt future climate-related disruptions)
  - Diversifying trade partnerships
  - Supporting joint procurement initiatives
  - Expanding strategic reserves

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  - Diversifying trade partnerships
  - Supporting joint procurement initiatives
  - Expanding strategic reserves

- Reforming the electricity markets reducing the impact of marginal pricing to mitigate price volatility

- Results suggest that price-based mechanisms alone may be insufficient to induce sustained shift away from fossil fuels. In short to medium term, gas price shocks lead to substitution toward more carbon-intensive fuels, rather than renewables

Appendix A - Euro Area and United States energy statistics

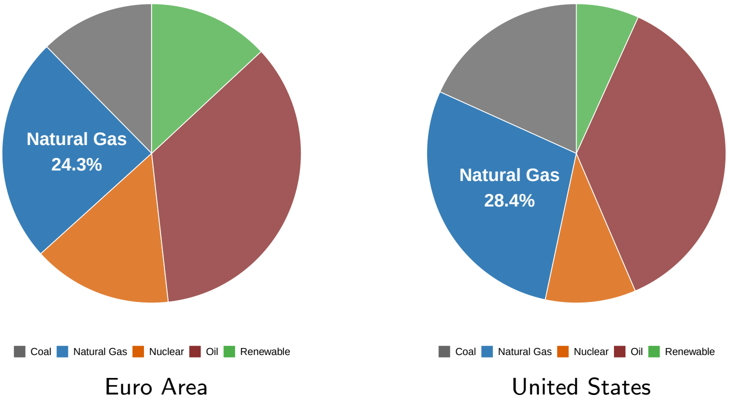
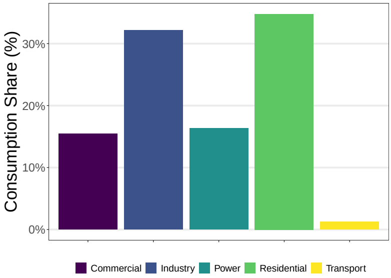


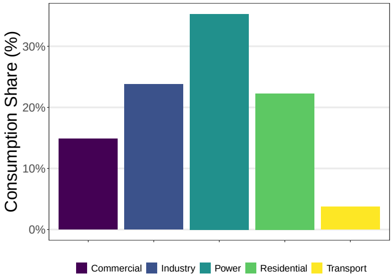
Figure: Total energy supplied by source

Back to gas markets

Appendix A - EA and US energy statistics (II)



Euro Area

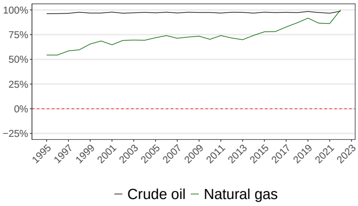


United States

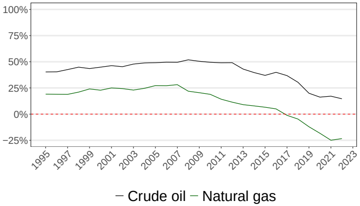
Figure: Natural gas consumption share by sector

Back to gas markets Back to supply and demand responses

Appendix A - EA and US energy statistics (III)



European Union



United States

Figure: Gas and oil import dependency

Back to gas markets

Appendix A - EA and US energy statistics (IV)

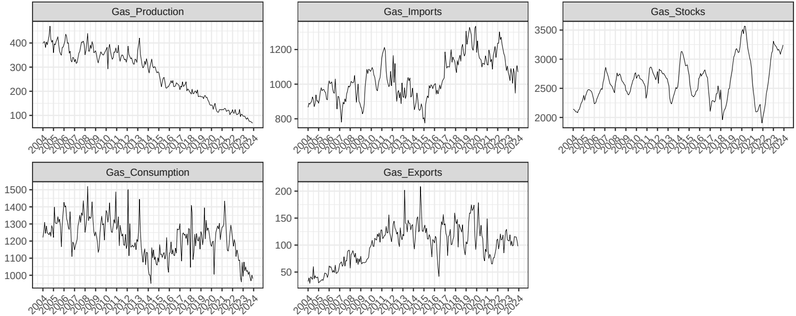


Figure: Gas Balances for the Euro Area

Appendix A - EA and US energy statistics (V)

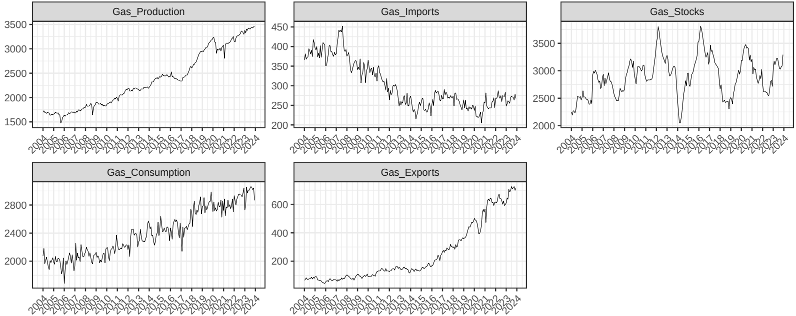
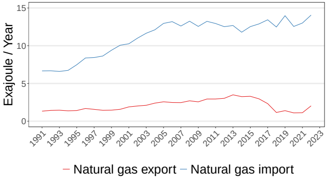


Figure: Gas Balances for the United States

Appendix A - EA and US energy statistics (VI)



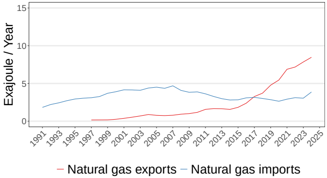
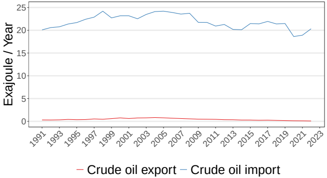
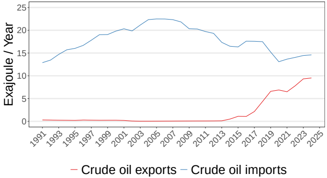


Figure: Natural gas imports and exports





European Union

United States

Figure: Crude oil imports and exports

Appendix B - TTF as the European benchmark for gas

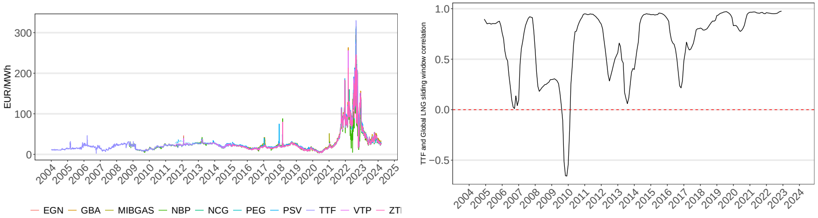


Figure: Left panel: TTF and other European gas hub prices. Right panel: rolling-window correlation between TTF and Global LNG price.

	NCG	VTP	PSV	ZTP	EGN	NBP	GBA	PEG	MIBGAS
TTF	1.00	1.00	1.00	0.97	0.98	0.93	1.00	0.97	0.97

Table: Correlation between TTF and other gas prices.

Back to gas markets

Appendix C - Additional details on gas supply instruments

Date	Event	daily %Δ (PC)
EA		
2009-01-06	Russia halts gas deliveries to Ukraine amid escalating gas dispute.	12.1
2010-10-28	UK expands LNG Capacity at the Isle of Grain terminal.	-1.3
2010-11-15	Unexpected drop in flows from Norway through Langeled pipeline.	3.4
2014-03-03	Gazprom threatens to cut gas exports amid the Crimea crisis.	5.7
2019-04-05	Pipeline blast reduces Russian gas supplies to Bulgaria by 60%	11.5
2020-08-03	Polish anti-monopoly UOKiK fines Gazprom over Nord Stream.	19.8
2021-10-28	Putin announces Gazprom ready to start pumping natural gas into European gas storage.	-9.9
2022-02-25	Auction result shows flows might resume via Yamal pipeline.	-28.3
2022-03-02	Supply fears peak amid Russia-Germany dispute over NS2, following invasion of Ukraine.	26.6
2022-06-14	Gazprom announces reduced supply through Nord Stream 1 due to repair works.	12.8
2022-06-15	Gazprom announces further reduction in gas flows through Nord Stream 1.	12.2
US		
2009-06-15	Kinder Morgan announces maintenance on natural gas Pipeline Co. of America Mainline.	4.5
2010-05-12	Gas outages across the South.	2.6
2012-07-24	Pipeline constraints limit supply in the Gulf Coast.	2.1
2012-09-21	Force Majeure at Julesburg compressor station.	3.2
2013-11-01	Transco begins full service on Northeast Supply Link project.	-2.1
2014-02-13	Columbia Gulf transmission pipeline shuts following explosion in Kentucky.	1.7
2014-09-15	Explosion at Chevron gas pipeline.	2.1
2017-05-10	FERC bans new drilling along Rover pipeline.	1.6
2022-06-08	Blast hits Freeport LNG plant, disrupting operations.	-4.3
2023-03-08	Unexpected flows drop at Freeport LNG related to outages.	-3.0
2023-06-30	Restrictions at Oxford and Stony Point compressors amid maintenance.	2.6

Table: Selected gas supply news for EA and US.

Back to examples of news

Appendix C - Gas supply instrument for the US

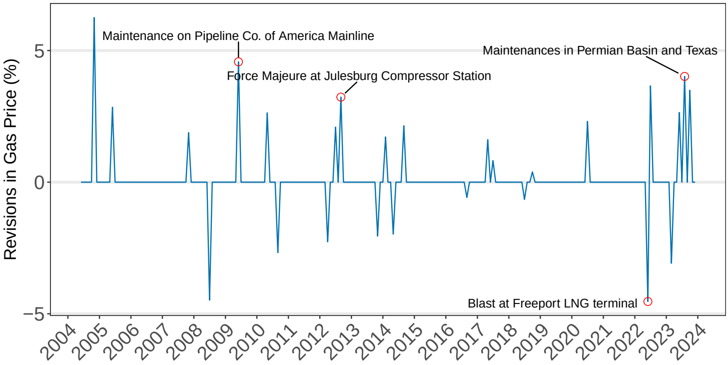
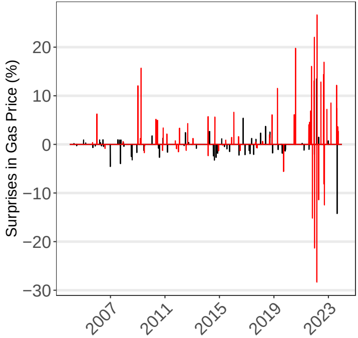


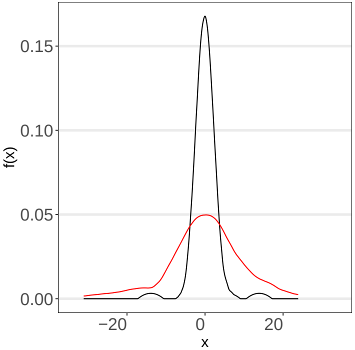
Figure: Gas price surprise series constructed from changes in gas futures prices around announcements (principal component spanning first year of HH gas futures term structure).

Back to gas supply shock

Appendix C - Assessing the instruments: noise (EA)



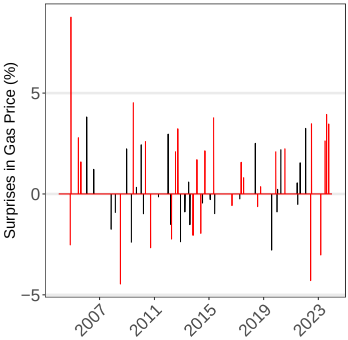
Daily surprises



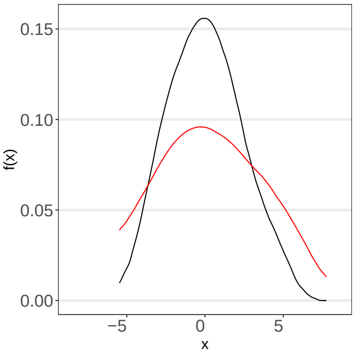
PDF

Figure: Left panel: daily changes in gas future prices on news and control days (chosen at random among non-news days). Right panel: empirical PDF.

Appendix C - Assessing the instruments: noise (US)



Daily surprises



PDF

Figure: Left panel: daily changes in gas future prices on news and control days. Right panel: empirical PDF.

Back to robustness

Appendix C - Assessing the instruments: Granger's tests

Variable	p-value EA	p-value US
Instrument Lags	0.26	0.93
Gas price	0.78	0.78
Oil price	0.44	0.60
Gas quantity demanded	0.36	0.68
Gas quantity supplied	0.29	0.62
Gas inventories	0.20	0.60
Headline inflation	0.19	0.98
Industrial production	0.28	0.91
Financial volatility	0.17	0.96
Interest rate	0.22	0.83
Nominal exchange rate	0.74	0.76
Stock market (STOXX50E/SP500)	0.31	0.62
Real economic activity	0.91	0.90
Joint Test	0.18	1.00

Table: Granger causality tests.

Back to correlations Back to robustness

Appendix C - Assessing the instruments: strength (EA)

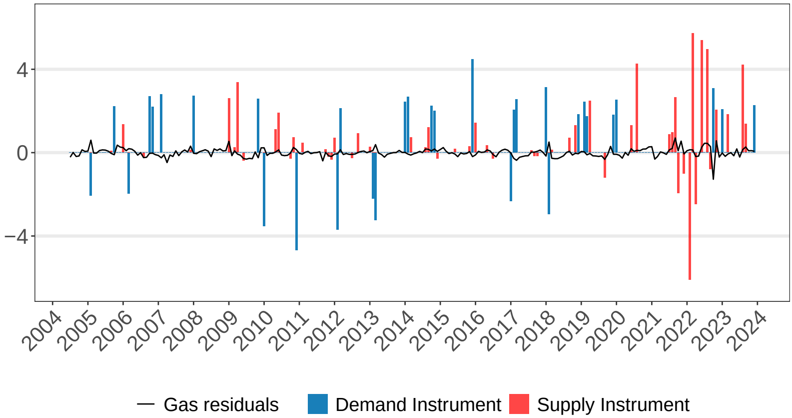


Figure: The figure shows how the gas and demand instruments are related to the reduced-form residuals. The series are rescaled to have unit variance.

Appendix C - Assessing the instruments: strength (US)

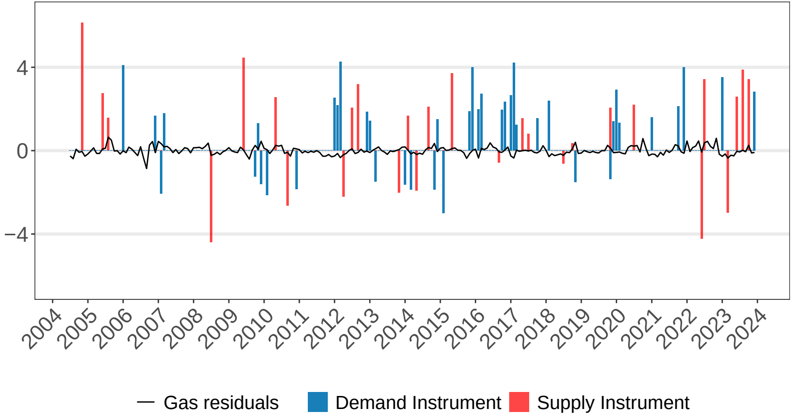


Figure: The figure shows how the gas and demand instruments are related to the reduced-form residuals. The series are rescaled to have unit variance.

Appendix C - Assessing the instruments: Posterior distributions, gas demand shock

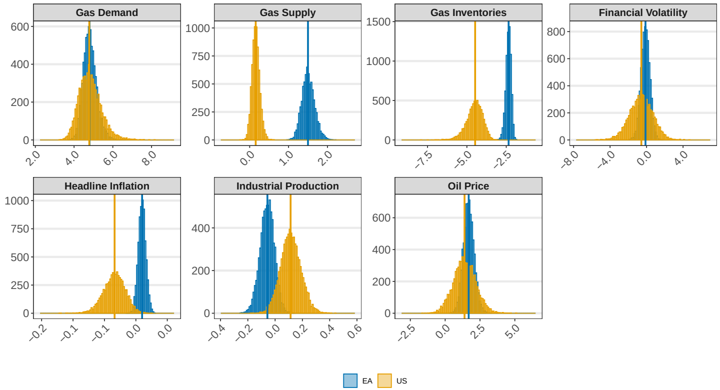


Figure: Posterior distributions of impact coefficients, gas demand shock.

Appendix C - Assessing the instruments: Posterior distributions, gas supply shock

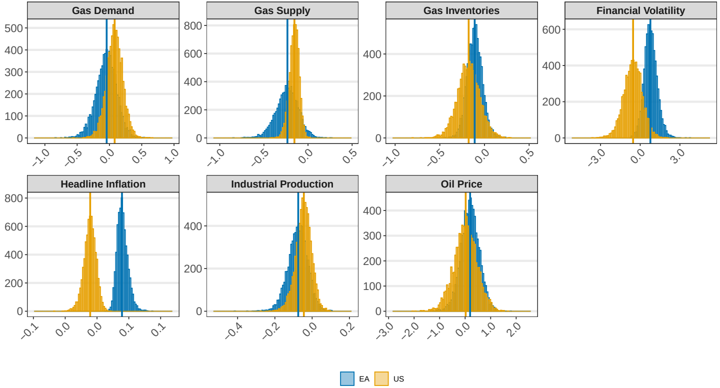


Figure: Posterior distributions of impact coefficients, gas supply shock.

Appendix D - Gas demand instrument for the US

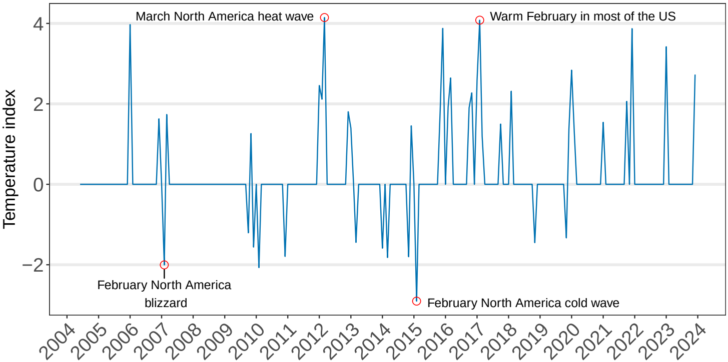


Figure: Temperature proxy series for the US.

Back to gas demand shock

Appendix E - Comparison with previous estimates

Our estimates:

- **Euro Area**: Demand elasticity $= -0.11$, Supply elasticity $= 0.76$
- **United States**: Demand elasticity $= -0.05$, Supply elasticity $= 0.33$

Note, we define

gas demand = consumption + exports
gas supply = domestic production + imports

Previous estimates:

Authors (year)	Region	Demand Quantity	Demand Estimate	Supply Quantity	Supply Estimate	Identification	Sample period
Casoli et al. (2024)	Europe	Consumption	-0.47	Production	0.34	Priors and sign restrictions*	2010M1–2022M7
Wiggins and Etienne (2017)	United States	Production	[-0.08; -0.18]**	Production	[0.15; 0.3]**	Sign restrictions	1976Q1–2015Q2
Rubaszek et al. (2021)	United States	Consumption	-0.42	Production	0.01	Priors and sign restrictions*	1978Q1–2020Q3
Farag (2024)	United States	Consumption	-0.177	Production + Imports	0.019	Priors and sign restrictions*	1992M1–2023M10

†* Baumeister and Hamilton (2019) identification strategy.
†** Wiggins and Etienne (2017) reports a range from a time-varying parameter model.

Appendix F - HD of the real price of natural gas (US)

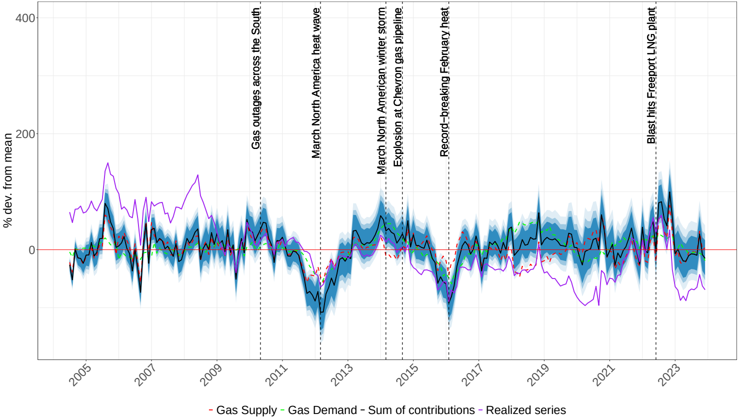


Figure: US: Historical decomposition of the real price of gas.
2010M5 gas outages in the South; **2012M3** North American heat wave; **2014M3** North American winter storm; **2014M9** Chevron pipeline explosion (Louisiana); **2016M2** record February warmth; **2022M6** Freeport LNG blast and shutdown.

Back to HD of gas price

Appendix G - Baseline responses: gas demand shock

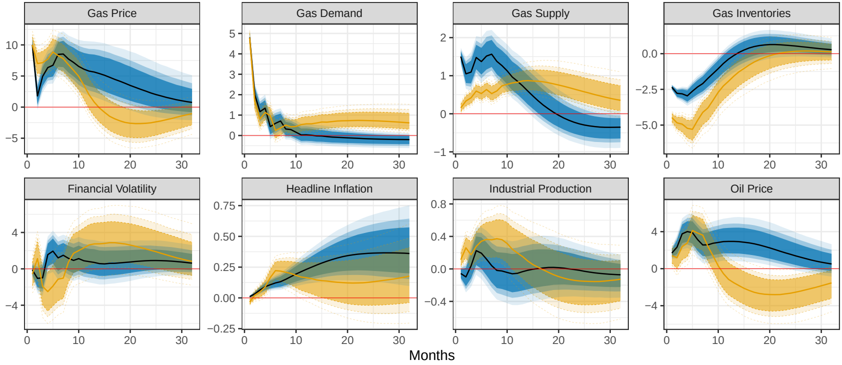


Figure: Full responses to a gas demand shock, baseline specification. Normalised to a one-time 10% increase in the real price of natural gas.

Appendix G - Baseline responses: gas supply shock

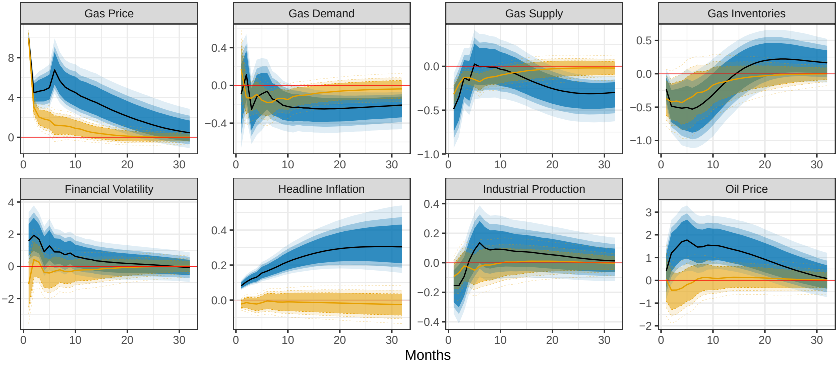


Figure: Full responses to a gas supply shock, baseline specification. Normalised to a one-time 10% increase in the real price of natural gas.

Back to baseline specification

Appendix H - Additional results: Drivers of supply responses

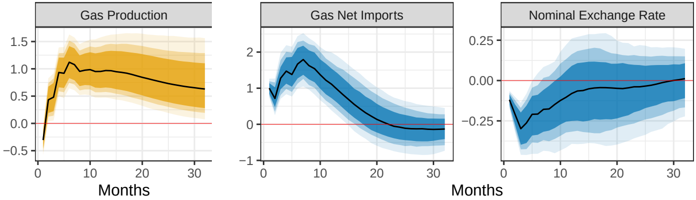


Figure: Drivers of gas supply. Additional responses to a gas demand shock: US in orange, EA in blue

Back to supply and demand responses

Appendix H - Additional results: Interfuel substitution in the power sector

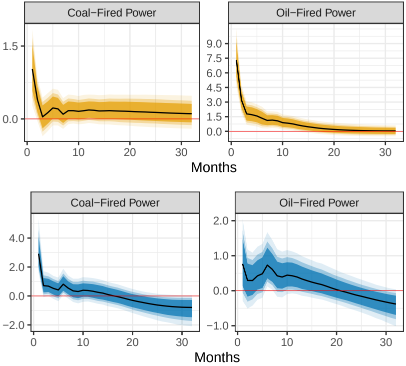


Figure: Interfuel substitution in the power sector. Additional responses to a gas supply shock: US in orange, EA in blue. EA sample starts in 2010 due to data availability.

Back to supply and demand responses
Back to environmental impact

Appendix H - Additional results: EA supply shock constructed only with expected events

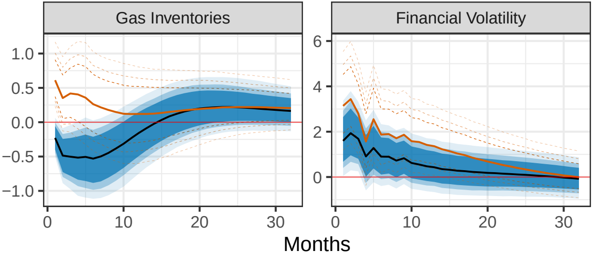


Figure: Responses to a gas supply shock in the EA: baseline specification (black solid line with blue shaded confidence bands) and alternative specification using an instrument constructed from news about expected supply disruptions only (red solid and dashed lines)

Back to uncertainty channel

Appendix H - Additional results: PPI Inflation in Europe

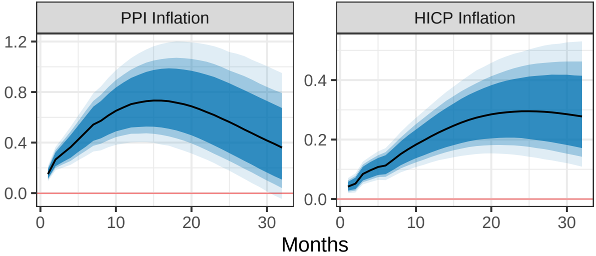
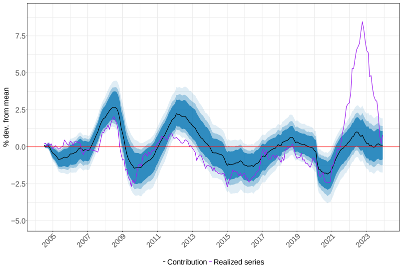


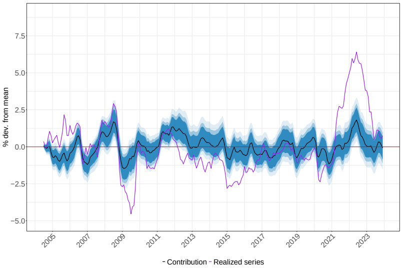
Figure: Responses of producer price and consumer price inflation

Back to macro impacts

Appendix H - Additional results: Contribution of oil shocks to historical decomposition of inflation



Euro Area



United States

Figure: Historical decomposition of headline inflation

Back to HD of inflation

Appendix I - Sensitivity checks: US demand instrument including summer months

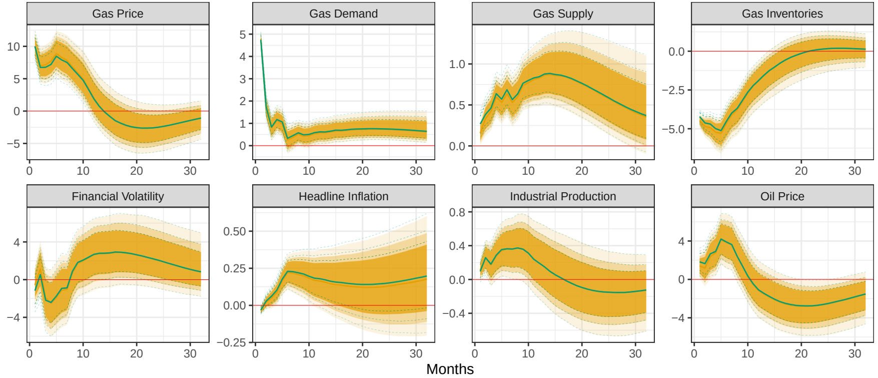


Figure: Responses to a gas demand shock, including summer months. Baseline in orange, responses using alternative instrument in green.

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Appendix I - Sensitivity checks: US demand with extended sample (1997-2023)

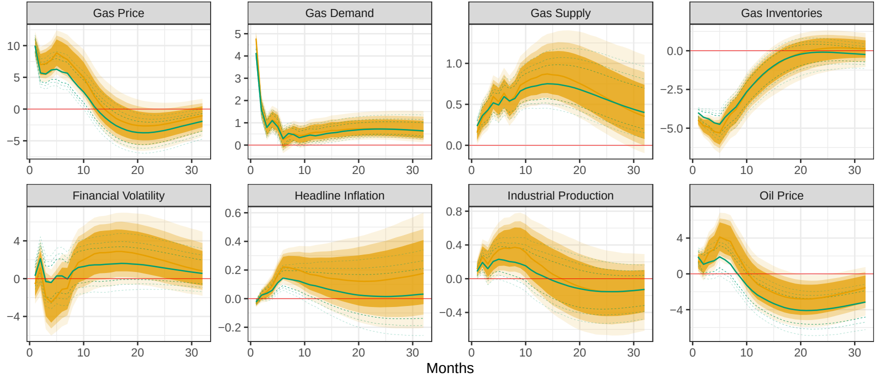

Figure: Full responses to a gas demand shock in the US, extended sample. Baseline in orange, extended sample in green.

Appendix I - Sensitivity checks: US supply with extended sample (1997-2023)

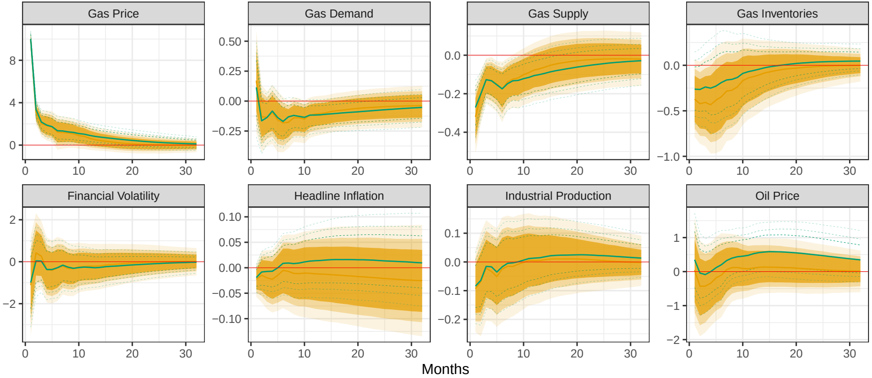

Figure: Full responses to a gas supply shock in the US, extended sample.

Back to robustness

Appendix I - Sensitivity checks: Informationally robust supply instrument

- For the exclusion restriction to hold, gas news must not convey information about confounding factors
- One potential confounder is food prices, also affected by the Ukraine war.
- Construct informationally robust instrument (Romer and Romer, 2004; Miranda-Agrippino and Ricco, 2021)
    1. Compute food surprises around same gas news, using MATIF wheat futures
    2. Build the "informationally-robust" surprises as the residuals of the regression:

$$GasSurprise_t^h = \alpha_0 + \sum_{j=1}^{l} \phi_j GasSurprise_{t-j}^h + \sum_{j=0}^{l} \theta_j FoodSurprise_{t-j}^h + \sum_{j=0}^{l} \mathbf{x}_{t-j}\Gamma_j + IRS_t$$

where $\mathbf{x}_t$ is a vector of monthly macroeconomic shocks sourced from the literature and IRS_t denotes the Informationally Robust Surprises

Appendix I - Sensitivity checks: Informationally robust gas supply shock

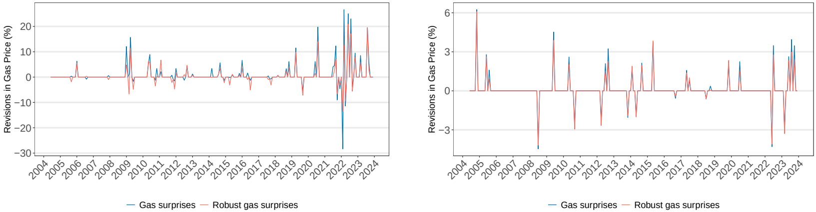

Figure: Gas surprise series (blue) and informationally-robust gas surprises series IRS_t (red). Europe shown in the left panel; United States in the right.

Back to correlations

Appendix I - Sensitivity checks: Informationally robust gas supply shocks

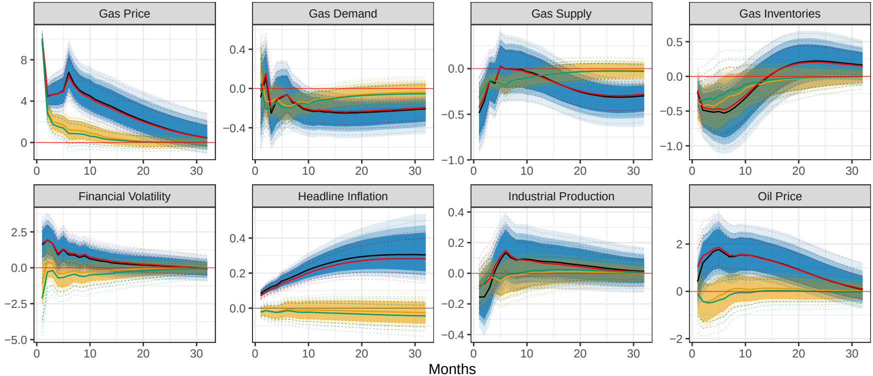

Figure: Responses to an informationally-robust gas shock. Euro Area-baseline: black solid line with blue shaded confidence bands; robust refinement: red solid line with dotted bands. United States-baseline: orange solid line with dashed/shaded orange confidence bands; robust refinement: green solid line with dashed bands.

Back to robustness

Appendix I - Sensitivity checks: Constructing high-frequency proxies as in Kilian (2024)

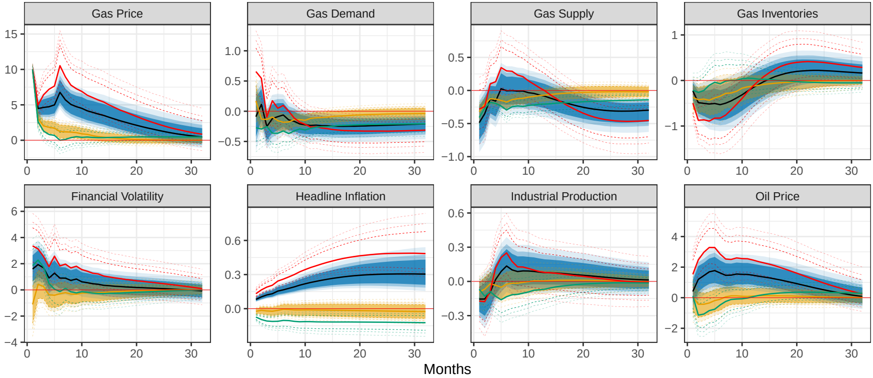

Figure: Responses to a gas supply shock, comparison of results obtained with baseline instrument and constructed using the temporal aggregation technique proposed by Kilian (2024). Back to robustness

Appendix I - Sensitivity checks: Internal instrument strategy, gas demand

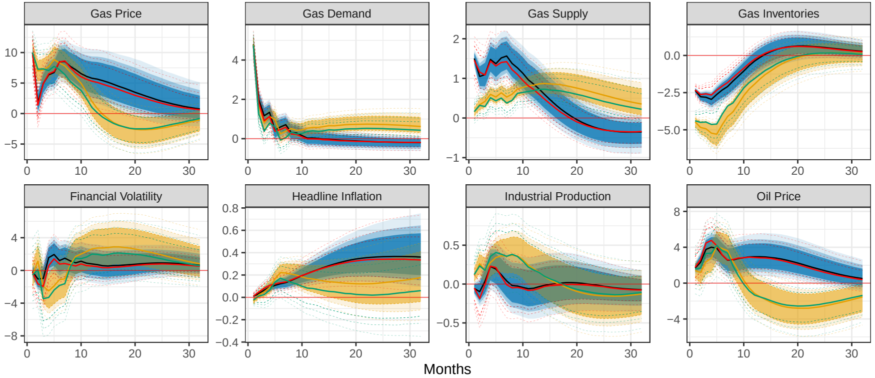

Figure: Responses to a gas demand shock, comparison of baseline and identified using the internal instruments approach by placing the demand instrument as the first variable in a recursive BVAR.

Appendix I - Sensitivity checks: Internal instrument strategy, gas supply

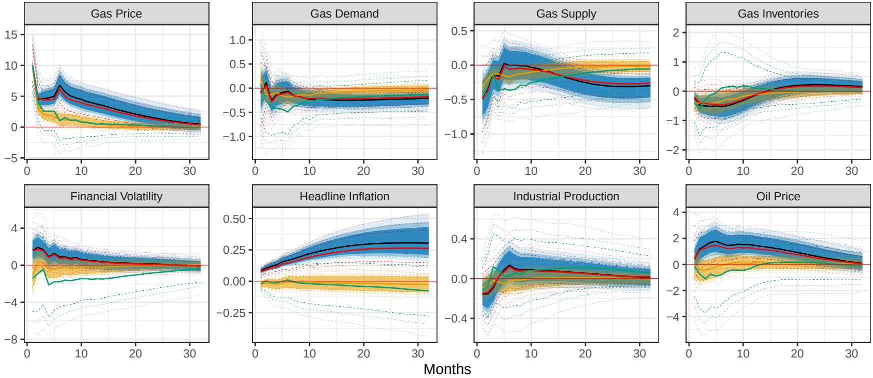

Figure: Impulse responses to a gas supply shock, comparison of baseline and identified using the internal instruments approach by placing the supply instrument as the first variable in a recursive BVAR. Back to robustness

Appendix I - Sensitivity checks: VAR-OLS

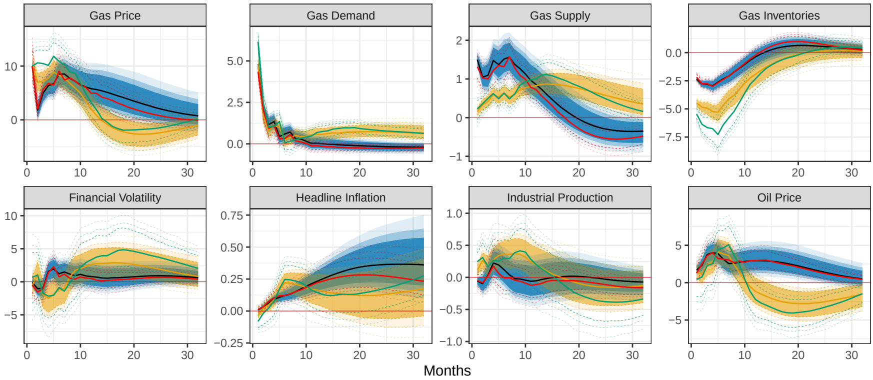

Figure: Responses to a gas demand shock, estimated by VAR-OLS.

Appendix I - Sensitivity checks: VAR-OLS - II

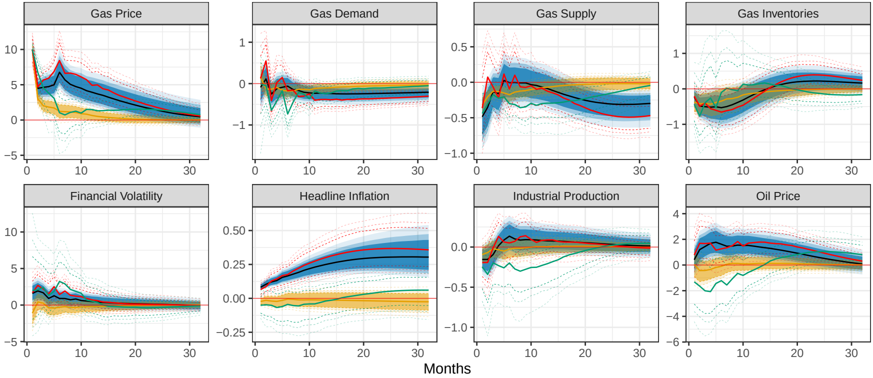

Figure: Responses to a gas supply shock, estimated by VAR-OLS.

Back to robustness

Appendix I - Sensitivity checks: Local Projections (LP-IV) gas demand shock

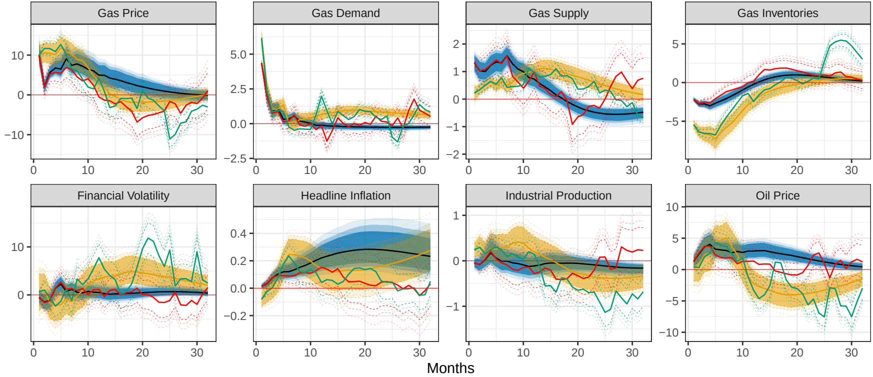

Figure: Responses to a gas demand shock, comparison of responses estimated by VAR-OLS and LP-IV.

Appendix I - Sensitivity checks: Local Projections (LP-IV) gas supply shock

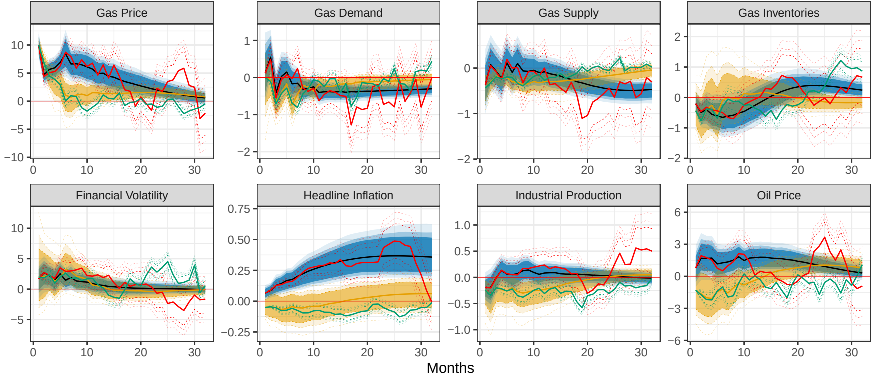

Figure: Responses to a gas supply shock, comparison of responses estimated by VAR-OLS and LP-IV. Back to robustness

Appendix I - Sensitivity checks: orthogonalising the structural shocks

- When several shocks are identified, the instrument-identified shocks are generally *not* orthogonal in sample; we therefore impose a recursive (Cholesky) ordering to orthogonalize them, following (Mertens & Ravn, 2013).

- Results are broadly robust to the ordering choice, with only minor deviations from the baseline when the shock is placed *second* in the recursive structure.

Appendix I - Sensitivity checks: orthogonalising the shocks, EA demand

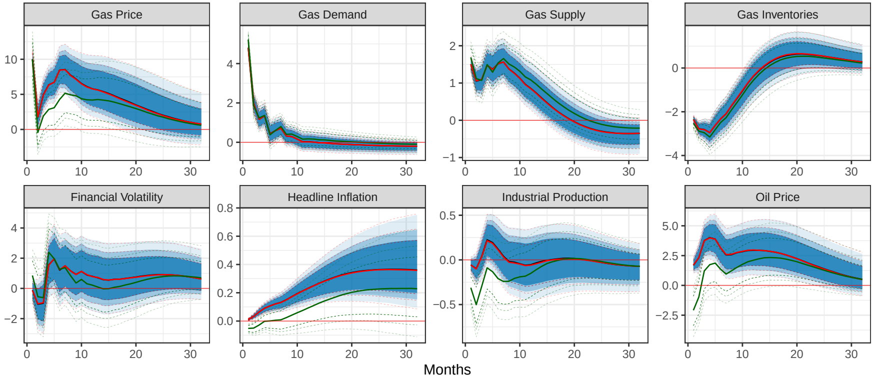

Figure: Responses to a gas demand shock, ordered first (red IRFs) and ordered second (green IRFs).

Appendix I - Sensitivity checks: orthogonalising the shocks, EA supply

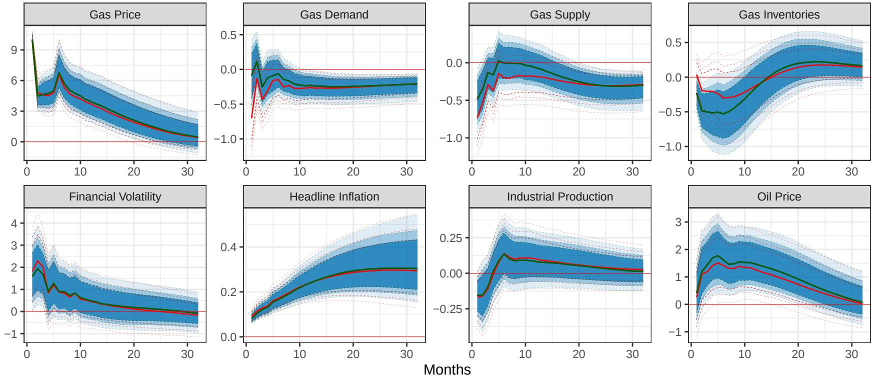

Figure: Responses to a gas supply shock, ordered first (red IRFs) and ordered second (green IRFs).

Appendix I - Sensitivity checks: orthogonalising the shocks, US demand

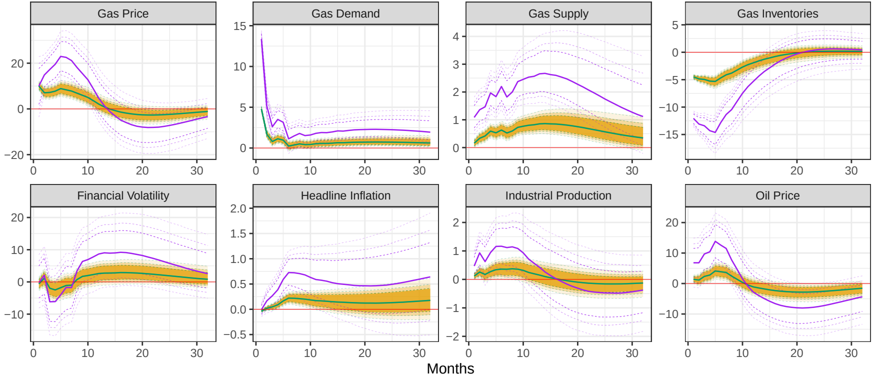

Figure: Responses to a gas demand shock, ordered first (orange IRFs) and ordered second (purple IRFs).

Appendix I - Sensitivity checks: orthogonalising the shocks, US supply

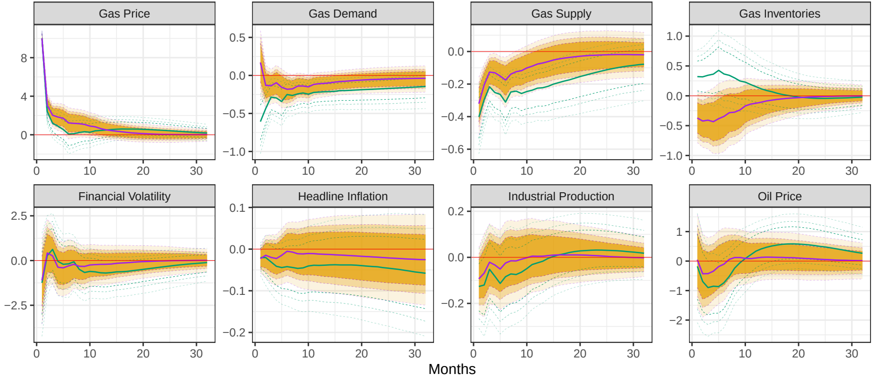

Figure: Responses to a gas supply shock, ordered first (orange IRFs) and ordered second (purple IRFs).

Back to robustness

Appendix L - Comparison with alternative gas supply instrument for Europe

- **Technical:** ENDEX *vs* TRPC, 2010M1-2022M11 identification and 2000M1-2022M11 estimation *vs* 2004M1- 2023M12 for both.
- **Substantive:** Only surprises in 1M futures *vs* also longer maturities $\Longrightarrow$ cleans from noise and captures effects also via future expectations (shown to be very relevant)
- **Obtain different proxies:** modest correlation (0.30)
- **Different results:** Positive effect on gas demand

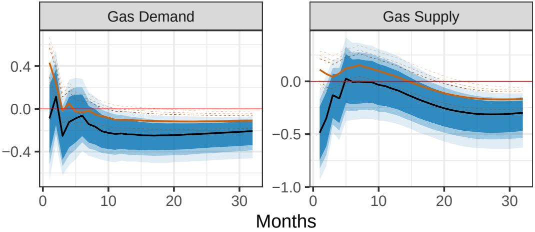

Figure: Selected impulse responses obtained by using the Alessandri and Gazzani (2025) gas supply instrument in our baseline specification.

Appendix L - Comparison with alternative gas supply instrument for Europe (II)

Source	Shock	ρ	n
This study	Temperature demand shock	-0.10	155
Baumeister and Hamilton (2019)*	Oil demand	0.13	155
Caldara et al. (2019)*	CCI oil supply	-0.23	72
Jarociński and Karadi (2020)	Information median monetary policy (EA)	0.19	155

Table: Correlation of Alessandri and Gazzani (2025) instrument with other shocks.

- Instrument is correlated with demand-side indicators and may capture some demand-side component
- Inclusion of news potentially confounded by demand.
  Example: approval of Italy's LNG terminal on October 21, 2022 coincided with an unseasonal heatwave in Europe