The effects of the 2021-2022 energy crisis on medium-sized and large industrial firms: evidence from Italy

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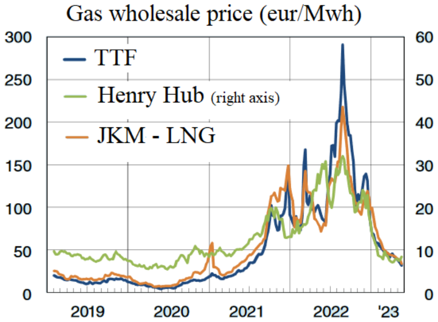


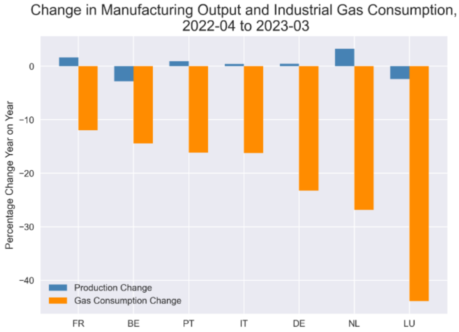


Figure: Sources: Bank of Italy and Moll (2023)

- EU policy makers concerned that recent energy price spikes would have large negative effects on output.
- Some economists (Bachmann et al., 2022) disagree on the ground that firms (and markets) can easily adjust.
- Still, EU governments allocated € 758 billion to support policies.

Our paper contributes to this debate

- provides credible identification of micro ϵ_D from the recent energy crisis (IV/DiD)
- explores rich heterogeneity in responses
- investigates (heterogeneous) effects on other margins of adjustment

Preview of results: heterogeneity is key

Energy demand

- electricity 💡 elasticity is always very close to zero
- gas 🔥 elasticity larger and highly heterogeneous: [0,-1]
  - large gas consumers respond more and partially substitute away from gas ⚙️ 🪛
  - elasticity increased over time, picking up in 2022h2

Other behavioral responses

- large consumers ↑ output prices 💲 and ↓ capacity utilization 🏭
- no impact on margins 💰 for large nor small consumers

⇒ consistent with aggregate picture

Literature

1. **Price elasticity of energy demand for firms**:
   - Labandeira et al. '17: meta analysis. Heavy reliance on "macroeconomic" IVs
   - Fontagnè et al. '23: use micro data on French firms in 1996-2019.

   Contributions: micro data on current crisis, firm-level IV unconfounded by aggregate shocks.

2. **Effects of the 2021-2022 energy crisis on industry**:
   - Alessandri and Gazzani '23; Bachmann et al. '22; Corsello et al. '23; Ruhnau et al. '22.

   Contribution: Isolate $p_e \Rightarrow q_e$ and other outcomes at micro level, net of other behavioral factors e.g. public attention, awareness etc. Display dynamic and heterogeneous effects.

Research design for 2021: elasticity of energy demand

Survey questions on 2021
(designed in 2021h2; answered in 2022h1)

Rising energy prices

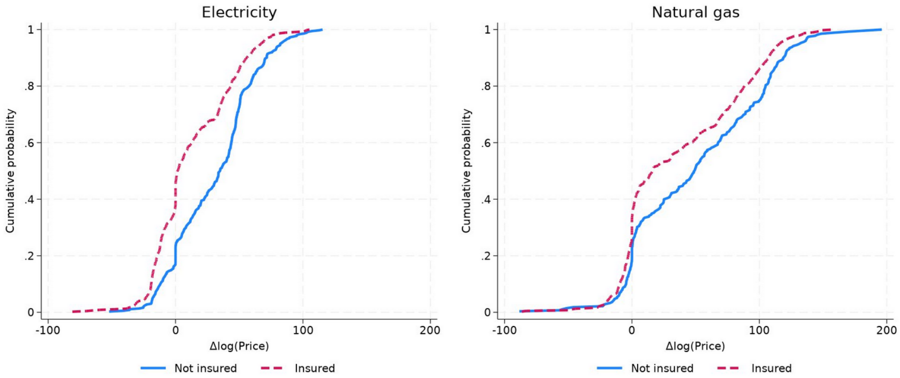
At the beginning of 2021, did your firm own any instruments that protected it, wholly or partly, from energy price increases over the second half of the year? [ ] **E11**

1 No
2 Yes, fixed-price contracts
3 Yes, financial derivatives
4 Yes, other instrument

	In the first half of the 2021		**In the second half of the 2021**	
Please indicate, even approximately, the purchased quantity and the respective cost of the following products:	Purchased quantity	Total cost (thousands of euros)	Purchased quantity	Total cost (thousands of euros)
Electricity	**E9A** MWh	**E7A** €	**E9B** MWh	**E7B** €
Natural gas	**E10A** Scm	**E8A** €	**E10B** Scm	**E8B** €

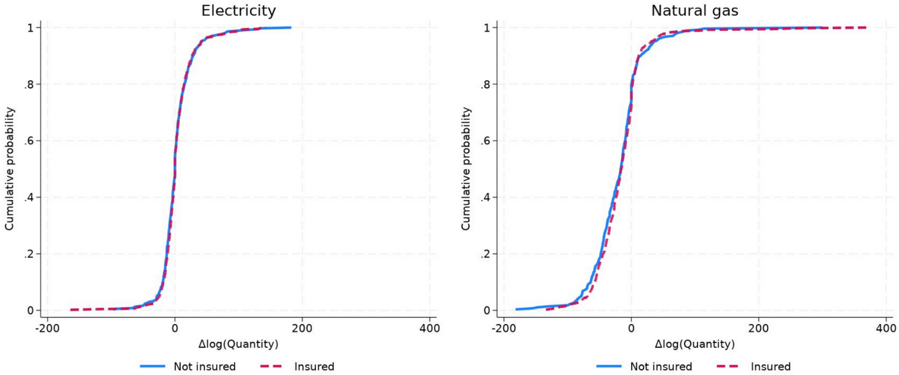
- Data cleaning and validation with Eurostat price and ETS quantity data

Z_i strongly predictive of price changes (first stage)



- K-P F Stat ≈ 80 for electricity and ≈ 13 for gas

Z_i not predictive of quantity changes (reduced form)

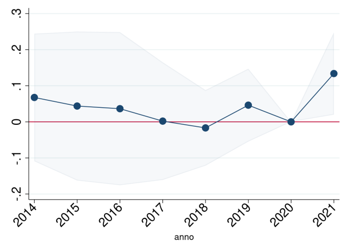


- Implied elasticity is precisely estimated zero.

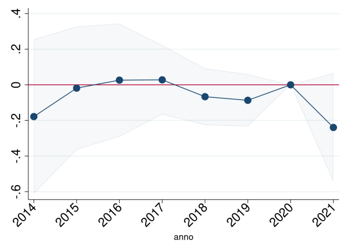
Sample of large gas consumers (EU-ETS): in 2021 protected firms consume relatively more gas and less substitutes

$$\log(consumption_{it}) = \mu_i + \gamma_t + \sum_k \lambda_k \cdot Z_i \cdot \mathbf{1}(\text{year} = k) + \varepsilon_{i,t}. \quad (1)$$

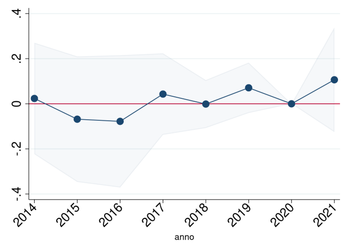
(a) log (gas)



(b) log (substitutes)



(c) log (gas + substitutes)



Research design for 2021-2022: elasticity of energy demand

Survey questions on 2022

(designed in 2022h2; answered in 2023h1)

Rising energy prices

In 2022, did your firm have instruments (for example fixed-price contracts or derivatives) to protect itself, even partially, from the rises in the prices ...				If yes, how many months did this protection last in 2022?
A ...of electricity?	(Yes/No)	E11A	⇨	E12A
B ...of gas?	(Yes/No)	E11B	⇨	E12B

Please indicate, even approximately, the amount of electricity and natural gas purchased and their costs (gross of any tax credit): *(put 0 if you didn't purchase any during the semester)*

	In the first half of the 2022		**In the second half of the 2022**	
	Purchased quantity	Total cost (thousands of euros)	Purchased quantity	Total cost (thousands of euros)
Electricity	E9A MWh	E7A €	E9B MWh	E7B €
Natural gas	E10A Scm	E8A €	E10B Scm	E8B €

- Data cleaning and validation with Eurostat price and ETS quantity data
- 4 cohorts: always protected; protected until mid 2022; protected until end 2021; unprotected. details

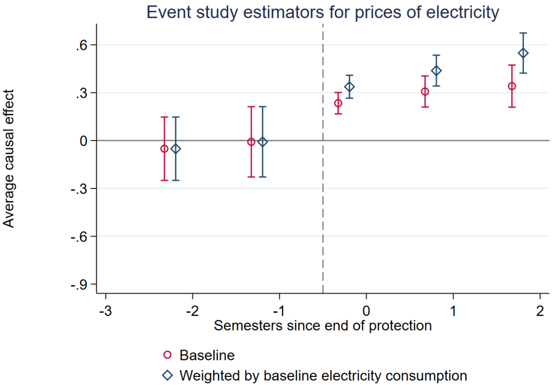
Diff-in-Diff design using both 2021 and 2022 waves

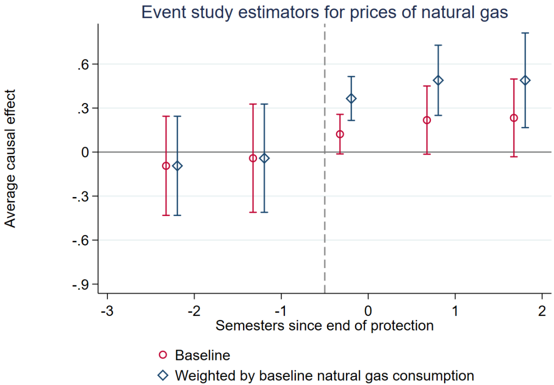
Staggered diff-in-diff model on balanced panel of firms (i) observed during each semester (t) of 2021-2022:

$$\log Y_{it} = \alpha_i + \gamma_t + \sum_{k=-3}^{3} \beta_k \cdot \mathbf{1}(t - E_i = k) + \epsilon_{it}, \tag{2}$$

- Y_{it} either p or q, separately for electricity and gas
- **Control group**: protected firms (at that point in time, or always)
- E_i is the treatment cohort. k = time since contract expiration = time since exposure to shock
- Estimate by OLS and four new estimators that avoid "forbidden comparisons":
  - Borusyak et al. '21, de Chaisemartin and D'Haultfoeuille '20, Sun and Abraham '20, Callaway and Sant'Anna, '20

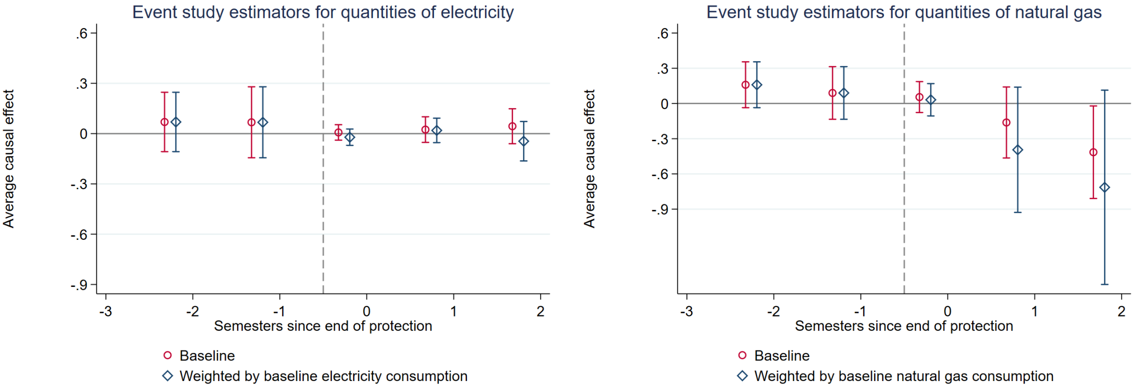
$$\log p_{it} = \alpha_i + \gamma_t + \sum_{k=-3}^{3} \beta_k \cdot \mathbf{1}(t - E_i = k) + \epsilon_{it}, \quad (3)$$





- Robust to different DiD estimators and to the inclusion of covariate-specific trends

$$\log q_{it} = \alpha_i + \gamma_t + \sum_{k=-3}^{3} \beta_k \cdot \mathbf{1}(t - E_i = k) + \epsilon_{it}, \quad (4)$$



- Robust to different DiD estimators and to the inclusion of covariate-specific trends

Annual panel 2017-2022: firms performance

Research design using annual panel with standard questions

Staggered diff-in-diff model on long **annual** (t) panel of firms (i) observed since 2017:

$$Y_{it} = \alpha_i + \gamma_t + \sum_{k=-4}^{1} \beta_k \cdot \mathbf{1}(t - E_i = k) + \epsilon_{it}, \tag{5}$$

- Y_{it} is either:
  - the % change in the price of final output 💲 relative to previous year
  - the % change in capacity utilization 🏭 relative to previous year
  - a dummy for worsening of the profit margin 💰 relative to previous year
- E_i is the treatment cohort. As before, but at the annual level
- **Two treatment cohorts**: treated in 2021; treated in 2022
- **Control group**: protected firms (still, or forever)

Not much adjustment for the average firm

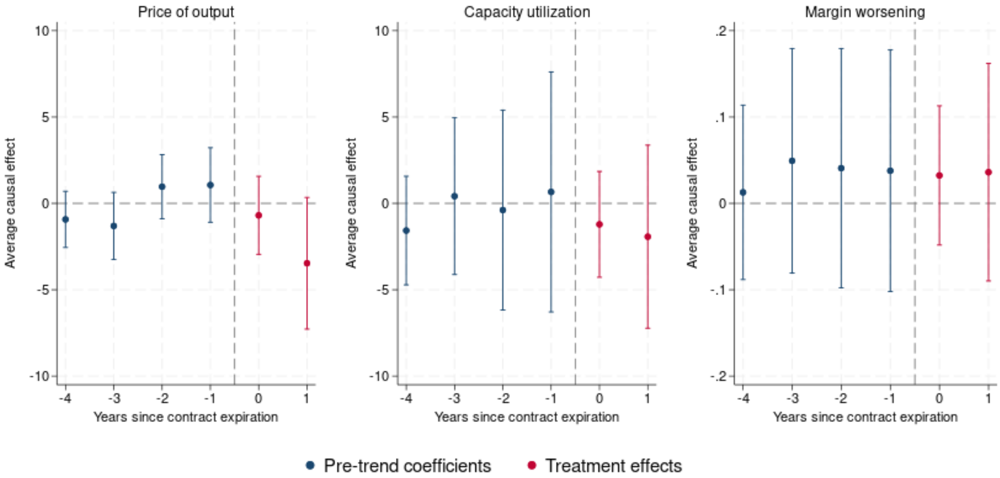


Figure: Unweighted estimates

Among large gas consumers: prices increase more and output drops more.

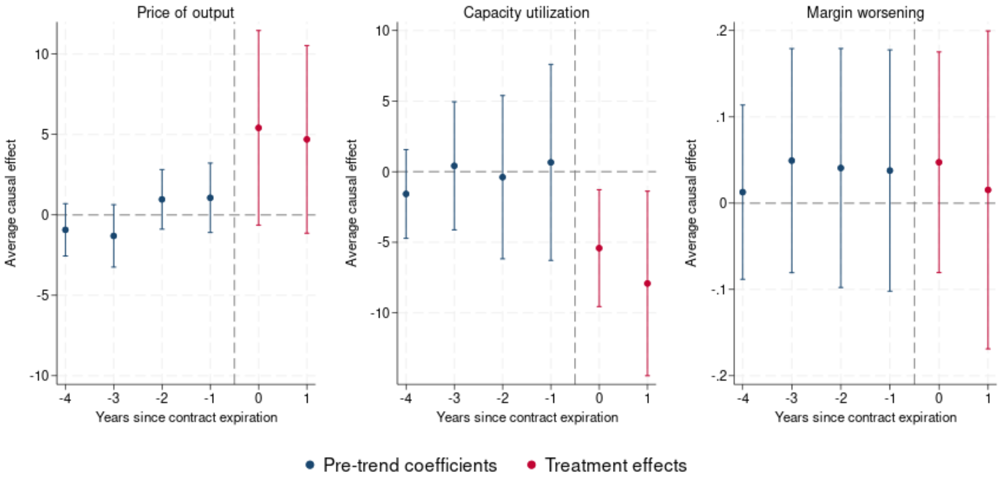


Figure: Weighted by baseline gas consumption

Conclusions

Results

- The surge in gas price lead to drop in demand. Not true for electricity.
- Only among large gas consumers, the increase in the cost of energy induced firms:
  - to reduce output
  - to increase final prices
- No evidence of change in the profit margins

Implications

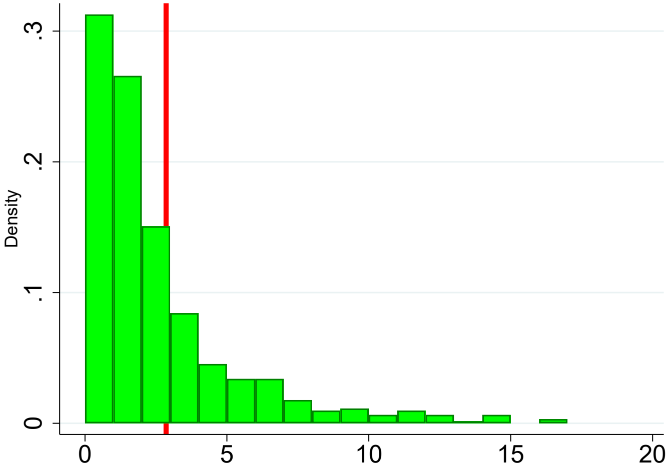
- Heterogeneity consistent with the large drop in energy demand coupled with little consequences on production: in the industrial sector, large consumers account for more than 50% of gas demand, but less than 7% in VA
- Support policies, if any, better take the heterogeneity across firms and energy sources into account.

Next steps

- Exploit admin data at monthly frequency on energy consumption by energy-intensive firms.

Back-up slides

Incidence of energy costs on sales



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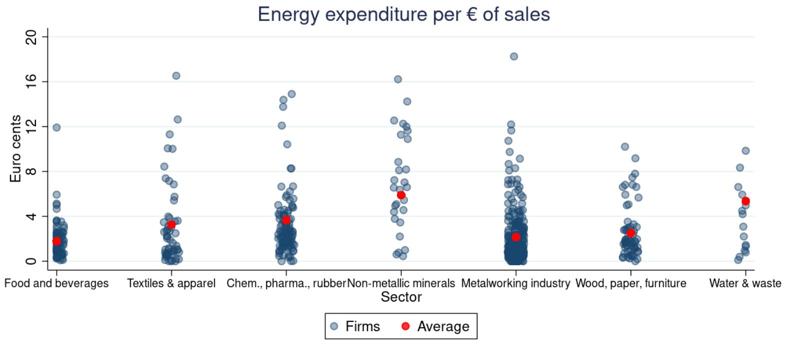
Incidence of energy costs on sales across sectors



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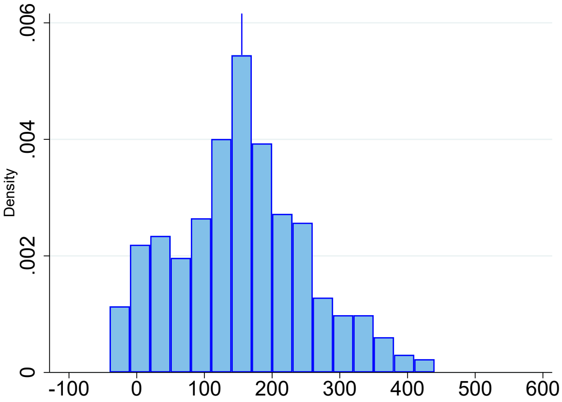
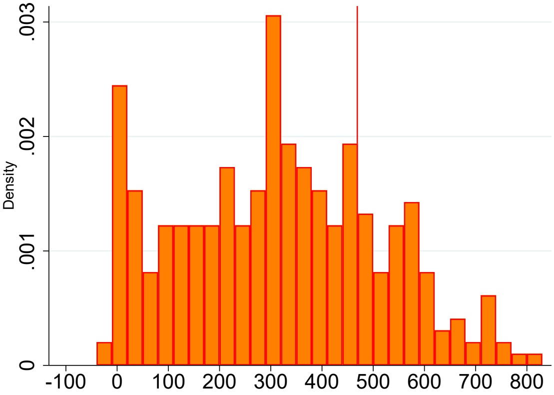
% Price changes 2022h2 vs 2021h1

electricity and natural gas





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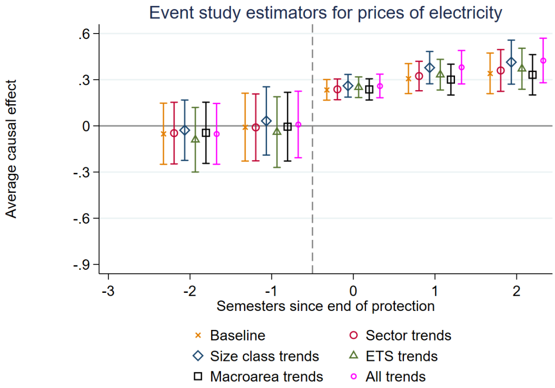
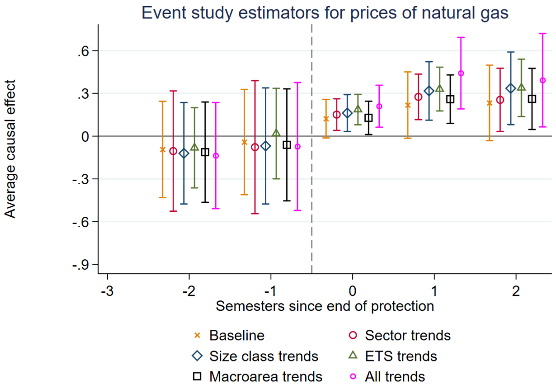
Inclusion of trends in price regressions





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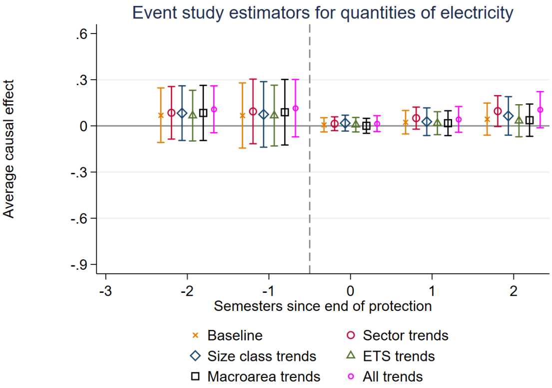
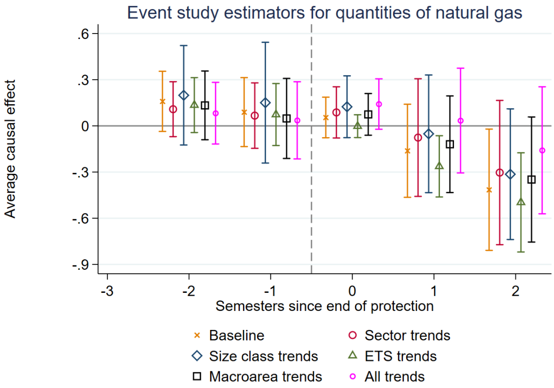
Inclusion of trends in quantity regressions





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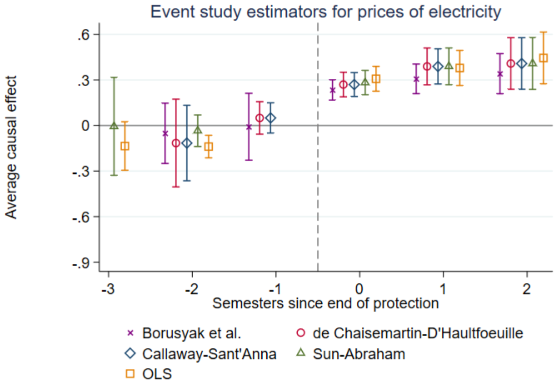
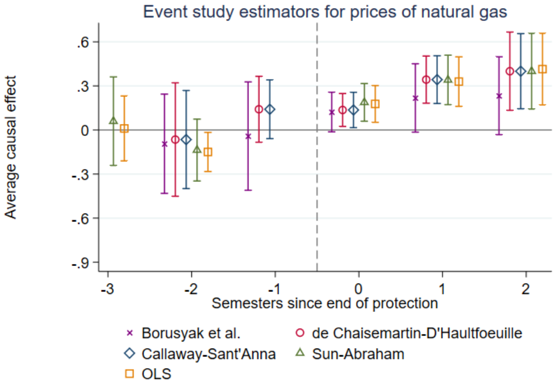
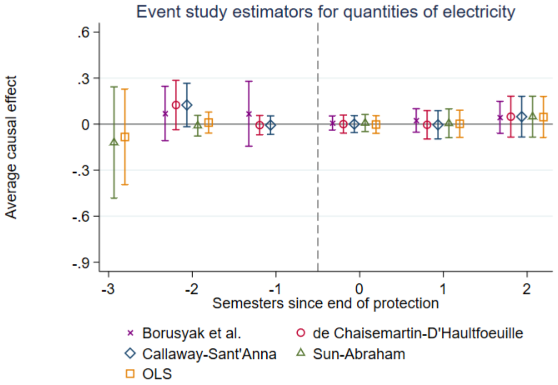
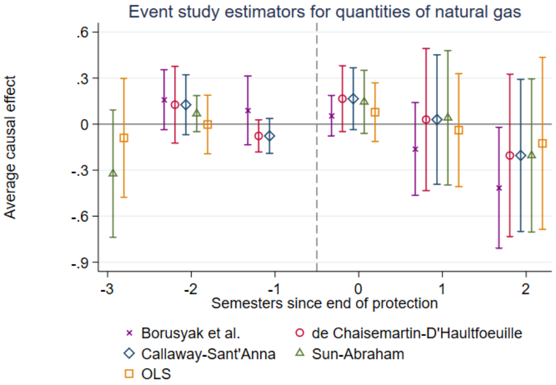
$$\log p_{it} = \alpha_i + \gamma_t + \sum_{k=-3}^{3} \beta_k \cdot \mathbf{1}(t - E_i = k) + \epsilon_{it}, \quad (6)$$





$$\log q_{it} = \alpha_i + \gamma_t + \sum_{k=-3}^{3} \beta_k \cdot \mathbf{1}(t - E_i = k) + \epsilon_{it}, \quad (7)$$





Retail prices of energy are heterogeneous

- Almost exclusively negotiated on the free market
- Retail price includes several components
  - fees for transport and distribution
  - taxes and levies (lower for large consumers)
  - quantity of energy (MWh)
  - power capacity (MW)
- Some of these components are fixed costs i.e. not a function of quantity purchased

→ **average price declines with quantity**

- Two main types of contracts for the energy component:
  - **Fixed price** for typically 12 to 24 months **(rolling basis)**
  - **Floating price**, indexed to wholesale price

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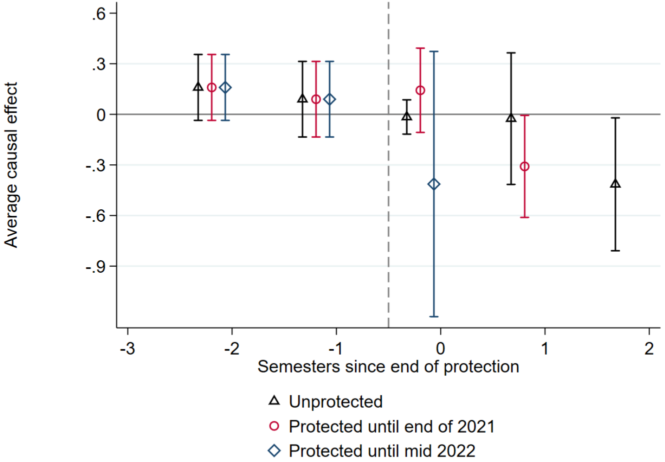
Gas consumption by cohort: both early and late treated adjust in 2022h2



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Treatment cohorts

We define four treatment cohorts

1. Unprotected
   - Had no fixed price instrument at beginning of 2021, nor during 2022.
2. Protected until end of 2021
   - Had a fixed price instrument at beginning of 2021, but had none for 2022
3. Protected until mid 2022
   - Had a fixed price instrument at beginning of 2021 and had one for 6 months in 2022
4. Always protected
   - Had a fixed price instrument at beginning of 2021 and had one for 12 months in 2022

- We cannot rule out "holes" in protection. e.g. protected for half 2021 and then the whole of 2022
- Notice we exclude firms who were not protected at the beginning of 2021 but are in 2022

levels of p ele | levels of p gas | levels of q ele | levels of q ele | back

Non-response bias in 2021

- 1844 interviews, 1500 replies to insurance question, 848 valid electricity obs. and 682 valid gas obs.
- Check balance on observables across samples and perform IPW (Woorldridge 2002)
- Check for selection in energy sample based on insurance status:

$$\mathbf{1}(\text{electricity sample})_i = \theta_1 \text{insured}_i + \theta_2 \text{uninsured} + u_i$$

$$\mathbf{1}(\text{gas sample})_i = \theta_1 \text{insured}_i + \theta_2 \text{uninsured} + v_i$$

  and test $H_0 : \theta_1 = \theta_2$

- Lee (2009) bounds (applied to IV - new?): where do the "extra"-insured come from in the outcome distribution of first stage and reduced form? Take ratios

Non-response bias: selection on insurance status
Depvar: Pr(being in the combined 21-22 estimation sample)

	(1) Electricity	(2) Gas	(3) Electricity	(4) Gas
insured	0.389***	0.307***	0.391***	0.305***
	[0.350,0.428]	[0.270,0.344]	[0.316,0.466]	[0.231,0.378]
not insured	0.310***	0.207***	0.319***	0.201***
	[0.274,0.347]	[0.174,0.239]	[0.244,0.393]	[0.130,0.273]
$H_0 : \theta_1 - \theta_2 = 0$, p-value	0.569	0.879	0.939	0.763
Observations	815	614	815	614
Controls	NO	NO	YES	YES

Note: Regressions at firm-level of a dummy equal to one if the firm is responding to the energy-related questions against two binary indicators: one equal to unity if the respondent states that the company is insured, and the other equal to unity if the respondent states that the company is not insured against energy price shocks. Columns (3) and (4) include: turnover, labour force, hours worked, number of layoffs and hirings, and expenditure for intermediate goods reported in 2021 but for the previous year; whether the firm belongs to the EU ETS and whether the firm is energy intensive (*energivora* status); class size, sector, and macroregions.

Non-response bias: selection on quantities consumed
Depvar: Pr(being in the combined 21-22 estimation sample)

	(1) Electricity	(2) Gas	(3) Electricity	(4) Gas
Electricity consumption I sem. (GWh)	0.00698***		0.00433*	
	[0.00260,0.0114]		[-0.000334,0.00900]	
Electricity consumption II sem. (GWh)	-0.00702***		-0.00438*	
	[-0.0113,-0.00279]		[-0.00881,0.0000428]	
Gas consumption I sem. (GJ)		-0.000000110		-0.000000105
		[-0.000000249,2.82e-08]		[-0.000000256,4.50e-08]
Gas consumption II sem. (GJ)		0.000000124		0.000000120
		[-2.77e-08,0.000000277]		[-4.61e-08,0.000000286]
$H_0 : \theta_1 - \theta_2 = 0$, p-value	0.001	0.113	0.060	0.162
Observations	779	614	779	604
Controls	NO	NO	YES	YES

Note: Regressions at firm-level of a dummy equal to one if the firm is responding to the energy-related questions against quantities consumed in 2021h1 and 2021h2. Columns (3) and (4) include: turnover, labour force, hours worked, number of layoffs and hirings, and expenditure for intermediate goods reported in 2021 but for the previous year; whether the firm belongs to the EU ETS and whether the firm is energy intensive (*energivora* status); class size, sector, and macroregions.

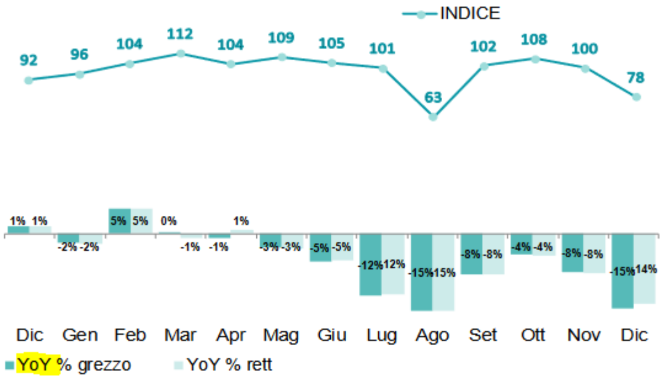

Figure: Source: Industrial electricity consumption index in Italy (IMCEI), Terna[1]