ESTIMATING THE RISE IN EXPECTED INFLATION FROM HIGHER ENERGY PRICES Paula Patzelt and Ricardo Reis

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How much do energy prices matter?

- Energy prices (gas) are one of the top two determinants of people's information and expectations of inflation. D'Acunto et al (2023)
- Coibion Gorodnichenko, 2015: a 1% increase in oil prices raises expected inflation by 1.6 bp. Significant but tiny.
- through oil price shocks

Energy prices matter for expected inflation, but how much do they matter?

• Policymakers' use: look through inflation expectations data, much like look

THE SETTING

Questions and time series variation



I. By how much does expected inflation over the next year increase on average when energy prices rise by 1%?

2. By how much more does it do so when those expectations are less well anchored?

Source: Patzelt Reis (2024)





Cross-section variation: expected inflation



 Consumer expectations survey: 9,000-22,000 respondents, 2020:4-2023:12, I l countries, expected inflation 12 months ahead

• $\pi^{e}_{i,c,g,t}$ expected inflation person *i*, country c, group g, month t

Eight demographic groups g crossing

- gender (male/female)
- income bracket (above/below 60th percentile)
- education (college/below)





Variation in expected inflation in the data Figure 1: Variation in expected inflation: Germany vs. Italy



- Lots of variation
- Large country and group fixed effects



Inflation anchor: also lots of variation

Figure 2: Variation in anchoring: Germany vs. Italy



- $a_{c,g,t}$ measure of how unanchored
- <u>Higher-order moments of the distribution</u> of long-term inflation expectations: 6month change in the interquartile range of expected inflation 3-years ahead within country-group
 - Difference between expected inflation and the inflation target: 6-month change in the absolute difference between expected inflation 3-years ahead and the ECB's inflation target averaged by country-group.



Electricity prices across countries and time

Figure 3: Variation in electricity prices across countries



HIC HIC Who HEI $e_{c,t}$ log electricity prices per country

- 25% of energy consumption
- Segmented markets
- HICP electricity paid by households inclusive of taxes and subsidies
- Alternatives: energy, wholesale, city index

	HICP electricity	HICP energy	Wholesale electricit
CP electricity	1.00		
CP energy	0.60***	1.00	
olesale electricity price	0.37^{***}	0.63***	1.00
PI index	0.59^{***}	0.78^{***}	0.54^{***}



SIMPLE THEORY

Connection energy and inflation

Link between inflation and energy prices:

• Agent observes e_c to track π given goal $V(\pi, e_c)$

 $\pi_t = F(e_t, e_{c,t} - e_t)$

 $\max_{p(\pi|e_c)} \mathbb{E}_{e_c} \left| \int \left(V(\pi, e_c) - \lambda_{g,c} \log \left(p(\pi | e_c) \right) \right) p(\pi | e_c) d\pi \right|.$

Signal extraction

• Impact of an increase in energy prices

 $\frac{\partial \pi_t^e}{\partial e_{c,t}} = \alpha \frac{\partial}{\partial e_{c,t}} \mathbb{E}(e_t) + \beta \frac{\partial}{\partial e_{c,t}} \mathbb{E}(e_{c,t} - e_t)$

• Ratio of estimates without and with time fixed effects reveals size of α/β

• Let $\pi^e(e_c)$ be the solution with $\lambda = 0$, after linear-quadratic approximation

 $\pi_t^e = \alpha \mathbb{E}(e) + \beta \mathbb{E}(e_c - e)$

Rational inattention

individual shocks ε normal:

 $\pi^e_{i,g,c} = \pi$

Interguartile cross-section range

$$a(e) = 1.34898 \sqrt{\left| \lambda_g \pi^{e'}(e) / v(e) \right|} \quad \Rightarrow \quad \pi^{e'}(e) = \left(\frac{v(e)}{2\lambda_g} \right) a(e)^2.$$

• let $v(e_c) = -\partial^2 V(.)/\partial \pi \partial e_c(\pi^e(e_c), e_c)$. The optimal $p(\pi | e)$ is such that with

$$\tau^{e}(e_{c}) + \frac{\lambda_{g}\pi^{e'}(e_{c})}{v(e_{c})} \varepsilon_{i,g,c}$$

Anchoring

 $\frac{\partial \pi^e}{\partial e} = \left(\frac{v(e)}{2\lambda_o}\right) a^2(e) \,.$

- those expectations must not be so costly.
- Therefore, she is less attentive, and so there is more unanchoring.
- Energy shocks generate endogenous attention wedges that will appear as markup shocks in a Phillips curve.

• When expectations are very sensitive to shocks, then the mistakes in forming

REGRESSION

Specification $\Delta^{6} \pi^{e}_{i.c.g.t} = \beta \Delta^{6} e_{c,t} + \gamma \Delta^{6} e_{c,t} \times \Delta^{6} a_{c,t}$

- β : by how many basis points does expected inflation over the next year increase on average when energy prices rise by 1%?
- γ : by how many more basis points does the 1% rise in energy prices increase inflation expectations when those expectations are less well anchored?
- Notes on types of variation and their role (1) Both cross-section and time-country variation: care about macro effects (2) No *i* variation on the right, individual data sharpening estimates (3) The g,c variation identifies anchoring while sharpening first answers (4) On t variation: control for common policy and differential country inflation

$$u_{c,g,t} + \alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \psi \Delta^6 i_t + \varepsilon_i$$



Table 1: The impact of electricity prices on expected inflation

Revision of expectation	(1)	(2)	(3)	(4)	(5)	(6)
Change in electricity prices	1.404^{***}	1.167^{***}	1.222^{***}	1.531^{***}	1.397^{***}	0.372**
	(0.296)	/(0.103)	(0.229)	(0.329)	(0.294)	(0.181)
Change in electricity prices	0.596***	0.199***	2.609***	1.499***	0.617***	0.146
× Unanchoring	(0.171)	(0.061)	(0.466)	(0.374)	(0.173)	(0.089)
Average past inflation	0.004	-0.025***	-0.001	0.009	0.005	0.004
	(0.028)	(0.009)	(0.025)	(0.027)	(0.028)	(0.079)
ECB deposit rate change	-0.436***	-0.449***	-0.442***	-0.438***	-0.437***	
	(0.119)	(0.031)	(0.113)	(0.118)	(0.119)	
Observations	362756	2472	362756	362756	362756	362756
R^2	0.016	0.343	0.018	0.016	0.016	0.032
Country & group fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	No	No	No	No	No	Yes
Country-group fixed effects	No	No	No	No	Yes	No

Note: This table presents estimates of the regression in equation (1): $\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \beta \Delta^6 e_{c,t}$ $\alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \psi \Delta^6 r_t + \varepsilon_{i,c,g,t}$. Column (1) has the baseline estimates, (2) uses the average $\pi^e_{c,g,t}$ as the dependent variable, (3) uses as measure of unanchoring the deviation of long-run expected inflation from target, (4) uses anchoring at the country level only $a_{c,t}$, (5) includes country-group fixed effects, and (6) includes time fixed effects. In parentheses are standard errors clustered by month for the regressions using individual expectations. 16

Robustness

(1) Standard errors: two-way clustering, Driscoll-Kray, Huber-White, (2) Other energy measures, energy squared in a horse race with anchoring (3) Anchoring: by itself and more on distance from target (4) Balanced panel of 6 countries (6) Time variation: results by country (7) Horizon: I-6 months

(5) Cross variation: weighing by country size, using median, only 6 major countries



US regression

Table 4: The impact of energy prices on expected

	(1)	(2)	(3)	(4)	(5)	(6)
Change in energy prices	1.804**	1.942***	1.939**	0.300	1.690***	0.864***
	(0.740)	(0.721)	(0.743)	(1.049)	(0.301)	(0.220)
Change in energy prices \times Unanchoring	-0.024	0.058	0.766	0.002	0.062	0.043
	(0.132)	(0.100)	(0.478)	(0.137)	(0.086)	(0.049)
Average past inflation	0.002	-0.094	0.005	-0.003	-0.064	-0.067
	(0.085)	(0.061)	(0.085)	(0.097)	(0.077)	(0.081)
Change in FFR	0.047 (0.397)	-0.058 (0.408)	0.033 (0.401)		-0.169 (0.343)	-0.160 (0.421)
Observations	17903	7100	17903	17903	17907	17907
R ²	0.016	0.008	0.017	0.022	0.018	
Country & group fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	No	No		Yes	No	No

Note: This table presents estimates of the regression in equation (1): $\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \beta \Delta^6 e_{c,t}$ $\alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \varepsilon_{i,c,g,t}$ for the US SCE. Columns 1–4 show estimates for state-level electricity prices. Column (1) has the baseline estimates, (2) uses the average $\pi^{e}_{c,g,t}$ as the dependent variable, (3) uses as measure of unanchoring the deviation of long-run expected inflation from target, and (4) includes time fixed effects. Columns (5) and (6) respectively use the national gas and oil price instead of regional electricity prices. Past inflation is computed using the state-level CPI from Hazell et al. We exclude all individuals part of state-demographic groups with less than 5 members in the month. In parentheses are standard errors clustered by month for the regressions using individual expectations.

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• Survey of Consumer Expectations

- Sample is a little longer
- Groups are not as precise

US regression

Table 3: The impact of energy prices on expected inflation in the US

	(1)	(2)	(3)	(4)	(5)	(6)
Change in energy prices	3.075***	3.331***	2.409***	-0.416	4.210***	2.297***
	(0.712)	(0.141)	(0.722)	(0.617)	(0.325)	(0.274)
Change in energy prices \times Unanchoring	0.209	0.114**	1.589**	0.200	0.077	0.078
	(0.210)	(0.044)	(0.754)	(0.193)	(0.092)	(0.065)
Average past inflation	0.036	0.124***	0.109***	-0.008	-0.067***	-0.060**
	(0.036)	(0.007)	(0.033)	(0.068)	(0.024)	(0.024)
Change in FFR	-0.126 (0.107)	-0.047*** (0.013)	-0.580*** (0.095)		-0.126** (0.049)	-0.077 (0.049)
Observations	44650	8380	24597	44650	59205	65129
R^2	0.003	0.116	0.011	0.046	0.024	0.017
Country & group fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	No	No	No	Yes	No	No

Note: This table presents estimates of the regression in equation (1): $\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \beta \Delta^6 e_{c,t}$ $\alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \varepsilon_{i,c,g,t}$ for the US. Columns 1–4 show estimates for regional electricity prices. Column (1) has the baseline estimates, (2) uses the average $\pi_{c,g,t}^e$ as the dependent variable, (3) uses as measure of unanchoring the deviation of long-run expected inflation from target, and (4) includes time fixed effects. Columns (5) and (6) respectively use the national gas and oil price instead of regional electricity prices. Regional electricity prices are constructed as within-region unweighted averages of state-level prices. Past inflation is the regional CPI from the BLS, which coincides with the MSC regions used except for the inclusion of Guam, Puerto Rico, and the US Virgin Islands. In parentheses are standard errors clustered by month for the regressions using individual expectations.

- Michigan survey
- Longer time sample
- Limitations of Michigan:
- (i) only 4 regions so quite limited regional variations,
- (ii) very few observations per group, so cannot pin down anchoring



CAUSAL QUESTIONS



European electricity market



Two more questions

- Causal questions now, focus on reverse causality
- By how much does expected inflation over the next year increase on average after a 1-standard deviation shock to the supply of energy
 - 2. By how much more does it do so when those expectations are less well anchored?



Expenditure share pre-2019

Figure A4: Electricity expenditure shares by country





 S_c the share of electricity in household consumption per region in 2019 from the Eurostat HICP

Varies with

- Household characteristics: income, size, location, housing tenure, home ownership
- Building characteristics: heating system, size, type, age

Exogenous with respect to future expected inflation





Oil and wind shocks



 k_t - Kanzig (2021) high-frequency change in oil futures prices following OPEC production announcements,

 $W_{c,t}$ - total energy generated through wind in each region and month from Ember





Specification

 $\Delta^{6} \pi^{e}_{i,c,g,t} = \beta \Delta^{6} z_{c,t} + \gamma \Delta^{6} z_{c,t} \times \Delta^{6} a_{c,t}$

- Previous estimates dominated by inv
- $z_{c,t} = e_t s_c$: shift-share, cross-country differences in expenditure shares affect expected inflation, but do not affect aggregate prices. Share is exogenous
- $z_{c,t} = k_t s_c$: Both shift and share are now exogenous
- $z_{c,t} = w_{c,t}$: Wind is exogenous to demand, mostly about wind speed
- Dynamics:

$$\pi^{e}_{c,g,t+h} = \beta^{h} \left(\sum_{p=0}^{P} z_{c,t-p} \right) + \gamma^{h} \left(\sum_{p=0}^{P} z_{c,t-p} \right) A_{c,g,t} + \alpha^{h}_{c} + \eta^{h}_{g} + \theta^{h} \bar{\pi}_{c,t-6} + \phi^{h} + \varepsilon_{c,t-6} + \phi^{h} + \phi^{h} + \phi^{h} + \phi^{h} + \phi^{h} +$$

$$\alpha_{g,t} + \alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \psi \Delta^6 i_t + \varepsilon_{i,c}$$

Vasion of Ukraine





Impact of a I-StDev shock to energy prices

Revision of expectation	(1)	(2)	(3)	(4)	(5)
Energy price shock	0.185***	0.613***	0.339***	0.044	0.603**
	(0.060)	(0.061)	(0.102)	(0.100)	(0.265)
Energy price shock	0.244***	0.138***	-0.002	-0.042	0.146***
× Unanchoring	(0.031)	(0.029)	(0.062)	(0.076)	(0.050)
Average past inflation	-0.025	0.081***	-0.079	-0.051*	0.213
	(0.025)	(0.021)	(0.086)	(0.027)	(0.144)
ECB deposit rate change	-0.352***	-0.423***	-0.103	-0.370**	-0.708**
	(0.117)	(0.061)	(0.228)	(0.142)	(0.267)
Observations	362756	362756	305037	362224	197950
R ²	0.018	0.027	0.015	0.012	0.029

Note: This table presents estimates of the regression equation $\Delta^h \pi^e_{i,c,g,t} = \beta \Delta^h z_{c,t} + \gamma \Delta^h z_{c,t} \times \Delta^h a_{c,g,t} + \alpha_c + \alpha_c$ $\eta_g + \theta \bar{\pi}_{c,t-6} + \Delta^6 r_t + \varepsilon_{i,c,g,t}$ where the first four columns use different measures of $z_{c,t}$. The energy shocks are, in order: (1) the change in HICP electricity prices by country, (2) the *h*-month change in EA-side HICP electricity times country-specific electricity expenditure weights in 2019, (3) OPEC supply shocks to oil prices cumulated over *h* months times country-specific expenditure weights in 2019, and (4) the *h*-month change in wind-source electricity generation, all standardised to increase electricity prices. The first four columns set h = 6, while the fifth column uses the oil shocks with h = 12. In parentheses are standard errors clustered by month.

Table 2: The impact of energy shocks on expected inflation



(c) Oil shifts and energy shares





(b) EA electricity prices with country shares

(d) Wind

Source: Patzelt Reis (2024)

COUNTERFACTUALS

How large are the estimates? • Weight of energy in the HICP basked: Coefficient is 4 times higher

• Estimate same equations with actual inflation as opposed to expected: Coefficient is 6.5 times higher

- People don't pay too much attention to energy!
- They are still inattentive in absolute terms, even if attentive.

How much of the increase in expected inflation in 2021-22 was due to higher energy prices?

Figure 5: The contribution of electricity prices to expectation revisions

Note: The figure plots the survey-weighted average of actual revisions of expected inflation and the corresponding prediction based on the specification in equation (1), over the following six months. The energy prediction line shows the counterfactual expectation revisions due to changes in energy prices (and anchoring) only, making a prediction including only the β and γ terms.

Between May 21 and May 22, according to fitted values of the equation:

0.53 pp (2.9 in data) Partial R² from energy prices is: 0.39 **Very little**

Figure 2: The time-varying impact of electricity prices on expected inflation

Note: The figure plots the predicted effect on EA average expected inflation from doubling electricity prices over the following 6 months, calculated as a function of the extent of unanchoring over the same period, using the coefficients estimated in column 1 of table 1. In red are estimates using disagreement about longrun expected inflation as a measure of unanchoring, and in green are those using the absolute difference between expected long-run inflation and target. Source: Patzelt Reis (2024)

CONCLUSION

Conclusion

- Does expected inflation over-react to energy prices?
 - Yes, they pay disproportionate attention to it and it stands out among fundamentals. But data revealed
 - see through.

 - expectations in accounts.

• Significant effect that is larger sharper and more persistent on individual. Don't

• Drift in 2021-22 was real, not just energy prices, monetary policy contributed.

• Anchoring matters, and helped in 2023, no separation supply shocks vs