

Economic Activity, Inflation, and Monetary Policy after Extreme Weather Events: ENSO and its Impact on the Peruvian Economy

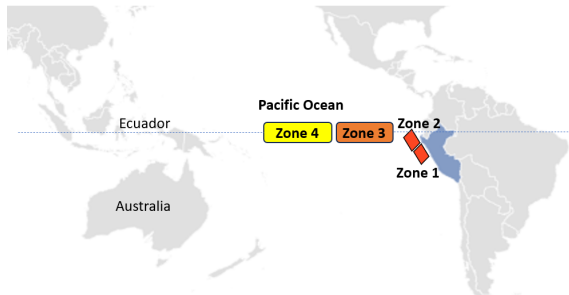
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The opinions expressed correspond solely to the authors and do not represent those of the Central Reserve Bank of Peru.

El Niño Costero: the relevant climate shock for Peru



- Warming of sea surface temperatures off Peru and Ecuador (**Zone 1+2**), measured by the **ICEN** index.
- Hits mainly fishing, agriculture and infrastructure (floods, landslides), and disrupts distribution chains.
- Large events ($\text{ICEN} > 1$) matter for monetary policy; La Niña effects are mild and short-lived.

El Niño in Peru: a recurrent, costly phenomenon

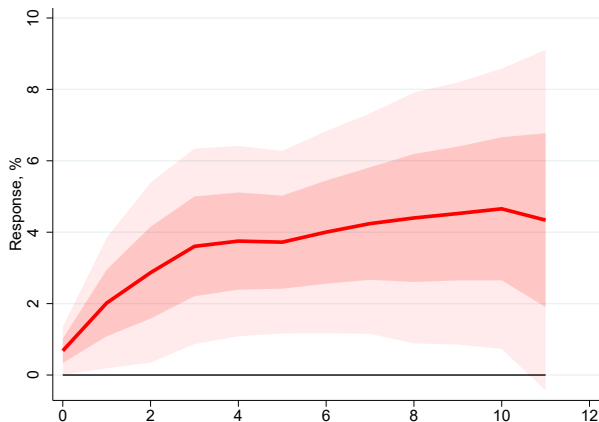
- Since 1980, **11 events** of moderate intensity or greater.
- **3 events in the last decade** $\Rightarrow$ rising frequency consistent with climate-change concerns.
- Large-size episodes have generated GDP losses of **1–12%**.
- **1982–83** and **1997–98** remain the benchmark “Very Strong” episodes.

Event	Dur.	Peak severity	GDP losses
9/1982-9/1983	13	Very Strong	11.6% ^b
3/1992-6/1992	4	Strong	2.5% ^c
4/1997-7/1998	16	Very Strong	6.2% ^e
6/2014-7/2014	2	Moderate	2.3% ^f
2/2017-4/2017	3	Moderate	0.8% ^g
3/2023-1/2024	11	Strong	1.1% ^h

How we measure the effects (in one slide)

- **State-dependent Local Projections** (Jordà, 2005), monthly data 1994–2019; El Niño regime: $ICEN_{t-1} \geq 1$.
- **Identification:** ENSO shocks are the residuals of an ARMA(2,3) model for ICEN. This purges ICEN's persistence, which otherwise biases the responses.
- **Calibrated shock:** a typical strong El Niño, lasting **9 months** with average ICEN of **1.7**.
- Controls: oil prices, terms of trade, exchange rate, interest rate, liquidity.
- Robust to a post-COVID sample, ICEN levels, seasonality/predictability controls, a TVP-VAR-SV and a Threshold-BVAR.

Headline inflation: a large and persistent increase



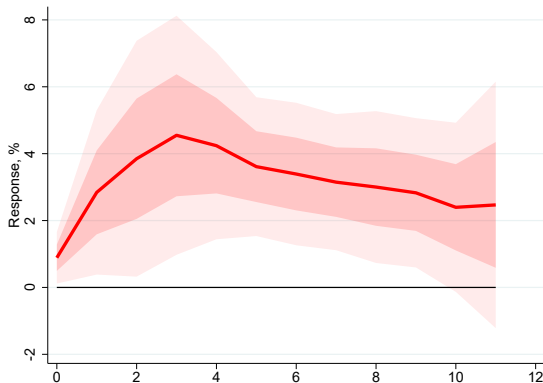
CPI (cumulative %). Shaded: 68%/90% CI. x-axis: quarters.

- The price level rises close to $\approx 4\%$ within the first year.
- The additional increase in year 2 is small (≈ 0.3 pp).
- But the **higher price level persists** three years after the shock.

Why so persistent? Because of how the shock moves across CPI components.

The relay: from food & energy to core inflation

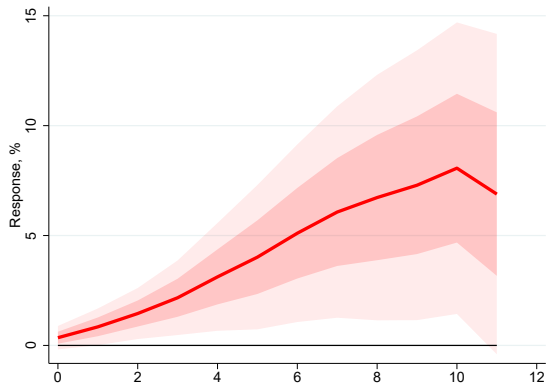
A. Food & Energy CPI



Year 1 – first-round effects

Food & energy peaks at $\approx +4.5\%$ after four quarters, then reverts gradually. Driven by food at home; energy is almost unaffected.

B. CPI excluding Food & Energy (core)

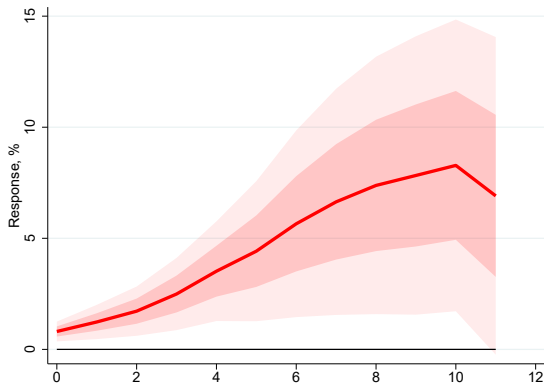


Years 2–3 – second-round effects

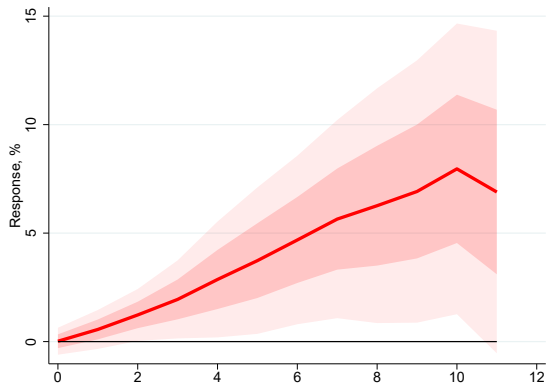
Core rises gradually to $\approx +5.5\%$ after two years. Goods react first, services later. Core reverts only after about 10–11 quarters.

Inside core inflation: goods first, services later

A. Goods Core CPI



A. Services Core CPI



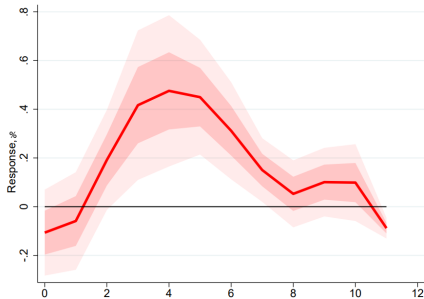
LP responses of 2-digit CPI components.

- **Goods** respond within the first year.
- **Services** barely move in year 1, then rise steadily in year 2 and stay elevated.

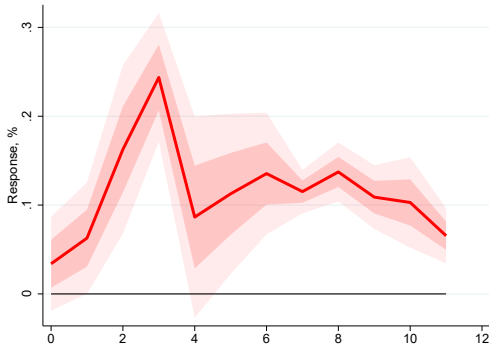
Second-round effects arrive just when monetary policy lags would operate.

Inflation expectations: transmission, but weaker

A. 12-months ahead

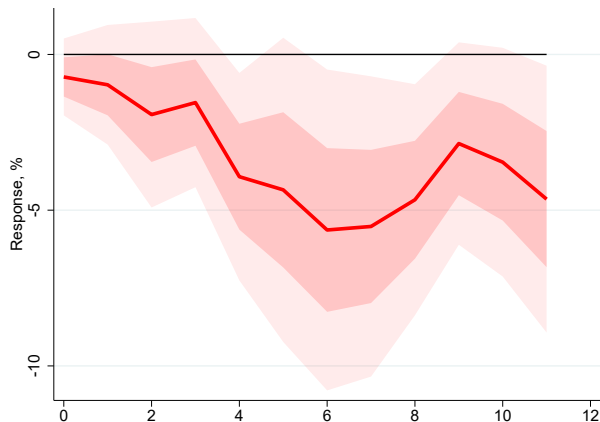


B. 24-months ahead



- **Inflation expectations** rise modestly (≈ 45 bps at 1yr), but return to target faster than realized inflation.
- With the post-COVID sample, expectations react earlier and more strongly.

Activity: the supply-shock signature



GDP (cumulative %). Shaded: 68%/90% CI.

- -0.6% on impact, led by fishing and agriculture.
- Trough $\approx -5\%$ in year 2 as non-primary sectors (commerce, construction, services) follow.
- Still $\approx -4.5\%$ after three years: **potential output** falls.

Prices up, output down: the “divine coincidence” breaks.

Monetary policy implications: credibility beats aggressiveness

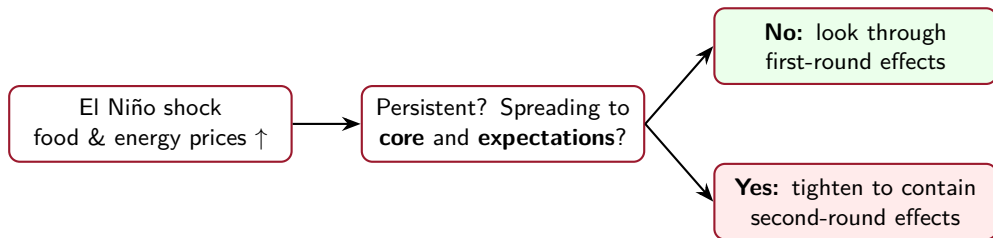
Semi-structural model with non-linear El Niño channels, matched to our LP responses. Loss $L = \alpha \text{var}(y) + \text{var}(\pi)$; 1,000 simulations of 20 years.

Taylor rule ϕ_π	Baseline frequency ($\sigma_{ICEN} = 1$)			High frequency ($\sigma_{ICEN} = 2$)		
	1.2	1.5	2.0	1.2	1.5	2.0
Perfect credibility	2.05	2.01	1.96	11.27	10.92	10.52
High credibility	2.49	2.34	2.19	16.65	14.66	12.88
Low credibility	3.83	3.20	2.69	29.78	22.45	16.99

Strong El Niño ($ICEN > 1.7$) occurs 3.2% of the time at baseline and 11.3% at high frequency.

- **More frequent and intense El Niños raise stabilization costs** sharply: non-linear channels kick in.
- A **hawkish stance pays off most when credibility is weak** (loss -43% vs. -7% under perfect credibility).
- Yet even an aggressive policy under low credibility does worse than a moderate one under perfect credibility.

Supply shocks: when to look through, when to act



Horizon	Indicator	Signal for policy
Quarters 1–4	Food & energy CPI	Expected to rise: first-round effect, look-through zone
Quarters 2–4	12m expectations	if start rising $\Rightarrow$ asses de-anchoring risk
Quarters 4–8	Core CPI (goods, then services)	Sustained acceleration $\Rightarrow$ second-round effects
Quarters 1–12	24m expectations	Persistent drift $\Rightarrow$ credibility channel at work
Quarters 4–8	Non-primary GDP	Depth of the output cost: the trade-off

The key question is not whether inflation rises, but whether it spreads.

Conclusions

- El Niño is a **persistent, non-linear supply shock**: food & energy lead in year 1, **core inflation sustains** it in years 2–3.
- Expectations react, but less than inflation. **Anchoring determines how persistent** the shock becomes.
- **Credibility** lowers the cost of stabilization.

Gracias!

Appendix

Appendix: Empirical specification

$$y_{t+h} - y_{t-1} = (1 - I_{t-1}) [\alpha_{0,h} + \beta_{0,h} \hat{\varepsilon}_t + B_{0,h} X_t] + I_{t-1} [\alpha_{1,h} + \beta_{1,h} \hat{\varepsilon}_t + C_{1,h} X_t] + e_{t+h}$$

$$I_{t-1} = \mathcal{I}(x_{t-1} \geq 1), \quad x_t = \rho_0 + \sum_{j=1}^2 \rho_j x_{t-j} + \varepsilon_t + \sum_{j=1}^3 \phi_j \varepsilon_{t-j}$$

- $\hat{\varepsilon}_t$: ENSO shock, the ARMA(2,3) residual for the ICEN index x_t .
- I_{t-1} : lagged indicator, ensuring lead/lag exogeneity.
- $\{\beta_{1,h}\}$: El Niño-state responses of interest.

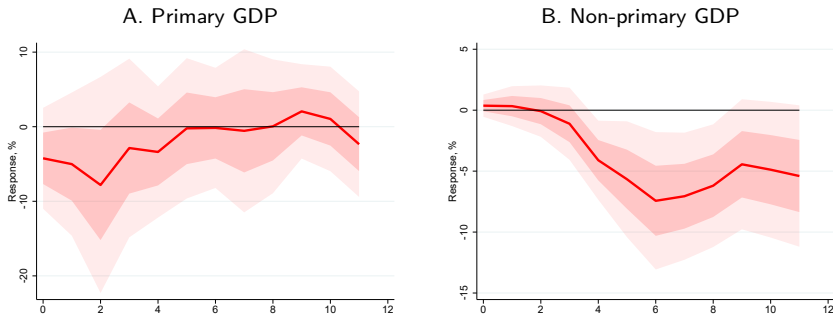
Appendix: Semi-structural model channels

Five non-linear channels through which El Niño affects the economy:

- ICEN > 1: **food & energy inflation** (level and persistence) and **aggregate demand** (income effect).
- ICEN > 1.7: **potential GDP** (capital and infrastructure losses) and **inflation expectations**.
- **Credibility stock** C_t (Benes et al., 2017): repeated deviations from target raise the backward-looking weight in expectations.

Parameters calibrated by matching the LP impulse responses.

Appendix: Sectoral heterogeneity



- **Primary** sectors (fast, large): fishing $\approx -27\%$, primary manufacturing $\approx -8\%$, agriculture $\approx -5.5\%$ (persistent).
- **Non-primary** sectors (delayed, persistent): commerce, construction, services, non-primary manufacturing.