Tariffs, Uncertainty, and the Exchange Rate

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- **DGE-based** theory:
  Bianchi and Coulibaly (2025), Monacelli (2026), Bergin and Corsetti (2023), Kalemli-Özcan et al. (2025), Kalemli-Özcan et al. (2026), Auclert et al. (2025)

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- This paper: contribution to both empirics and theory
- Particular emphasis on exchange-rate puzzle

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   - (ii) $\downarrow$ CPI *inflation* $\rightarrow \uparrow$ CPI inflation in medium run
   - (iii) **Depreciate** U.S. dollar effective exchange rate
   - (iv) S-shaped deterioration of **trade balance** ($TB(+) \rightarrow TB(-)$)
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3. Explain **non-negligible** share of **variance** of key variables (FEVD)
4. In both trade wars (2018-19 & 2024-25) contribute to **ex. rate depreciation**

Paper in a Nutshell II

5. Effect depends on **structural** trade policy **uncertainty** (S-TPU) $\rightarrow$

   When a tariff is announced, firms and markets face question: is this a lasting change in the trade-policy regime, or "negotiation theater"?

   (i) Estimate S-TPU from state-space stochastic-volatility model of tariff rates
   (ii) S-TPU **low** $\rightarrow$ tariffs raise economic activity + inflation + appreciate the exchange rate (textbook)
   (iii) S-TPU **high** $\rightarrow$ tariffs **depreciate** exchange rate + depress economic activity + accommodative monetary policy response

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6. Build a **NK-DGE model** with tariff policy **uncertainty** & incomplete markets

7. Effects of tariff on **exchange rate** depend on **perceived** persistence of trade policy

Tariff shocks in a narrative-Bayesian VAR

Tariff Data

- **Tariffs:** baseline **WIT1** = duties / *dutiable* imports (Franconi-Hack 2025); alternatives WIT2, TRI.
- **Exchange rate:** U.S. **NEER** and **REER**
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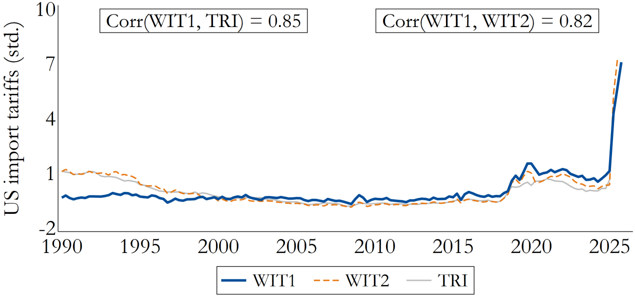

WIT1, WIT2, and TRI highly correlated over the sample

Narrative-Dominance Identification

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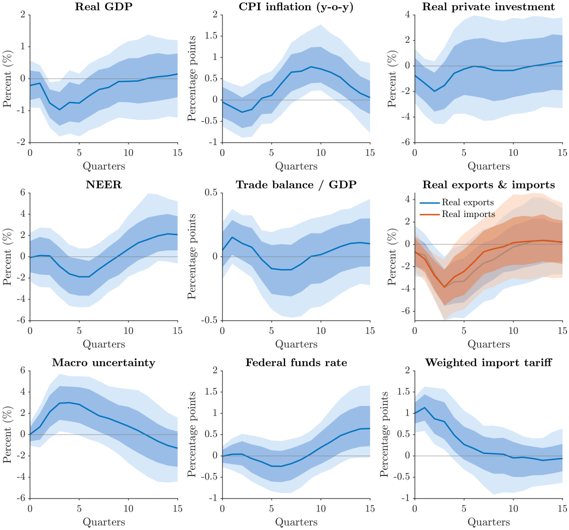
3. **Narrative dominance.** Tariff shock is the **largest** positive contributor to the **one-step-ahead forecast error** of the tariff index variable.
4. **Sign restriction.** Tariff shock reduces real **imports** at horizon h=1,2 but **not** in h=0 (avoid front-loading)

Narrative dates

Date	$z(\Delta\tau)$	Narrative event
Panel A: Baseline		
2018Q4	+1.83	§301 List 3, $200B at 10%
2025Q2	+10.6	"Liberation Day" reciprocal tariffs
Panel B: Extended		
2019Q3	+1.33	§301 List 4A
2019Q4	+1.48	WTO-Airbus countermeasures

VAR extended date

Identified tariff shock depreciates NEER (1990–2025)



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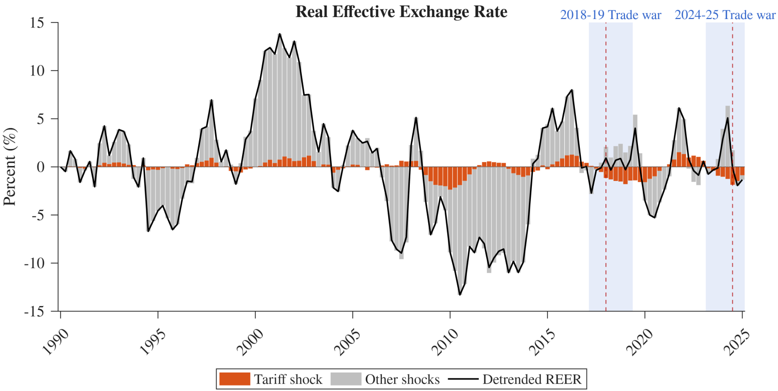
Short sample

REER

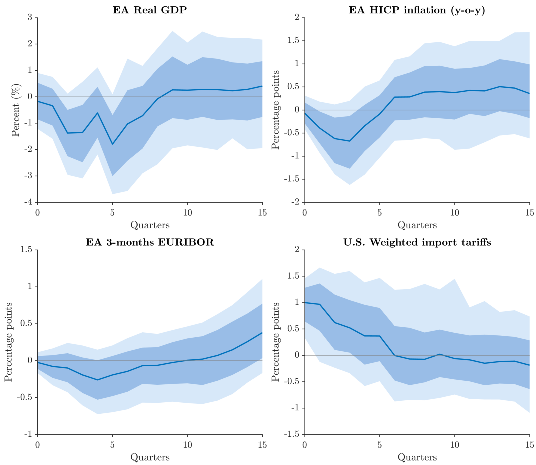
Historical contribution of tariffs



In *both* trade wars the tariff contribution points to depreciation

FEVD

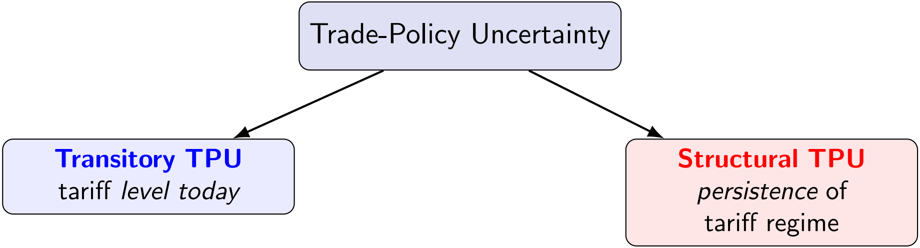
U.S. tariffs and the Euro area



- US tariffs transmit to Euro area as negative demand shock
- EA monetary policy accommodative

Tariffs and Trade-Policy Uncertainty

Taxonomy of Trade-Policy Uncertainty



Transitory TPU

- uncertainty over **level** of the tariff *today*
- (i) *100 % tariff on China*; (ii) statutory–actual gap
- resolved at implementation

Structural TPU

- uncertainty over **persistence** of trade-policy *regime* + future tariffs
- e.g. withdrawal from multilateral agreements as TPP (2017) +
- shifts expected tariffs

Estimating S-TPU: Stochastic-Volatility State-Space Model

Measurement equation

$$\tau_t = \underbrace{\tau_{S,t}}_{\text{structural}} + \underbrace{\tau_{T,t}}_{\text{transitory}}$$

State equations

$$\tau_{S,t} = \rho_S \, \tau_{S,t-1} + \exp(\sigma_{S,t}) \, \varepsilon_{S,t}, \qquad \varepsilon_{S,t} \sim \mathcal{N}(0,1)$$

$$\tau_{T,t} = \rho_T \, \tau_{T,t-1} + \exp(\sigma_{T,t}) \, \varepsilon_{T,t}, \qquad \varepsilon_{T,t} \sim \mathcal{N}(0,1)$$

$$\sigma_{S,t} = (1 - \rho_{\sigma_S})\bar{\sigma}_S + \rho_{\sigma_S}\sigma_{S,t-1} + \eta_S u_{S,t}, \qquad u_{S,t} \sim \mathcal{N}(0,1)$$

$$\sigma_{T,t} = (1 - \rho_{\sigma_T})\bar{\sigma}_T + \rho_{\sigma_T}\sigma_{T,t-1} + \eta_T u_{T,t}, \qquad u_{T,t} \sim \mathcal{N}(0,1)$$

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\end{aligned}$$

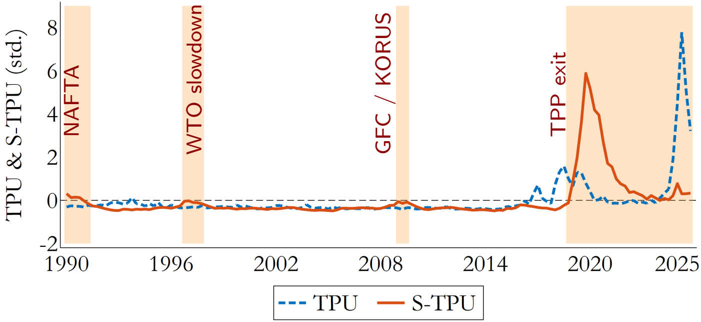
S-TPU index: filtered conditional **variance** of regime innovations

$$\text{S-TPU}_t \equiv \exp(2\sigma_{S,t})$$

Implementation

- Particle filter (Born–Pfeifer, 2014) applied to standardized **WIT1**

S-TPU (top 30% shaded) vs aggregate TPU



- **2017–20**: TPP exit, regime renegotiation ⇒ **S-TPU spikes**.
- **2025**: Liberation Day, aggregate TPU explodes ⇒ **S-TPU muted**.

⇒ **S-TPU** rises at regime change, not at noisy announcements

Index construction

State-dependent local projections

- High-S-TPU indicator (top 30%): $H_t = \mathbf{1}\{STPU_t > p_{70}\}$

State-dependent local projections

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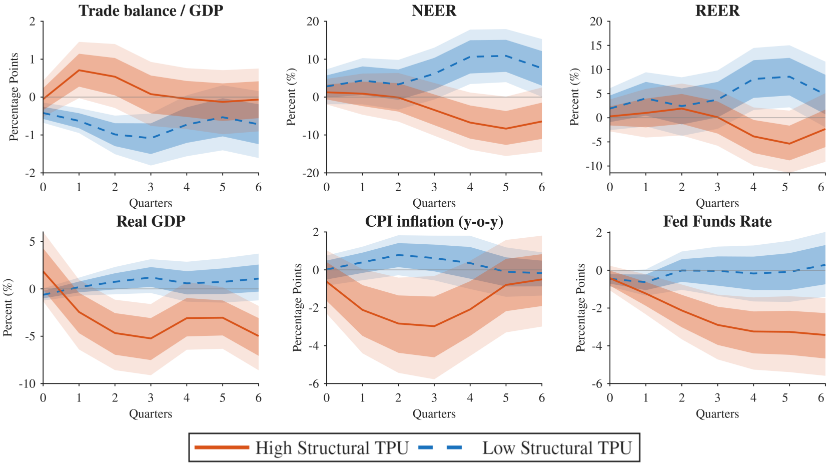
- State-dependent LPs (Jordà 2005; Ramey-Zubairy 2018) on the BVAR tariff shock ε_t^τ:

$$y_{t+h} = \alpha_h + \beta_h \varepsilon_t^\tau + \beta_h^H \underbrace{H_t \varepsilon_t^\tau}_{\text{interaction}} + \delta_h H_t + \sum_{j=1}^{4} \gamma_{j,h} y_{t-j} + u_{t+h}$$

- Low state: β_h. High state: $\beta_h + \beta_h^H$.

S-TPU treated as an **exogenous** state for the tariff shock

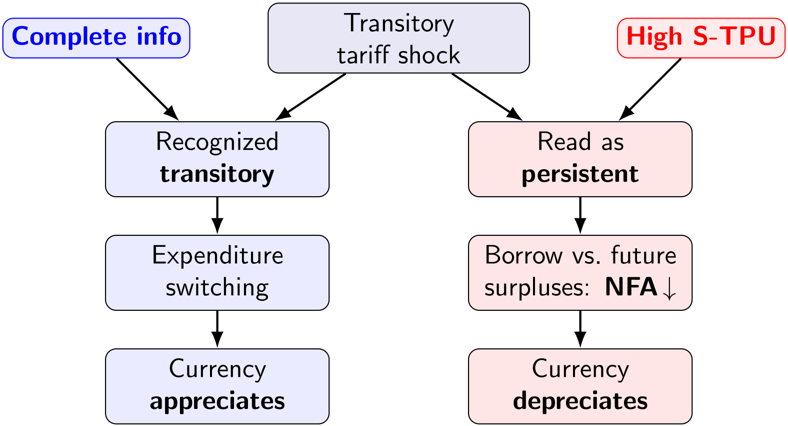
State-dependent transmission (top 30% S-TPU)



Low S-TPU: textbook **appreciation**; **High S-TPU**: GDP and inflation contract, TB (NFA) improves, NEER/REER **depreciate**, MP eases

Cutoff robustness

Mechanism of S-TPU



Certainty: expenditure switching ⇒ appreciation.

High S-TPU: persistence channel ⇒ depreciation.

A model of the exchange rate under trade-policy uncertainty

Ingredients

- SOE + **incomplete markets** + import tariffs
- Foreign assets s.t. **portfolio adjustment cost** $\psi \Rightarrow$ financial segmentation.
- Segmentation **breaks UIP** $\Rightarrow$ forward-looking channel through **net foreign assets**.

Modified real UIP

Real UIP with financial premium

$$e_t^r = \mathbb{E}_t e_{t+1}^r + r_t^* - r_t \qquad \underbrace{-\psi b_t}_{\text{financial premium}}$$

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- Intertemporal budget constraint

$$b_t = -\sum_{j=1}^{\infty} \beta^j \, \mathbb{E}_t \left\{ tb_{t+j} \right\} \tag{1}$$

UIP in present-value form

$$e_t^r = \underbrace{\sum_{j \geq 0} \mathbb{E}_t (r_{t+j}^* - r_{t+j})}_{\text{real-rate differentials}} + \underbrace{\psi \sum_{j \geq 0} \mathbb{E}_t \, tb_{t+j}}_{\text{expected trade balance path}}$$

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Anticipated future **trade surpluses** $\Rightarrow$ **borrow** today $\Rightarrow \downarrow b_t \rightarrow$ ex.rate **depreciation**

Inference problem

Agents observe τ_t, not its decomposition:

$$\begin{cases} \tau_{S,t} = \rho_S \tau_{S,t-1} + \varepsilon_{S,t}, & \varepsilon_{S,t} \sim \mathcal{N}(0, \sigma_S^2) \\ \tau_t = \tau_{S,t} + \varepsilon_{T,t}, & \varepsilon_{T,t} \sim \mathcal{N}(0, 1) \end{cases}$$

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S-TPU $\equiv \sigma_S^2$

Uncertainty about **persistence** of tariff movement.

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Uncertainty about **persistence** of tariff movement.

Tariff surprise: $\zeta_t \equiv \tau_t - \mathbb{E}_{t-1}\{\tau_{S,t}\}$.

Persistent stance $\rho_S \simeq 1 \Rightarrow$ shifts the **entire** expected path

Bayesian split

Optimal decomposition of tariff surprise

$$\underbrace{\zeta_t}_{\text{surprise}} = \underbrace{\mathbb{K}(\sigma_S^2)\,\zeta_t}_{\text{persistent stance}} + \underbrace{\left(1 - \mathbb{K}(\sigma_S^2)\right)\zeta_t}_{\text{transitory}}$$

- $\mathbb{K}(\sigma_S^2) \in (0,1)$: Kalman gain, **increasing** in S-TPU.
- **High S-TPU**: weak confidence on prior knowledge ⇒ larger share read as persistent.
- **Low S-TPU**: strong confidence on prior knowledge ⇒ barely revise.

S-TPU determines whether the shock is read as persistent

Kalman gain details

Persistence Channel of Exchange Rate

Real UIP under S-TPU & transitory tariff shocks

$$e_t^r = \underbrace{\sum_{j\geq 0} \mathbb{E}_t\{r^*_{t+j} - r_{t+j}\}}_{\text{real-rate differentials}} + \underbrace{\psi\, \Gamma(\rho_S)\, \Lambda\, \mathbb{K}(\sigma_S^2)\, \varepsilon_{T,t}}_{\text{estimated persistence effect}}$$

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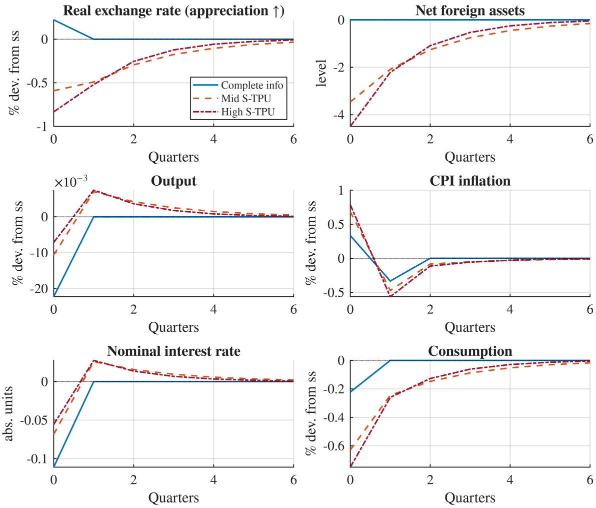
- Under certainty ($\mathbb{K} = 0$): persistence channel is **zero**.
- What matters is **perceived** persistence.
- Scales with $\mathbb{K}(\sigma_S^2)$, ψ, and $\Gamma(\rho_S)$.

Simulated impulse responses



Complete info: expenditure switching ⇒ **appreciation**

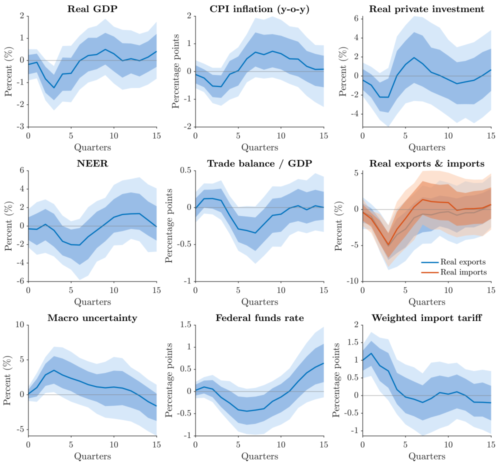
High S-TPU: NFA ↓, MP eases ⇒ **depreciation**

Takeaways

- Macroeconomic effects of **tariff shocks**
- Post-1990 tariff shocks **depreciate** US dollar, overturning textbook result.
- **S-TPU** – uncertainty about tariff regime **persistence** – governs macro transmission.

Appendix

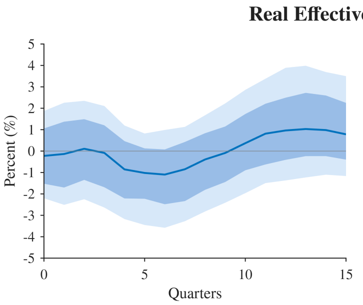
Even sharper in the short sample (2002–2025)



S-shaped trade balance and REER more tightly estimated

Back

Real exchange rate (REER)



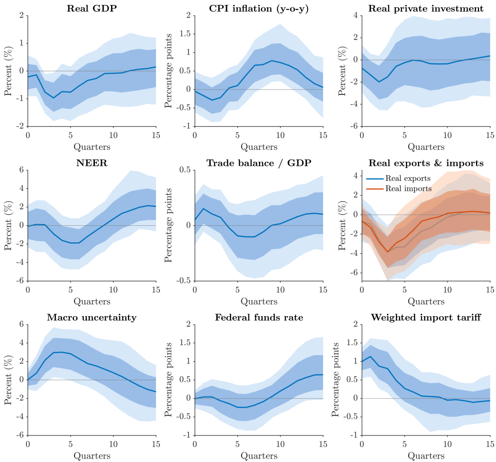
(a) 1990–2025

(b) 2002–2025

REER depreciation and missing appreciation

Back

Robustness: extended narrative dates



Adding 2019Q3 (List 4A) and 2019Q4 (Airbus): responses essentially unchanged

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FEVD: share explained by the tariff shock

	Forecast horizon (quarters)			
	1	5	10	15
REER	3.5	6.4	11.0	15.5
Real GDP	4.2	6.0	12.7	14.2
CPI Inflation	3.8	7.3	16.7	20.1
Trade Balance/GDP	3.9	11.2	12.3	13.2

Posterior median share of forecast-error variance (%)

Back

Constructing S-TPU

We measure structural trade-policy uncertainty as the conditional volatility of innovations to the persistent component of U.S. tariff policy.

$$\tau_t = \tau_{S,t} + \tau_{T,t}$$

- τ_t: observed effective tariff rate.
- $\tau_{S,t}$: persistent trade-policy stance.
- $\tau_{T,t}$: transitory tariff component.
- S-TPU is the conditional variance of shocks to $\tau_{S,t}$.

$$STPU_t \equiv \exp(2\sigma_{S,t})$$

S-TPU captures uncertainty about the tariff regime, not short-run tariff noise

Back

State-space tariff process

The observed tariff rate is decomposed into a persistent component and a transitory component:

$$\tau_t = \tau_{S,t} + \tau_{T,t}$$

$$\tau_{S,t} = \rho_S \tau_{S,t-1} + \exp(\sigma_{S,t})\varepsilon_{S,t}, \qquad \varepsilon_{S,t} \sim \mathcal{N}(0,1)$$

$$\tau_{T,t} = \rho_T \tau_{T,t-1} + \exp(\sigma_{T,t})\varepsilon_{T,t}, \qquad \varepsilon_{T,t} \sim \mathcal{N}(0,1)$$

- $\varepsilon_{S,t}$ shifts the persistent regime and therefore affects expected future tariffs.
- $\varepsilon_{T,t}$ captures tariff movements assigned to the transitory component.

Back

Stochastic volatility blocks

Each tariff component has a separate stochastic-volatility process:

$$\sigma_{j,t} = (1 - \rho_{\sigma j})\bar{\sigma}_j + \rho_{\sigma j}\sigma_{j,t-1} + \eta_j u_{j,t}, \qquad u_{j,t} \sim \mathcal{N}(0,1), \qquad j \in \{S, T\}.$$

- $\sigma_{S,t}$ governs the volatility of shocks to the persistent tariff regime.
- $\sigma_{T,t}$ governs the volatility of transitory tariff shocks.
- The model therefore separates structural trade-policy uncertainty from short-run tariff volatility.

$$STPU_t = \exp(2\sigma_{S,t})$$

Structural uncertainty is volatility in the persistent tariff regime

Back

Calibration

The calibration separates a persistent trade-policy regime from short-lived tariff disturbances.

Symbol	Value	Description
ρ_S	0.975	Persistence of structural tariff $\tau_{S,t}$
ρ_T	0.200	Persistence of transitory tariff $\tau_{T,t}$
$\rho_{\sigma S}$	0.950	Persistence of structural log-volatility $\sigma_{S,t}$
$\rho_{\sigma T}$	0.500	Persistence of transitory log-volatility $\sigma_{T,t}$
η_S	0.250	Innovation volatility of $\sigma_{S,t}$
η_T	0.900	Innovation volatility of $\sigma_{T,t}$
$\bar{\sigma}_S$	-2.00	Long-run mean of structural log-SD
$\bar{\sigma}_T$	-2.00	Long-run mean of transitory log-SD

Identification comes from the maintained distinction between a slow-moving regime and short-run tariff noise

Back

Particle filtering

Conditional on the calibrated parameters, the latent states are recovered with a bootstrap particle filter applied to the standardized WIT1 tariff series.

$$p(\tau_{1:T} \mid \theta) = \prod_{t=1}^{T} p(\tau_t \mid \tau_{1:t-1}, \theta)$$

- The filter integrates over the latent tariff components and volatility states.
- At each date, the observed tariff rate is used to update the distribution of the latent state.
- The procedure delivers filtered estimates of

$$\tau_{S,t}, \qquad \sigma_{S,t}, \qquad \sigma_{T,t}.$$

Filtering maps the observed tariff path into a persistent stance and two volatility states

Back

Particle-filter implementation

At each date t, the filter uses a cloud of 100,000 particles. Each particle represents a candidate value of the latent state:

$$\{\tau_{S,t}, \sigma_{S,t}, \sigma_{T,t}\}.$$

Since τ_t is observed, the transitory component is recovered residually:

$$\tau_{T,t} = \tau_t - \tau_{S,t}.$$

- Particles are weighted by the likelihood of the implied $\tau_{T,t}$ under its calibrated AR(1) process.
- Particles implying plausible transitory movements receive higher weight.
- The weighted particle cloud is systematically resampled at each date.

Back

Reported S-TPU index

Let $\widehat{\sigma}_{S,t|t}$ denote the filtered median estimate of structural tariff log-volatility at date t. The reported S-TPU index is:

$$STPU_t = \exp\left(2\widehat{\sigma}_{S,t|t}\right).$$

- The index is the filtered variance of innovations to the persistent tariff component.
- The median is computed across the resampled particle cloud.
- Since filtering is performed on standardized tariffs, the variance is converted back to tariff-level units using the squared standard deviation of WIT1.

High S-TPU means high uncertainty about persistent tariff-regime shocks

Back

Steady-state Kalman gain

$$\mathbb{K}(\sigma_S^2) = \frac{W}{1+W}, \qquad W = \frac{\rho_S^2 W}{1+W} + \sigma_S^2$$

- W: steady-state prediction variance.
- Gain **increasing** in S-TPU: $\frac{d\mathbb{K}}{d\sigma_S^2} = \frac{1}{(W+1)^2}\frac{dW}{d\sigma_S^2} > 0$.
- Stability: $\rho_S(1 - \mathbb{K}(\sigma_S^2)) < 1$.

Less precise prior $\Rightarrow$ more weight on the current signal

Back

Robustness: high-S-TPU cutoff

- Baseline: top 30% of the S-TPU distribution.
- State dependence robust to top **40%, 20%, 10%** cutoffs.
- Robust to baseline-vs-extended dates and to excluding the VAR constant.

The sign reversal is not an artifact of the cutoff

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References I

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