Tariffs, Uncertainty, and the Exchange Rate*

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Abstract

We estimate the macroeconomic effects of U.S. tariff shocks in a Bayesian VAR identified through narrative dominance. In the short run, tariffs transmit as a negative demand shock: they reduce both activity and inflation, and prompt a monetary policy easing. Furthermore, they depreciate the effective U.S. dollar exchange rate, and generate an S-shaped improvement in the trade balance. These average effects depend critically on structural trade-policy uncertainty (S-TPU) - uncertainty about the *persistence* of the trade-policy regime - which we estimate from a state-space stochastic-volatility model of tariff rates. When S-TPU is low, tariffs raise activity and inflation and appreciate the dollar, consistent with textbook predictions. When S-TPU is high, the same shock depresses activity, depreciates the dollar, and prompts a more accommodative monetary response. We rationalize these findings in an equilibrium model of the exchange rate with uncertainty about the *persistence* of tariff policy.

Keywords: tariff, exchange rate, structural trade-policy uncertainty.
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1 Introduction

The resurgence of protectionist trade policies in the United States has reignited interest in the macroeconomic effects of tariffs. Despite the salience of the issue, the empirical literature on the dynamic effects of tariff shocks remains surprisingly limited. Empirical contributions by Schmitt-Grohé and Uribe (2025), den Besten, Barnichon, Känzig, and Singh (2026), Franconi and Hack (2026), and Ostry et al. (2025), employing alternative identification schemes, are important recent exceptions. In parallel, a rapidly growing theoretical literature has developed to analyze the macroeconomic effects of tariffs through the lens of modern dynamic general-equilibrium models, distinct from the more traditional international-trade literature based predominantly on partial-equilibrium analysis.[1] Against this background, this paper makes *four* contributions, to both strands of the literature, organized around a single empirical puzzle: the effect of tariffs on the exchange rate.

Tariff shock identification First, and in the spirit of Antolín-Díaz and Rubio-Ramírez (2018), we propose a narrative-dominance strategy for the identification of tariff shocks in a Bayesian VAR (BVAR) on U.S. quarterly data from 1990 to 2025. The approach combines a sign restriction on real imports with historical-decomposition restrictions imposed at a small set of well-documented narrative tariff episodes. At each anchor date, the identified tariff shock is required to be the dominant contributor to the unexpected movement in the U.S. import tariff rate. Our approach ties identification to historical dates of unambiguous policy origin without taking a stance on the sign of the response of any variable other than real imports - in particular, it leaves the sign of the exchange-rate response to be estimated in the data. We find that positive tariff shocks transmit as *negative aggregate demand* shocks: they are contractionary on real economic activity, deflationary in the short run, and prompt an accommodative response by monetary policy. Furthermore, tariff shocks generate an S-shaped response of the trade balance (an improvement at first, followed by a deterioration), and - most strikingly - produce a persistent nominal and real *depreciation* of the U.S.-dollar effective exchange rate. The latter result is in stark contrast to the conventional textbook prediction of exchange rate appreciation, typically working via expenditure-switching from foreign currency (imported goods) towards the domestic currency (domestically produced goods).
We then extend the analysis to study the transmission of U.S. tariff shocks to the Euro area. To this end, we estimate a quarterly BVAR that combines Euro area variables with the U.S. block and identify tariff shocks using the same narrative-

[1] We discuss the existing empirical and theoretical literature in a dedicated paragraph below.

dominance strategy. Since the baseline U.S. tariff dates do not coincide with any major Euro area retaliation, the shocks can be interpreted as plausibly external to the Euro area economy. We find that U.S. tariff shocks transmit abroad primarily as adverse demand shocks: Euro area activity contracts, HICP inflation falls at short horizons, and monetary policy initially turns more accommodative.

Structural trade-policy uncertainty Our second contribution is to show that the effects of tariffs on the exchange rate, as well as on other key macroeconomic variables, depend on the underlying degree of *structural* trade-policy uncertainty (S-TPU). Conceptually, what matters for agents' forward-looking decisions is not only the tariff rate in force today, but also the uncertainty about the *persistence* of the underlying trade-policy stance, which is unobserved. We decompose the observed tariff measure into two components: (i) a persistent component, modelled as a near-unit-root AR(1) process, and (ii) a transitory tariff disturbance. Empirically, we define S-TPU as the conditional variance of the structural innovations to the persistent component of tariff policy. We construct an empirical measure of S-TPU by estimating a state-space stochastic-volatility model. Our S-TPU index is the resulting filtered series of the structural volatility state. Notably, it is conceptually distinct from the aggregate tariff volatility TPU index estimated in the univariate approach by Caldara et al. (2020). The aggregate TPU index pools two components, which we estimate separately: announcement-driven transitory uncertainty and uncertainty about the persistent trade-policy regime. S-TPU isolates the latter and differs from the aggregate index in its timing: it rises around episodes of genuine regime change - e.g., the 2017 U.S. withdrawal from the Trans-Pacific Partnership and the USMCA ratification - while remaining relatively muted around tariff threats and announcements that, ex post, leave the trade-policy regime unaltered.

State-dependent transmission Our third contribution is to document that, in U.S. data, the empirical response of the exchange rate to an import tariff shock is *state-dependent*. Using S-TPU as a conditioning variable in state-dependent local projections, we find that the conventional textbook implications - a nominal and real appreciation of the exchange rate, a tightening of monetary policy, an expansion in economic activity and a rise in inflation - prevail in states of *low* S-TPU. In states of *high* S-TPU, by contrast, the same tariff shock generates an exchange rate depreciation, an accommodative monetary-policy response, a contraction in both economic activity and inflation. Notably, conditioning on the aggregate TPU index of Caldara et al. (2020) eliminates the asymmetry, suggesting that it is structural, not noise-driven, trade-policy uncertainty that governs the macroeconomic transmission of tariff shocks.

Exchange rate under S-TPU Finally, we develop a small open-economy model with incomplete financial markets where households feature constant-absolute-risk-aversion (CARA) preferences. Our key assumption is that the level of tariffs is the sum of two components: (i) a persistent structural component and (ii) a noisy disturbance. The persistence of the structural component is itself random and unknown one period in advance. S-TPU is defined as the variance of the persistence random variable. Consequently, a tariff increase shifts not only the expected path of future tariffs but also their conditional variance, in proportion to S-TPU and to the tariff level itself. A tariff shock is therefore never only a first-moment shock: because the conditional variance of the future tariff equals the (squared) tariff level scaled by S-TPU, the same shock also widens the distribution of future tariffs, thereby endogenously raising uncertainty.[2] With CARA preferences, such an increase in uncertainty induces precautionary saving. Lower consumption, in turn, improves the trade balance and, for any given level of output, induces a fall in the relative price of domestic goods, i.e., a real exchange rate depreciation. Symmetrically, in the asset market, higher saving puts downward pressure on the real return of domestic assets, inducing - via uncovered interest parity - an expected future real exchange rate appreciation, which can be delivered via an impact depreciation.

In equilibrium, the real exchange rate is therefore governed by two opposing forces. The conventional expenditure-switching channel pushes toward appreciation, whereas a forward-looking *precautionary channel* - whose strength depends on the interaction between the tariff stance and uncertainty about its persistence - pushes toward depreciation. When persistence is deterministic, the precautionary channel is inactive and higher tariffs appreciate the exchange rate. Under high S-TPU, however, a tariff increase widens the distribution of future consumption, inducing households to save more. For a given level of output, goods-market clearing requires a deterioration in the terms of trade, which depreciates the real exchange rate and improves the trade balance. Above a threshold level of S-TPU, the precautionary force dominates, reproducing the depreciation documented in our state-dependent local projections.

Literature review Our paper speaks to two complementary strands of the literature on the macroeconomic effects of tariffs. The first is an *empirical* literature that uses time-series methods to estimate the dynamic effects of tariff shocks. Boer

[2] Notice that both ingredients are needed for the second moment to matter. A small tariff change moves the variance negligibly even when S-TPU is high, and no tariff moves it when S-TPU is zero; only a large tariff enacted under elevated S-TPU constitutes, in itself, a volatility event.

and Rieth (2024) provide one of the first SVAR-based assessments for the United States, combining sign and narrative restrictions and emphasizing that tariff shocks raise trade-policy uncertainty in addition to inflation. Franconi and Hack (2026) construct a quarterly-weighted import-tariff series and document the systematic response of U.S. monetary policy to tariff shocks. Schmitt-Grohé and Uribe (2025), in a latent state-space framework, separate transitory and permanent tariff shocks and show that the two carry sharply different implications for inflation, output, and the external accounts. den Besten, Barnichon, Känzig, and Singh (2026) construct a long-run narrative instrument for plausibly exogenous U.S. tariff changes, exploiting major legislative actions from 1840 to 2024. Their evidence shows that tariff increases are systematically contractionary, with sharp declines in imports and delayed declines in exports. Jeanne and Son (2024) provide complementary evidence from the 2018-2019 U.S.-China first trade war, showing that tariff actions have significantly depreciated the renminbi. Garimella et al. (2025) conducts an event-study on the April 2025 tariff announcement. They find that asset prices embedded a persistent deterioration in expected profits and an abnormal depreciation of the U.S. dollar against safe-haven currencies. Ostry et al. (2025) estimate local projections of the U.S. dollar exchange rate on effective U.S. tariff shocks, allowing the response to differ with foreign retaliation. They find that unilateral tariff shocks appreciate the dollar, whereas retaliated tariff actions weaken it. Our contribution to this strand of the literature is twofold. First, we propose a narrative-dominance identification scheme on quarterly frequency data. Second, we document that tariff shocks generate a persistent depreciation of the U.S. dollar effective exchange rate, and that this response is state-dependent in the underlying degree of structural trade-policy uncertainty.

The second is a fast-growing *theoretical* literature that interprets the macroeconomic effects of tariffs through dynamic general-equilibrium models. Earlier contributions - Barattieri et al. (2021), Auray et al. (2022, 2025), Bergin and Corsetti (2023), and Erceg et al. (2023) - analyze tariffs in New Keynesian open-economy environments, emphasizing, respectively, firm entry, strategic and self-enforcing trade policy, optimal monetary stabilization, and equivalence to fiscal-devaluation. The renewed protectionist stance of the United States has triggered a second wave of contributions, emphasizing especially the interaction between tariff policy and monetary policy - Kalemli-Özcan, Soylu, and Yıldırım (2025), Monacelli (2025), Bianchi and Coulibaly (2025), Cuba-Borda et al. (2025), and Werning et al. (2025) - as well as the positive effects and normative implications of macroeconomic tariffs - Itskhoki and Mukhin (2025), Costinot and Werning (2025), and Auclert et al. (2025).

Closest to our analysis is Kalemli-Özcan, Soylu, and Yıldırım (2026), who also study how tariff uncertainty can overturn the textbook prediction of currency appreciation, motivated by the 2025 "Liberation Day" dollar-depreciation episode. In their two-country model with CARA households and risk-sensitive intermediaries operating in segmented financial markets, an increase in tariff volatility raises precautionary savings and generates a positive risk-premium wedge in the UIP condition, producing contemporaneous home-currency depreciation even as tariff levels rise. Our framework complements Kalemli-Özcan et al. (2026): rather than relying on financial segmentation and the risk-bearing capacity of intermediaries, we emphasize a precautionary-saving channel in which structural uncertainty about the *persistence* of the tariff regime raises the conditional variance of future tariffs in proportion to the current stance, and - via incomplete international financial markets - leads prudent agents to cut consumption and save. The ensuing contraction in demand for the home good, with output fixed, is a force that pushes towards a depreciation of the exchange rate, which coincides with an improvement in the trade balance. Crucially, while Kalemli-Özcan et al. (2026) model tariff uncertainty as exogenous general volatility shocks, we characterize it narrowly as uncertainty about the *persistence* of the tariff regime. This identifies an additional result: uncertainty does not move the exchange rate on its own, but rather renders the response of the exchange rate to a tariff *level* shock *state-dependent*, turning on only when a large tariff coincides with genuine uncertainty about how long it will last. The same shock therefore appreciates the currency in normal times but can depreciate it - alongside an improvement in the trade balance - precisely when the durability of the tariff regime is uncertain, that is, when S-TPU is most elevated.

The remainder of the paper is organized as follows. Section 2 describes the data and presents the narrative-dominance VAR evidence. Section 3 introduces the distinction between announcement-driven and structural trade-policy uncertainty, constructs the S-TPU index, and documents the state-dependent transmission of tariff shocks. Section 4 develops the equilibrium model and characterizes the persistence channel analytically. Section 5 concludes.

2 Tariff Shocks in a Narrative Bayesian VAR

In this section, we specify the tariffs and exchange rate data employed in the analysis. We also present the methodology and results of our Narrative Bayesian VAR.

Tariff data Our baseline measure of trade policy is the Weighted Import Tariff rate, *WIT1*. Following Franconi and Hack (2026), we measure U.S. import tariffs as customs duties collected relative to the value of *dutiable* imports. This construction delivers a trade-weighted tariff rate and therefore gives limited weight to tariff changes applied on small trade flows. Compared with the alternative measures discussed below, WIT1 has a narrower scope but a more transparent interpretation.

Alternative tariff measures: WIT2 and TRI We also consider two alternative trade-policy measures used in the literature and compiled by Schmitt-Grohé and Uribe (2025). The first is an alternative Weighted Import Tariff rate, *WIT2*, defined as customs duties collected relative to the value of *total* goods imports, including duty-free imports. The second is the Trade Restrictiveness Index, *TRI*, a welfare-based tariff measure first introduced by Anderson and Neary (1994). The TRI can be interpreted as the uniform tariff rate that, in a given period, delivers the same level of welfare as the observed tariff schedule. Importantly, the TRI increases not only with the average level of tariffs, but also with their cross-sectional dispersion. It therefore captures the welfare costs associated with the uneven allocation of tariffs across goods. Figure 1 shows that both alternative measures, WIT2 and TRI, are highly correlated with our benchmark WIT1 over the sample period.[3]

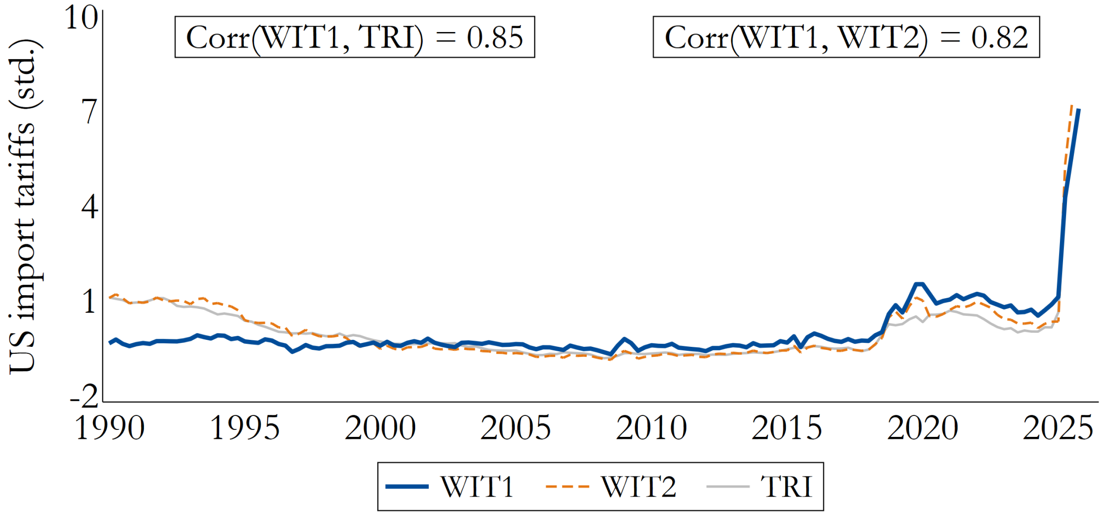
We restrict our analysis to a sample beginning in 1990Q1 for two main reasons. First, our preferred tariff index, WIT1, is available only starting in 1990. Second, the post-1990 period provides a more homogeneous trade-policy regime. This period coincides with the consolidation of the modern multilateral trading system - the GATT-to-WTO transition (1995) and the subsequent integration of China and other large emerging economies into world trade - and thus captures a phase of broadly stable and deepening global trade integration.

Exchange rate data Our baseline exchange-rate measure is the U.S. nominal effective exchange rate (*NEER*). The *NEER* is constructed as a trade-weighted average of bilateral exchange rates against the major U.S. trading partners. The weights vary over time and capture both direct trade with each partner and competition with that partner in third markets. An increase in the index denotes a U.S. dollar appreciation.

As an alternative to the NEER, we consider the U.S. Dollar Index (*DXY*), a fixed-weight index of the dollar against six major currencies. Unlike the NEER, which is a trade-weighted measure based on a broad and time-varying set of trading

[3] We also replicate the empirical exercises below using the WIT2 and the TRI as the tariff measure.

Figure 1: U.S. import tariff: WIT1, WIT2, and TRI



Notes: Three alternative measures of U.S. import tariffs: the two weighted-import measures (WIT1, blue; WIT2, orange) and the Trade Restrictiveness Index (TRI, grey). The series are expressed in standard deviations, from 1990Q1 to 2025Q4.

partners, the DXY is a fixed-basket financial benchmark, heavily tilted toward the euro.[4] We also consider and present the results for the U.S. real effective exchange rate (*REER*), also from the BIS, which adjusts the nominal effective exchange rate for relative price movements across trading partners. For more details on all the data series adopted, see Online Appendix A.1.

2.1 BVAR Specification

We estimate a Bayesian VAR on a sample of key U.S. macroeconomic variables at quarterly frequency from 1990Q1 to 2025Q2 and use it to identify the macroeconomic effects of import tariff shocks. We adopt the main tariff measure introduced above - the weighted import tariff (WIT1) - and report results on the nominal and real exchange rates in the main text.

Let y_t denote an $n \times 1$ vector of endogenous variables with $n = 10$, ordered as

$$y_t = \begin{bmatrix} \text{Inv}_t & \text{X}_t & \text{M}_t & \text{TB}_t & \text{GDP}_t & \text{CPI}_t & \text{Unc}_t & \text{Ex. Rate}_t & \tau_t & i_t \end{bmatrix}'$$

where Inv_t is real private investment, X_t is real exports, M_t is real imports, TB_t is the trade balance as a share of nominal output, GDP_t is real output, CPI_t is CPI inflation, Unc_t is the Jurado et al. (2015) macroeconomic uncertainty index, Ex. Rate_t is the nominal (real) effective exchange rate, τ_t (WIT1) is the weighted

[4]Online Appendix A.1 provides further details on the construction of the exchange-rate series. We also replicate all empirical exercises using the DXY as the exchange-rate measure.

import tariff and i_t is the federal funds rate. All variables enter in levels, except for real private investment, real exports, real imports, real output, and the effective exchange rate, which enter in logs.

The reduced-form VAR(p) model is:

$$y_t = c + \sum_{j=1}^{p} A_j y_{t-j} + u_t, \qquad t = 1, \ldots, T \tag{1}$$

where c is an $n \times 1$ vector of intercepts, A_j are $n \times n$ coefficient matrices, and $u_t \sim \mathcal{N}(0, \Sigma_u)$ is the $n \times 1$ vector of reduced-form innovations with symmetric positive-definite covariance Σ_u. The benchmark specification includes $p = 4$ lags of the ten endogenous variables.

2.2 Narrative Identification of Tariff Shocks

We identify tariff shocks by exploiting a small set of historical episodes in which, based on public news and policy documents, movements in U.S. tariffs can be traced to discrete trade-policy actions. These episodes provide narrative anchors for the structural tariff shock. Our approach follows the narrative restriction framework of Antolín-Díaz and Rubio-Ramírez (2018), specialized to a single tariff shock, and is closely related to De Santis and Van der Veken (2026), who identify financial and uncertainty shocks using narrative restrictions while remaining agnostic about the impact matrix and the dynamic responses. In our setting, the narrative information disciplines the sign and timing of the tariff shock, while leaving the rest of the structural system unrestricted.

Narrative dominance restrictions Let $u_t = B\,\varepsilon_t$ be the structural decomposition of the reduced-form BVAR model in (1), where $u_t \sim \mathcal{N}(0, \Sigma_u)$ and $\varepsilon_t \sim \mathcal{N}(0, I_n)$. The structural impact matrix is constructed as $B = \text{chol}(\Sigma_u)\,Q$, with Q a randomly drawn orthogonal matrix, following Rubio-Ramírez et al. (2010). The k-th column of B is the structural impact vector associated with the innovation $\varepsilon_{k,t}$: it maps that scalar innovation into the reduced-form forecast errors u_t. Narrative restrictions therefore select which column of B, if any, is labelled as the tariff shock ε_t^{τ}. The remaining columns are not assigned any economic meaning. The unexpected change in variable i at date t (i.e., the one-step-ahead forecast error) admits the shock-by-shock decomposition:

$$\underbrace{y_{i,t} - \mathbb{E}_{t-1} y_{i,t}}_{u_{i,t}:\ \text{one-step-ahead forecast error}} \;=\; e_i' B \varepsilon_t \;=\; \underbrace{\sum_{j=1}^{n} b_{ij}\, \varepsilon_{j,t}}_{\text{shock-by-shock decomposition}} \tag{2}$$

where b_{ij} is the (i, j) element of B and e_i the i-th unit vector.

A *narrative dominance* restriction imposes, at a chosen date t^*, that the structural tariff shock ε^τ is the largest contributor to the forecast error of the tariff rate τ_t among those shocks whose contribution pushes the forecast error in the *same direction*. Let C_{τ,t^*} denote the contribution of the candidate tariff shock to the forecast error of τ_t at t^* (cumulated over t^* and the preceding quarter) and $C^{(k)}_{\tau,t^*}$ the analogous contribution of the k-th non-tariff shock. The restriction requires:

$$|C_{\tau,t^*}| \;>\; \max \left\{ \, |C^{(k)}_{\tau,t^*}| \;:\; \operatorname{sign}(C^{(k)}_{\tau,t^*}) = \operatorname{sign}(C_{\tau,t^*}) \, \right\} \tag{3}$$

Notice, following De Santis and Van der Veken (2026), that the above restriction is strictly weaker than the original Antolín-Díaz and Rubio-Ramírez (2018) requirement that ε^τ dominate *all* other shocks, $|C_{\tau,t^*}| > \max_k |C^{(k)}_{\tau,t^*}|$: an unrestricted shock may contribute more as long as it moves the tariff in the opposite direction. The flexibility matters here, because tariff increases are routinely accompanied by other disturbances - exchange-rate movements, changes in import composition, retaliation, monetary policy - which may push the effective tariff in the opposite direction. The set of anchor dates $\mathcal{T}^* = \{t_1^*, \ldots, t_K^*\}$ is chosen according to the criteria of narrative and statistical relevance, as outlined in Section 2.3 below.[5] Since every episode selected according to the criteria is a documented tariff increase, the restriction requires the candidate shock to be the largest *positive* contributor to the tariff forecast error at t^*.

Three features of this identification strategy are worth emphasizing. First, the object of the restriction is the *forecast error* of the tariff rate, not its level, at t^*. Identification is therefore obtained from the unanticipated component of each narrative episode. Second, the identifying variation is pinned down by narrative, plausibly exogenous tariff movements directly tied to observable trade-policy actions. Third, the strategy is deliberately agnostic about the responses of the variables whose sign is theoretically disputed. With the exception of real imports (see below), we do not restrict the sign responses of trade balance, output, inflation, or monetary

[5] The dominance restriction is imposed at the baseline horizon $h = 1$ and, as a robustness check, at $h = 3$.

policy. In particular, the sign of the exchange-rate response is left to be estimated from the data.

Sign restriction on real imports The dominance restriction (3) fixes the source of the tariff-index forecast error at t^* but is silent about its transmission. We therefore add a supplemental restriction on the impulse response of real imports. Let M_t denote log real goods imports and IRF_h^m the response of M_t to a unit positive tariff shock at horizon h. The standard demand effect implies that an import-tariff increase should reduce imported quantities, as higher tariff-inclusive import prices induce substitution away from foreign goods. Formally, we impose the restriction:

$$\mathrm{IRF}_h^m \; < \; 0 \qquad \text{for } h \in \{1, 2\} \tag{4}$$

where we deliberately leave the impact response unrestricted.[6] This choice is motivated by recent U.S. tariff evidence of a pronounced *front-loading* pattern: upon announcement, importers accelerate shipments to clear customs at the pre-hike rate, generating a transitory positive spike in volumes in the quarter the tariff takes effect.[7] Restricting the sign only at $h = 1, 2$ preserves the demand effect at the horizon at which front-loading has unwound, while remaining agnostic about the impact response.

Estimation Following Uhlig (2005); Rubio-Ramírez et al. (2010); Arias et al. (2018), we estimate the reduced-form VAR in (1) under a flat prior on $(A_1, \ldots, A_p, c, \Sigma_u)$[8] which yields the standard Normal-Inverse-Wishart posterior, centered at the OLS estimates and treating Σ_u as unknown. We then simulate from this posterior by rejection sampling. At each iteration, we draw a reduced-form parameter vector and retain it only if the implied VAR is stable,[9] which ensures that impulse responses are well defined and converge after a shock. For each stable reduced-form draw, we sample candidate orthogonal rotations Q of the impact matrix B described above. A structural draw is accepted if one candidate column satisfies the narrative dominance restriction (3) and the import sign restriction (4). This column is labelled the tariff shock, ε^τ, while the remaining shocks are left unidentified. The procedure is repeated until 1,000 structural draws are retained, allowing up to 100 candidate

[6] This means that we do *not* impose $\mathrm{IRF}_h^m < 0$ from $h = 0$.

[7] For evidence on the frontloading in reaction to Liberation Day tariffs see, among others, de Soyres and Machol (2025).

[8] The flat prior is the diffuse limiting case of the conjugate Normal-Inverse-Wishart family.

[9] Specifically, we write (1) in companion form, $Y_t = C + FY_{t-1} + U_t$, where $Y_t = (y_t', y_{t-1}', \ldots, y_{t-p+1}')'$ and F collects the autoregressive coefficients $(A_1, \ldots, A_p)$. A reduced-form draw is kept only if all eigenvalues of F have modulus below one.

rotations for each stable reduced-form draw. For each accepted draw, we compute impulse responses and the historical decomposition of τ_t. Impulse responses are reported over 15 quarters as posterior medians with 68% and 90% credible bands, normalized so that the impact response of the weighted import tariff equals one percentage point.

2.3 Selection of Narrative Dates

We select the dates $\mathcal{T}^*$ on the basis of three jointly applied criteria:

(C1) *Narrative clarity.* t^* must correspond to a clearly identified, publicly announced change in U.S. tariff policy, attributable to a specific instrument (executive order, USTR[10] determination, presidential proclamation, or statutory action).

(C2) *Sizeable movement in τ_t.* The change in the weighted tariff rate at t^* must be too large to be plausibly generated by composition effects, business-cycle feedback, or measurement noise. Formally, the standardized quarterly change $z(\Delta\tau_{t^*})$ must exceed unity in absolute value.

(C3) *Sign consistency.* The empirical sign of $\Delta\tau_{t^*}$ must be consistent with the direction of the announced policy change in (C1).

Notice that criterion (C2) restricts attention to episodes in which the tariff moves substantially, so that restriction (3) is anchored to an economically significant and informative movement at t^*. Criterion (C3) rules out dates at which a clear announcement coincides with an offsetting movement driven by other sources. Applying (C1)-(C3) to the 1990Q1-2025Q2 sample yields the baseline date set in Panel A of Table 1: the *2018Q4* imposition of the Section 301 List 3 tariffs and the *2025Q2* "Liberation Day" package. The same criteria deliver the extended set for robustness (Panel B) that adds *2019Q3* (List 4A) and *2019Q4* (Airbus countermeasures and List 4A continuation).

Figure 2 plots the quarter-on-quarter *changes* of three tariff measures - the TRI, the WIT1, and the WIT2 - together with the four narrative dates isolated above. All three series register sizable jumps at each of the narrative dates, indicating that the episodes we identify are large in magnitude regardless of how the aggregate tariff is measured.

[10]USTR is an acronym for Office of the United States Trade Representative.

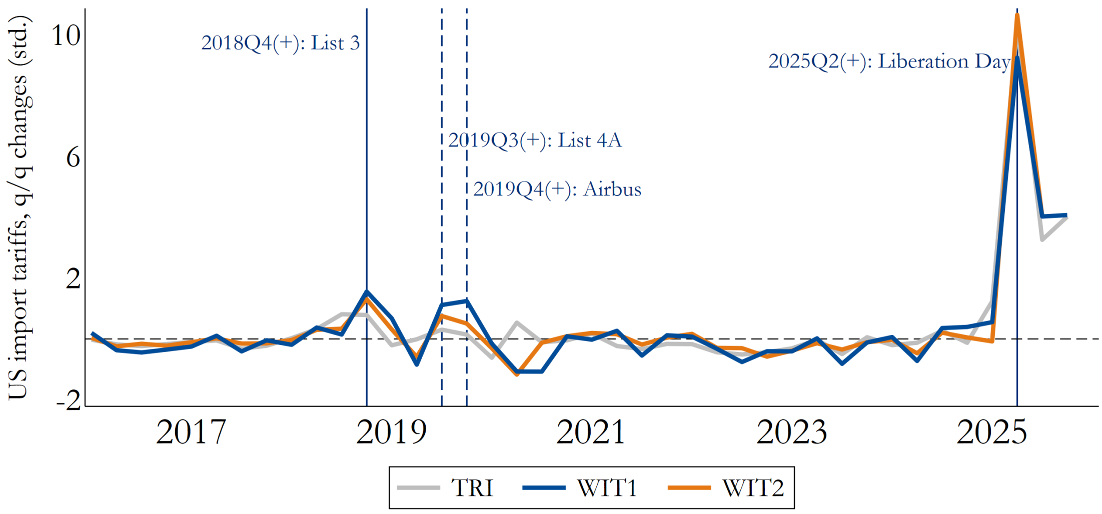
Narrative evidence by event More details on each individual narrative event and its salience are reported in the Online Appendix A.2.

Table 1: Narrative dates for tariff shock identification

Date	$(\Delta\tau)$ (std.)	Narrative event
Panel A: Baseline		
2018Q4	+1.56	§ 301 List 3, $200B at 10% (Sept. 24, 2018)
2025Q2	+9.24	"Liberation Day" reciprocal tariffs (Apr. 2, 2025)
Panel B: Extended		
2019Q3	+1.12	§ 301 List 4A, $112B at 15% (Sept. 1, 2019)
2019Q4	+1.25	WTO-Airbus countermeasures (Oct. 18, 2019) and § 301 List 4A continuation

Notes: The Table reports: (i) Dates: the narrative dates for tariff shock identification, (ii) $z(\Delta\tau)$ (std.): the corresponding standardized quarterly change in WIT1, and (iii) Narrative event: a brief description of the narrative event. Dates are selected on criteria (C1)-(C3). Panel A is the baseline set of dates for the main results; Panel B is the extended set used in the robustness in Online Appendix A.3. Because WIT1, WIT2 and TRI are constructed from duties *actually collected*, a measure that takes effect close to the end of a quarter is recorded in the following quarter's collections. The § 301 List 3 tariffs took effect on 24 September 2018, in the last week of 2018Q3, so the corresponding jump in WIT1 appears in 2018Q4.

Figure 2: Standardized quarter-on-quarter changes in U.S. import tariffs



Notes: Three alternative measures of U.S. import tariffs: the two weighted-import measures (WIT1, blue; WIT2, orange) and the Trade Restrictiveness Index (TRI, grey) from 2016Q1 to 2025Q4. Each series is standardized by its sample mean and standard deviation. Vertical lines mark narrative events.

2.4 Results from the BVAR

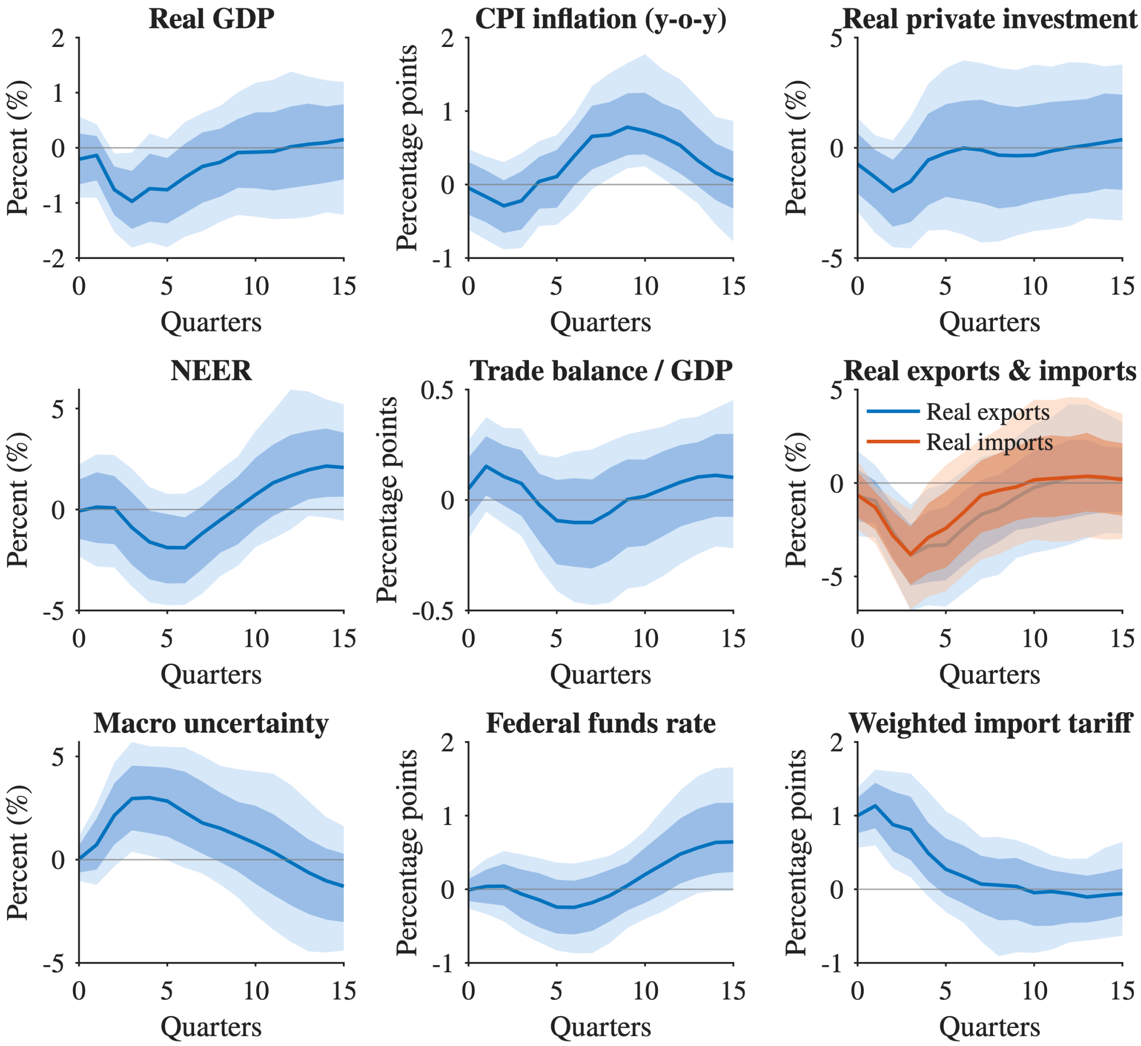
We estimate the effects of the identified shocks to the weighted import tariff index WIT1 within the Bayesian VAR based on the two baseline narrative events from Table 1. Figure 3 plots the response of the U.S. nominal effective exchange rate (NEER) and of a selected set of macroeconomic variables to a one-percentage-point weighted import-tariff shock, estimated over the sample 1990Q1-2025Q2, together with the corresponding 68% and 90% posterior credible bands. The exchange-rate index is normalized so that a decrease corresponds to a *depreciation* of the U.S. dollar. Figure 4 reports the same impulse responses estimated on a shorter sample starting in 2002Q1, while Figure 5 displays the response of the real effective exchange rate (REER) over the two samples.

Following a one-percentage-point increase in the weighted import tariff, both the NEER and the REER gradually depreciate and remain persistently below their pre-shock levels over the medium term, exhibiting a pattern consistent with the delayed-overshooting evidence of Eichenbaum and Evans (1995) for monetary shocks. The observed depreciation runs counter to the textbook prediction that higher import tariffs should induce an exchange-rate appreciation through an expenditure-switching channel, whether on currencies or goods.

A positive tariff shock is contractionary. Real GDP declines and remains below baseline for several quarters before gradually recovering. The contraction is initially more pronounced for real private investment, which displays a persistent decline. Inflation follows an S-shaped pattern, falling moderately over the first few quarters and rising significantly thereafter. Following the initial decline in real activity and inflation, monetary policy responds by lowering the nominal interest rate. The short-run pattern suggests that the tariff shock operates primarily through an aggregate-demand channel, and the increase in macroeconomic uncertainty reinforces this interpretation. On the external balance side, both exports and imports contract, consistent with weaker demand and lower trade flows. The trade-balance-to-GDP ratio follows an S-shaped pattern: it initially improves for a few quarters, and deteriorates over the medium horizon. The S-shaped pattern of the trade balance ratio is especially clear in the short sample estimate of Figure 4.

Robustness Our baseline identification anchors the tariff shock on two large, unanticipated tariff actions in 2018Q4 and in 2025Q2, reported in Panel A of Table 1. We assess whether the results depend on this event set by re-estimating the BVAR with the *extended* narrative set in Online Appendix A.3. This set adds the 2019Q3 Section 301 List 4A and the 2019Q4 WTO-Airbus tariffs, which are more

Figure 3: Estimated impulse responses of NEER and other macroeconomic variables to a 1 p.p. weighted-import tariff shock. A fall in the exchange rate is a depreciation

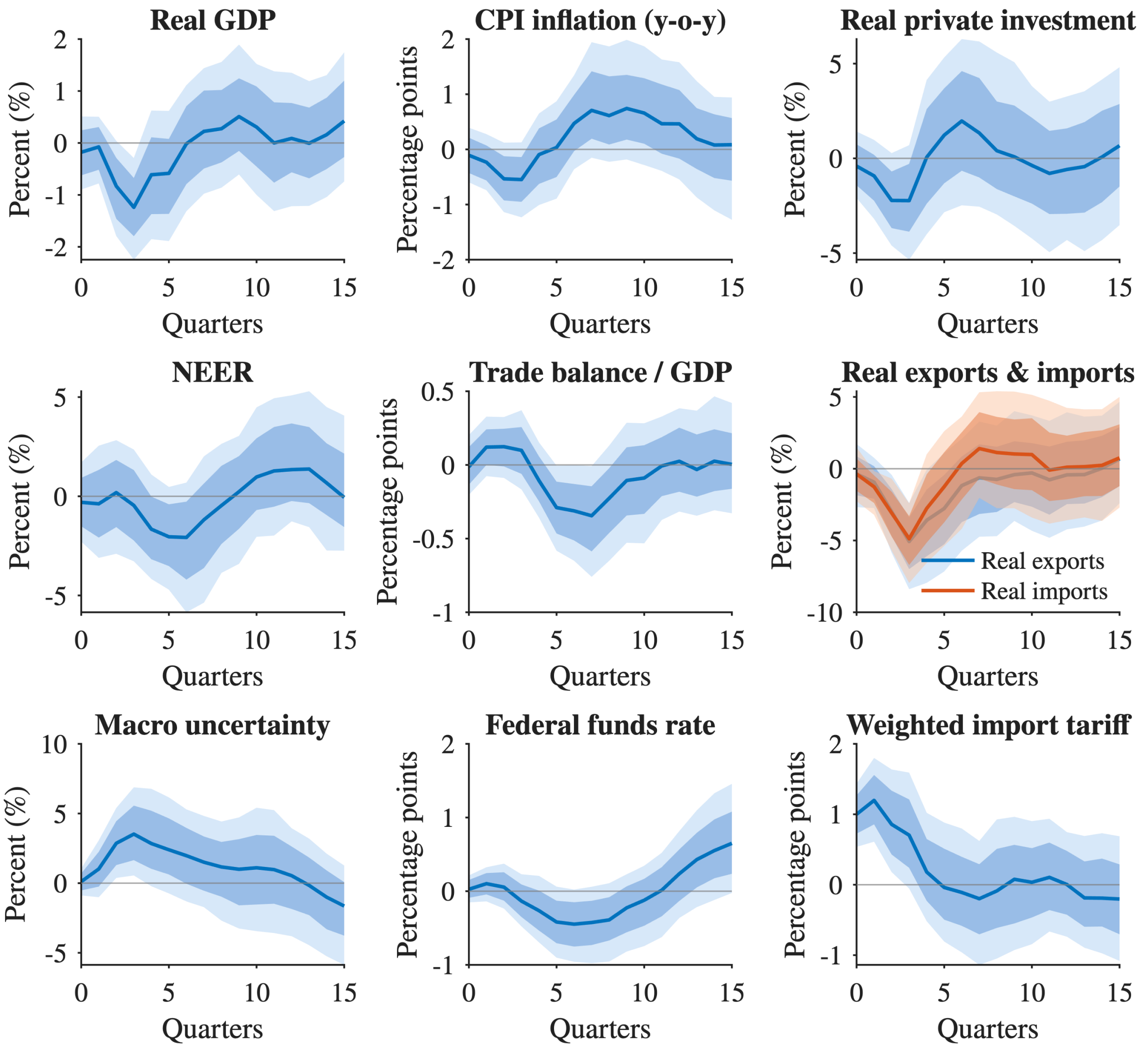


Notes: Impulse responses of real GDP, CPI inflation, real private investment, the nominal effective exchange rate (NEER), the trade balance as share of nominal output, real exports, real imports, the Macroeconomic Uncertainty index from Jurado et al. (2015) and the Federal funds rate to a 1 p.p. shock to the weighted import tariff, estimated in the BVAR in Section 2.1. The sample covers U.S. quarterly data from 1990Q1 to 2025Q2. The blue line represents the posterior median, and the shaded areas are 68% and 90% credible sets.

modest or goods-specific shocks documented in Panel B of Table 1. The estimated responses of the exchange rate and other macroeconomic variables are essentially unchanged. Additionally, results are robust to augmenting the BVAR with the ten-year Treasury yield, so that the identified tariff shock is not confounded with potential contemporaneous financial disturbances - see Online Appendix A.3 for details.

Summary of empirical findings We briefly summarize our empirical findings on the U.S. economy. Based on a narrative-dominance identification approach, positive tariff shocks generate (i) a persistent depreciation of both the nominal and the real

Figure 4: *Shorter sample.* Estimated impulse responses of NEER and other macroeconomic variables to a 1 p.p. weighted-import tariff shock. A fall in the exchange rate is a depreciation



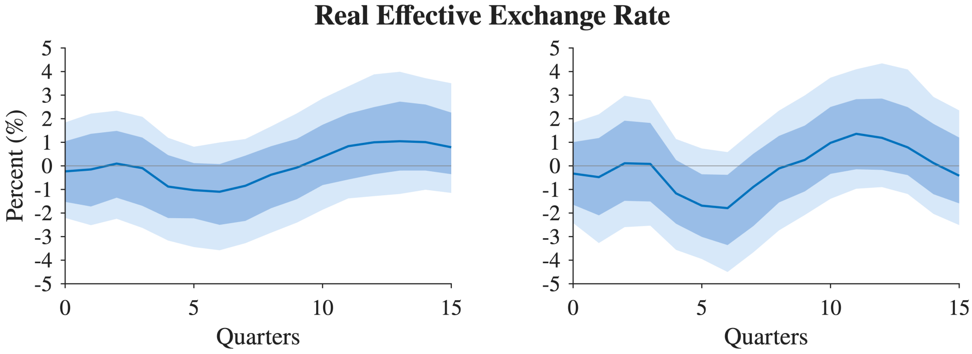
Notes: Same impulse responses as Figure 3, estimated on U.S. quarterly data from 2002Q1 to 2025Q2.

U.S. dollar effective exchange rate, (ii) a contraction in real GDP and investment, (iii) an S-shaped response of inflation, (iv) an accommodative monetary-policy reaction, (v) a rise in macroeconomic uncertainty, and (vi) an initial improvement of the trade-balance ratio followed by a deterioration. We now turn to an analysis of the effects of U.S. tariff shocks on the Euro area.

2.5 International BVAR

Next, we examine the effects of U.S. tariff shocks on the Euro area economy. We estimate a new quarterly Bayesian VAR over the sample 2002Q1-2025Q2, combining

Figure 5: Estimated impulse responses of the REER to a 1 p.p. shock to the weighted-import tariff. A fall in the exchange rate is a depreciation



(a) 1990–2025 (b) 2002–2025

Notes: Impulse response of the real effective exchange rate (REER) to a 1 p.p. shock to the weighted import tariff estimated in the BVAR in Section 2.1. Panel (a) reports results for the 1990Q1-2025Q2 sample, while Panel (b) reports results for the 2002Q1-2025Q2 sample.

Euro area variables and U.S. macro variables.[11] We identify the BVAR with the narrative approach outlined above, using the baseline tariff events selected in Table 1. The reduced-form VAR has the same structure as in equation (1). Let y_t denote the $n \times 1$ vector:

$$y_t = \begin{bmatrix} \mathrm{GDP}_t & \mathrm{CPI}_t & \mathrm{Ex.\ Rate}_t & \mathrm{TB}_t & \mathrm{Unc}_t & i_t & \mathrm{GDP}_t^{EA} & \mathrm{HICP}_t^{EA} & i_t^{EA} & \tau_t & \mathrm{M}_t \end{bmatrix}'$$

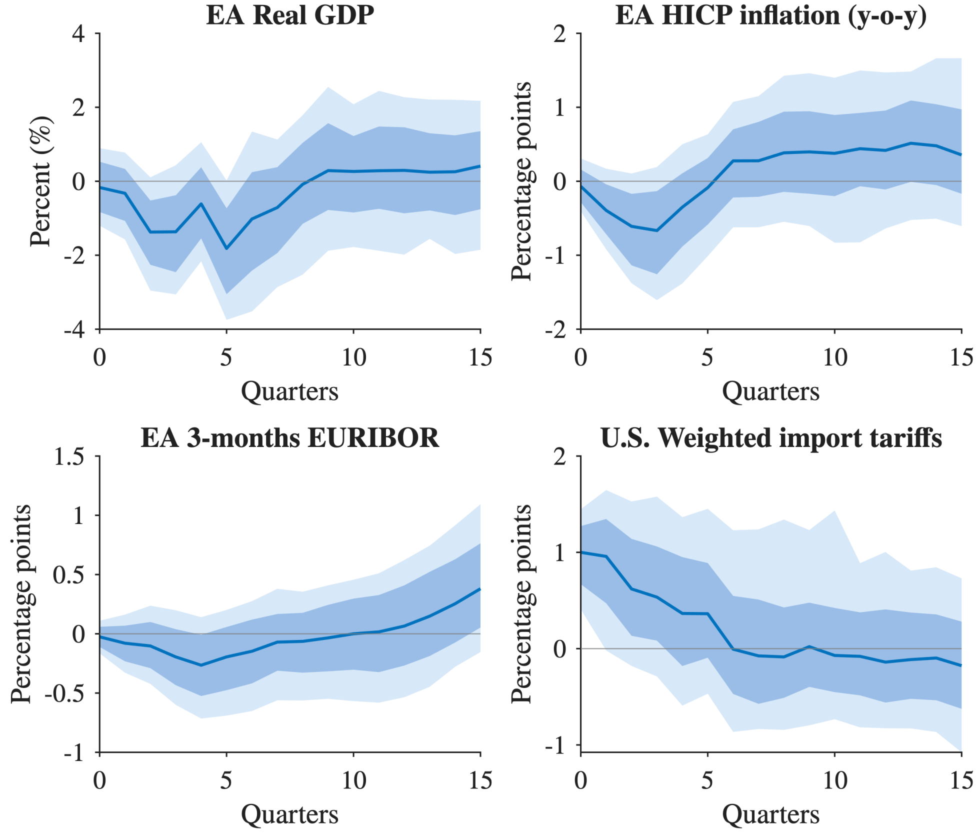
A potential concern is that the narrative U.S. tariff dates capture contemporaneous Euro area retaliation. We rule this out by inspecting Euro area trade-policy sources, namely European Commission and DG Trade releases, EUR-Lex, WTO records and the major newspapers. We find no evidence that any baseline U.S. tariff event satisfying C1-C3 coincides with an EU retaliatory measure.[12] Hence, in the baseline specification, the narrative-identified U.S. tariff shocks can be treated as plausibly external to the Euro area economy.

Results from the international BVAR Figure 6 reports the impulse responses of the Euro area real GDP, HICP inflation, and the 3-month EURIBOR rate to a 1 percentage point U.S. weighted-import tariff shock. The shock generates (i) a contraction in Euro area real GDP, concentrated in the first year after the shock,

[11]All U.S. variables keep the notation used in the benchmark specification; Euro area variables are denoted with an EA superscript; i_t^{EA} is the 3-month EURIBOR rate.

[12]We also audit EU tariff actions around the *extended* set of U.S. tariff dates. In response to the 2019Q4 U.S. Airbus tariff shock, the EU imposed WTO-authorized countermeasures on U.S. aircraft and selected agricultural and industrial products, with rates of 15 and 25 percent, respectively. These measures were goods-specific and only lasted from 2020Q4 to 2021Q1 (European Commission, 2020, 2021). In 2025Q2, the EU prepared, but did not enact, countermeasures in response to "Liberation Day" (European Commission, 2025).

Figure 6: *Shorter sample.* Estimated impulse responses of EA Real GDP, EA HICP, and EA 3-month EURIBOR to a 1 p.p. shock to the U.S. weighted-import tariff



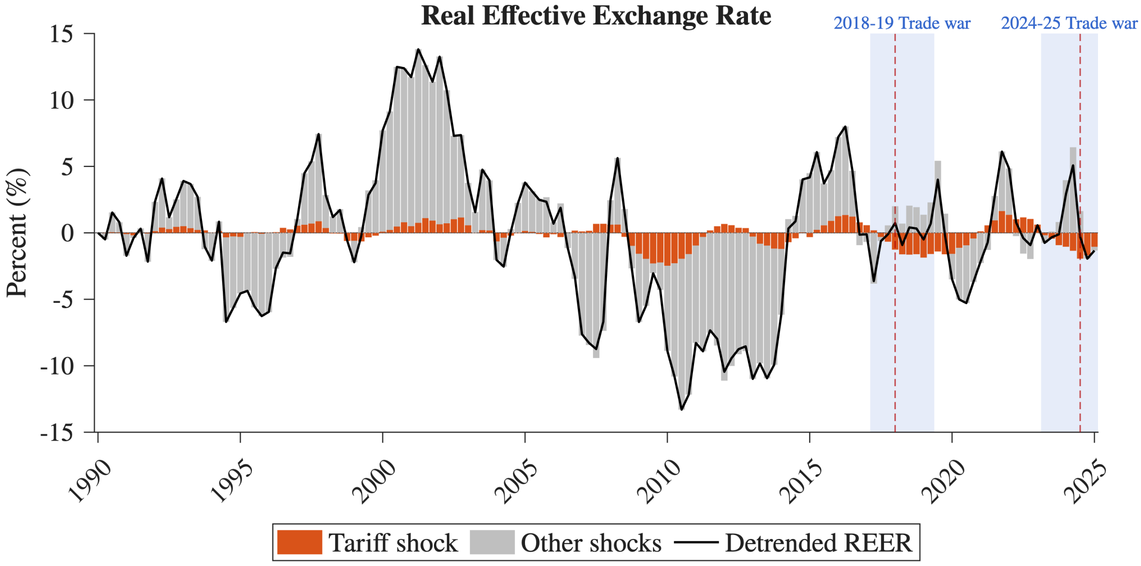
Notes: Impulse responses of Euro area variables (real GDP, HICP inflation, EA 3-month EURIBOR) to a 1 p.p. U.S. weighted-import tariff (WIT1) shock. Responses are obtained in the BVAR specified in Section 2.5, estimated on U.S. quarterly data from 2002Q1 to 2025Q2. For further details, see the note to Figure 3.

(ii) a short-run decline in HICP inflation followed by a medium-run mild increase, and (iii) an initially accommodative EURIBOR response that reverses as inflationary pressures materialize. The evidence therefore suggests that U.S. tariff shocks transmit to the Euro area as adverse external-demand shocks, lowering activity and inflation at short horizons.

2.6 How relevant are tariff shocks for the business cycle?

To assess the quantitative relevance of tariff shocks in driving REER dynamics, we compute a historical decomposition from the narrative BVAR. The raw series can be written as a linear combination of the underlying structural shocks, allowing us to isolate the contribution of tariffs from the rest. Figure 7 presents this decomposition, separating the weighted import tariff (WIT1) from the remaining shocks that jointly determine the REER. The contribution of the tariff component (in orange) grows markedly in the later part of the sample, reflecting two major tariff episodes in

Figure 7: Historical decomposition of the REER



Notes: The black solid line is the detrended U.S. real effective exchange rate (REER) and the orange bars show the historical contribution of tariff shocks. Vertical dotted red lines mark the baseline narrative dates. Shaded areas highlight the two-year periods of the trade wars, 2018-2019 and 2024-2025. The sample covers U.S. quarterly data from 1990Q1 to 2025Q4. A fall in the exchange rate is a depreciation.

the last decade (both shaded): the 2018-2020 trade war under the first Trump administration and the 2025 escalation under Trump II. Notably, the REER overall appreciates during the first episode while it depreciates during the second. Yet in *both* periods the estimated tariff contribution points toward a real *depreciation*. This implies that during the 2018-2020 trade war, shocks other than tariffs must have driven the overall real appreciation of the U.S. dollar.[13] Quantitatively, the tariff component accounts for no more than 4 percent of the REER decomposition before 2015, but rises to as much as 11 percent after 2016.[14]

What is the contribution of tariff shocks to the business cycle evolution of key macroeconomic variables? Table 2 reports the forecast-error variance decomposition (FEVD) - at quarter 1, 5, 10, and 15 - of the REER, real GDP, CPI inflation and trade-balance ratio. Overall, tariff shocks estimated by our methodology explain a non-trivial share of the FEVD of all variables, ranging from 3.5 to 15.8 percent for the REER, from 4.1 to 14.6 percent for real GDP, from 3.8 to 20.5 percent for CPI

[13]We conduct robustness checks on the choice of tariff measure. Findings hold under WIT2, but weaken considerably under the TRI, whose contribution is largely attenuated and changes sign in both episodes. This divergence follows from how the TRI is built: it tracks cross-sectional *dispersion* in tariffs, not their level. Because the 2018-2020 and 2025 packages raised tariffs broadly, they compressed dispersion even as the level rose sharply, so the TRI fails to register the same level shock that WIT1 and WIT2 capture.

[14]For each quarter t, we consider the contributions of tariffs in the historical decomposition in Figure 7. We compute the share of the squared tariff contribution in the total sum of squares, $\sum_{t\in W} C^2_{\tau,t} / \sum_j \sum_{t\in W} C^2_{j,t}$, over non-overlapping four-year windows W.

inflation and from 3.5 to 13.4 for the trade-balance ratio.

Table 2: FEVD: Share Explained by the Tariff Shock

	Forecast horizon (quarters)			
	1	5	10	15
REER	3.5	6.3	11.3	15.8
	[0.4, 13.7]	[2.2, 14.5]	[4.7, 22.9]	[7.3, 27.7]
Real GDP	4.1	5.8	13.0	14.6
	[0.4, 15.6]	[2.0, 14.8]	[4.0, 30.0]	[6.3, 27.5]
CPI Inflation	3.8	7.2	16.9	20.5
	[0.3, 15.9]	[2.6, 16.6]	[6.7, 30.1]	[10.2, 33.0]
Trade Balance / GDP	3.5	11.2	12.5	13.4
	[0.3, 15.6]	[4.0, 27.5]	[5.3, 24.3]	[6.3, 24.6]

Notes: Entries report the posterior median share of the forecast error variance (in percent) accounted for by the tariff shock. 68% credible intervals in brackets. The sample covers U.S. quarterly data from 1990Q1 to 2025Q4.

3 Which Trade-Policy Uncertainty?

In this section we show that our previous results depend on the underlying degree of trade policy *uncertainty*. Conceptually, the transmission of a tariff shock to the economy should depend on what agents infer about the trade policy behind it. Two beliefs are central. The first concerns the tariff *level* in force today: how credibly the announced rate will be enforced and how fully it will be collected at the border. We label this as *transitory* trade-policy uncertainty. The second type of uncertainty concerns the *persistence* of the trade-policy regime in place: whether it will be quickly reversed or consolidated into a lasting policy framework. Existing trade-policy uncertainty indexes - such as Caldara et al. (2020) and Baker et al. (2016) - tend to conflate the two types of uncertainty. Below we develop a taxonomy of trade-policy uncertainty and show how each type of uncertainty shapes the transmission of tariff shocks through different channels.

3.1 Transitory TPU

The first source of uncertainty concerns the current tariff rate level. We refer to this as *transitory* TPU because - in contrast to uncertainty about trade-policy persistence - it vanishes when tariffs are paid. We present two illustrative cases of transitory TPU about the level of tariff duties.

Tariff noise The first example of transitory TPU occurs before a policy is implemented, when agents observe announcements, threats, or proposals, but these signals need not coincide with the tariff rate eventually enacted. For example, a presidential threat of a 100 percent tariff may contain information about the direction of policy, but it is an imprecise signal of the rate that will ultimately become legally binding. This type of uncertainty is announcement *noise* and it is typically resolved at implementation, when the statutory tariff schedule becomes known.

Statutory vs actual tariffs The second example of transitory TPU occurs when a tariff is formally enacted, and the statutory rate may differ from the actual rate effectively collected at the border. Gopinath and Neiman (2026) document this *statutory-actual* tariff gap and report that, by September 2025, the trade-weighted statutory rate stood at 27.4 percent, while the actual collected rate was only 14.1 percent. This wedge reflects shipping lags, exemptions, USMCA compliance, and enforcement gaps.[15] Unlike announcement noise, this component of transitory TPU is not resolved immediately at implementation. It is gradually revealed over time as customs receipts accumulate.

3.2 Structural TPU

The second type of tariff policy uncertainty concerns the *persistence* of tariff measures. Whether a tariff is temporary or durable depends on the country's trade-policy regime. By trade-policy regime, we mean the policy rule or regime that governs the introduction, maintenance, and reversal of tariff measures. The regime pins down tariff persistence: a tariff is persistent when it reflects a durable reorientation of trade-policy, and temporary when it serves a transitory policy objective, such as bargaining leverage in trade negotiations or geoeconomic objectives. Uncertainty about the trade-policy regime therefore translates directly into uncertainty about tariff persistence. When the trade-policy regime is stable, tariff actions are tied to clear policy objectives, making their persistence easier to infer. In a more discretionary environment, the same tariff action is harder to interpret because both its policy objective and expected duration are less clear. We refer to uncertainty about the underlying trade-policy regime as *structural* trade-policy uncertainty, or *S-TPU*.

A clean illustration of an increase in S-TPU is the U.S. withdrawal from the Trans-Pacific Partnership (TPP) in January 2017. The episode did *not* change

[15] USMCA refers to the United States-Mexico-Canada Agreement, which replaced NAFTA on 1 July 2020.

applied tariff rates on impact. Hence, it did not create transitory trade-policy uncertainty about the tariff level. Instead, the TPP withdrawal raised uncertainty about the future orientation of U.S. trade policy. By weakening rules-based multilateral commitments, it made future tariff actions harder to link to clear policy objectives, casting doubt on tariff persistence.

We conjecture that S-TPU is central to the transmission of tariff shocks. In the theoretical model presented later, uncertainty about tariff persistence fundamentally changes the propagation of tariff shocks. For this reason, the remainder of the paper focuses on this second form of trade-policy uncertainty. The next section proposes a methodology to measure S-TPU in the data.

3.2.1 Constructing an S-TPU Index

We propose a measure of *structural* trade-policy uncertainty (S-TPU). The measure builds on the single-factor aggregate tariff stochastic-volatility framework of Caldara et al. (2020), but separates uncertainty about the *persistent* trade-policy regime from volatility in *transitory* tariff disturbances. Differently from Caldara et al. (2020), who use one latent volatility process for tariff innovations, we allow observed tariffs to reflect both a persistent and a transitory component, each with separate stochastic volatility. Empirically, S-TPU is defined as the conditional variance of the innovations to the persistent component. As such, S-TPU captures uncertainty about changes in the underlying trade-policy regime rather than transitory tariff fluctuations.

State-space representation of tariffs We model the effective tariff rate, denoted by τ_t, in state-space form. The tariff rate is observed, while its persistent and transitory components, together with their innovation volatilities, are latent states. The measurement equation reads:

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

where $\tau_{S,t}$ denotes the persistent tariff regime and $\tau_{T,t}$ denotes a transitory tariff noise component. The persistent component evolves as:

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

while the transitory component follows:

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

Innovations $\varepsilon_{S,t}$ shift the underlying trade-policy regime and therefore affect expected future tariffs. Innovations $\varepsilon_{T,t}$ instead capture tariff movements assigned to the transitory component. The two components have separate stochastic-volatility processes:

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

All innovations are mutually independent. The state $\sigma_{S,t}$ governs the conditional variance of shocks to the persistent trade-policy regime, while $\sigma_{T,t}$ governs the conditional variance of transitory tariff shocks. Empirically, we estimate the latent objects by filtering the observed tariff path. Conditional on the calibrated parameters, the S-TPU index is the filtered estimate of the conditional variance of innovations to the persistent trade-policy component:

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

Model calibration and filtering We calibrate the state-space stochastic-volatility model to distinguish between a slow-moving, stable trade-policy stance and short-lived, more volatile tariff noise. Conditional on the calibrated parameter vector, we apply the particle filter of Born and Pfeifer (2014) to the standardized U.S. effective tariff rate.[16] The filter delivers estimates of the latent persistent trade-policy stance, $\tau_{S,t}$, and of the log-volatilities of structural and transitory tariff innovations, $\sigma_{S,t}$ and $\sigma_{T,t}$. We report full details on the calibration and filtering procedures in Online Appendix A.4.

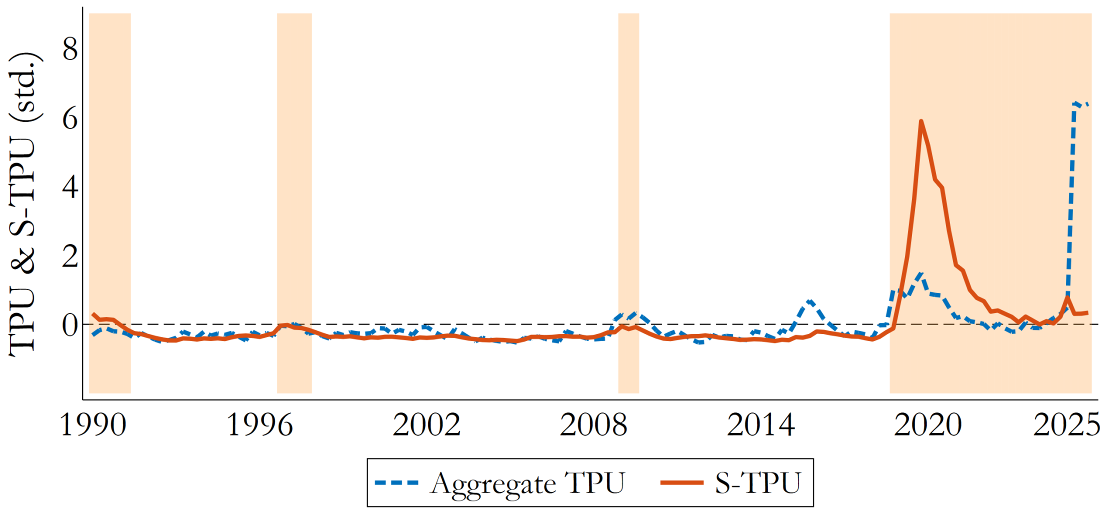
Structural versus aggregate TPU Figure 8 compares our narrower S-TPU index, estimated from the stochastic-volatility state-space model, with the broader trade-policy uncertainty index (TPU) of Caldara et al. (2020), which is estimated from a single-factor stochastic-volatility model in which one latent volatility process governs the conditional variance of *all* tariff innovations.[17] Before 2017 high-S-TPU episodes are short-lived, and both series remain relatively subdued. A major break occurs in the 2017-2020 trade-war period. As major trade-policy events raised un-

[16]Conditional on the calibrated parameter vector θ, the particle filter integrates over the latent tariff components and volatility states. It evaluates the marginal likelihood of the observed tariff path, $p(\tau_{1:T} \mid \theta) = \prod_{t=1}^{T} p(\tau_t \mid \tau_{1:t-1}, \theta)$, where each term is the one-step-ahead predictive density of the observed tariff rate.

[17]Besides the tariff-volatility-based TPU index, Caldara et al. (2020) also compute a newspaper-based TPU index, which measures the salience of trade-policy uncertainty in major outlets by counting articles containing at least one trade-policy term near at least one uncertainty term. Comparing S-TPU with that index leaves the conclusions of this section unchanged.

certainty about the durability of the existing U.S. trade-policy regime, S-TPU rises sharply, reaching about six standard deviations above its historical mean. The U.S. withdrawal from the Trans-Pacific Partnership (TPP) and the renegotiation of the North American Free Trade Agreement (NAFTA) into the United States-Mexico-Canada Agreement (USMCA) called into question the previous rules-based liberalization framework and signaled a shift toward more discretionary bilateral bargaining. The aggregate TPU index also rises during this period, but much less persistently and by a smaller magnitude, with a peak of roughly two standard deviations.

Figure 8: Aggregate TPU versus S-TPU index



Notes: Aggregate TPU of Caldara et al. (2020) (dotted) and estimated S-TPU index (solid). Shaded areas highlight observations in the top 30% of S-TPU. The sample covers data from 1990Q1 to 2025Q4 and all series are standardized.

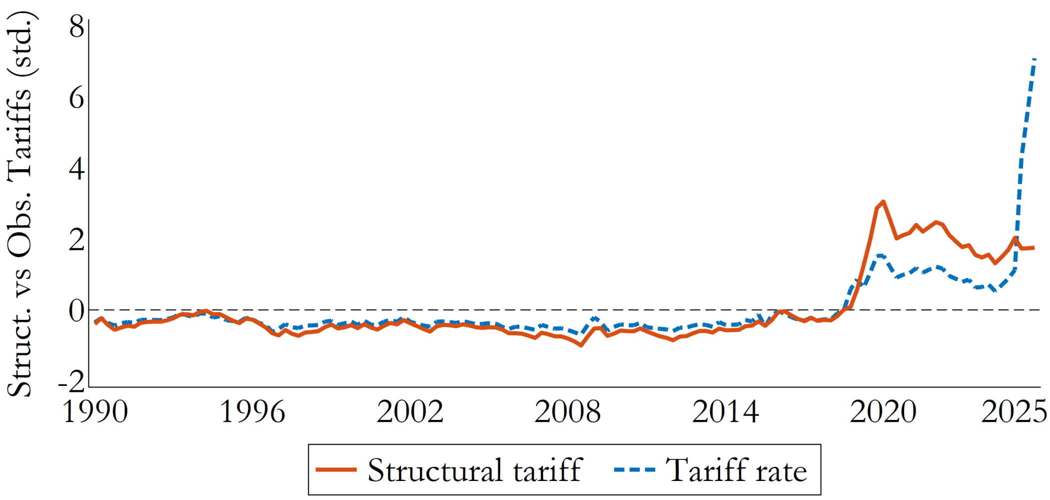
The contrast is reversed around the 2025 "Liberation Day" tariffs. Aggregate TPU spikes to an unprecedented level, about six standard deviations above its historical mean, whereas S-TPU responds only modestly. In the model, this divergence indicates that the 2025 episode was dominated by transitory uncertainty about announcements, implementation, and near-term tariff levels, rather than by structural uncertainty about the persistent trade-policy regime that determines the expected future path of tariffs.

The shaded areas in Figure 8 mark quarters in the top 30 percent of the S-TPU distribution. These episodes cluster around moments when the future conduct of U.S. trade policy was plausibly being redefined. Importantly, they are not confined to the tariff-war episodes. The early-1990s block coincides with the transition toward a new multilateral order, marked by NAFTA entering into force in 1994 and by the 1993 conclusion of the Uruguay Round, which laid the basis for the creation of the WTO. The late-1990s block captures uncertainty about whether the United States would continue to lead the trade-liberalization agenda. A central episode was the failure to renew the fast-track trade negotiating authority in 1997-1998, which weakened the President's ability to conclude new trade agreements and raised doubts about the future path of U.S. tariffs and trade policy. The short 2009 block is different again. Against the backdrop of the global financial crisis, the block captures heightened uncertainty about existing or pending liberalization commitments, including the Korea-U.S. Free Trade Agreement (KORUS).

Structural versus observed tariff rate Figure 9 plots the observed tariff rate, τ_t (WIT1), together with the filtered structural tariff, $\tau_{S,t}$, recovered from the stochastic-volatility model. Until the mid-2010s, the two series move closely together. This comovement breaks down during the 2018-2020 trade-war episode. The structural component rises sharply in this period, as the United States revived Section 201, Section 232, and Section 301 authorities to impose new tariffs and renegotiated trade agreements. The tariff increases of that period are therefore filtered as a persistent shift in the level of U.S. trade policy, rather than as transitory tariff movements.

The two series diverge again toward the end of the sample. The observed tariff rate remains elevated after 2020 and rises sharply with the 2025 "Liberation Day" package, whereas the structural tariff responds much less. The filter therefore maps only a limited part of the recent tariff surge to a further shift in the persistent trade-policy component.

Figure 9: Structural vs observed tariff rate



Notes: Quarterly evolution of the underlying structural tariff $\tau_{S,t}$ estimated in the data vs. WIT1 tariff rate τ_t from 1990Q1 to 2025Q4. All series are standardized.

3.3 State-Dependent Transmission of Tariff Shocks

We now use the S-TPU index to test the hypothesis that *Structural* TPU, and not the aggregate TPU index, governs the transmission of tariff shocks to the exchange rate and to other key macroeconomic variables. We run a set of local projections of the exchange rate - and other macroeconomic variables - in response to an identified tariff shock, for different states of the S-TPU index. S-TPU is therefore treated as an exogenous state of the economy that conditions the response to identified tariff shocks.[18]

S-TPU state-dependent local projections We consider the response of the exchange rate to a tariff shock for different states of the *Structural* TPU index. We follow the approach in Ramey and Zubairy (2018) and estimate state-dependent local projections (Jordà, 2005) of the exchange rate and other macroeconomic variables on narrative-identified tariff shocks extracted from the BVAR model.[19] Let H_t be an indicator variable that flags periods in which the estimated S-TPU index is in the high state. In the baseline specification, we consider the *top* 30% of the distribution:[20]

$$H_t = \mathbf{1}\{STPU_t > p_{70}\}$$

We interact H_t with the series of exogenous weighted import tariff shocks $\{\varepsilon_t^\tau\}$ identified in the BVAR. As endogenous variables, we consider the nominal effective exchange rate (NEER), the real effective exchange rate (REER), the Federal funds rate, the trade-balance-to-GDP ratio, CPI inflation, and real GDP. The sample spans from 1990Q1 to 2025Q2. For each horizon $h = 0, \ldots, 6$, and for each response

[18] State-dependent local projections identify the response to a large shock if the shock is exogenous and independent of the state (Gonçalves et al., 2024). Our narrative-identified tariff shocks are arguably exogenous to the state of Structural TPU. Results are also robust to lagging the uncertainty state by one quarter, replacing H_t with H_{t-1} in (5), which guards against contemporaneous feedback from the tariff shock to the measured state.

[19] The series of exogenous import tariff shocks is extracted from the Bayesian VAR estimated at quarterly frequency over 1990Q1-2025Q2 as specified in Section 2.1. Identification with narrative dominance is achieved by adopting the *extended* set of dates discussed in the Online Appendix A.2. The shocks are normalized to generate a one-percentage-point impact response of the weighted-import tariff rate. Results are robust to tariff shock series using baseline narrative dates and to excluding the constant from the VAR. For more information on the local projections, see Online Appendix A.5.

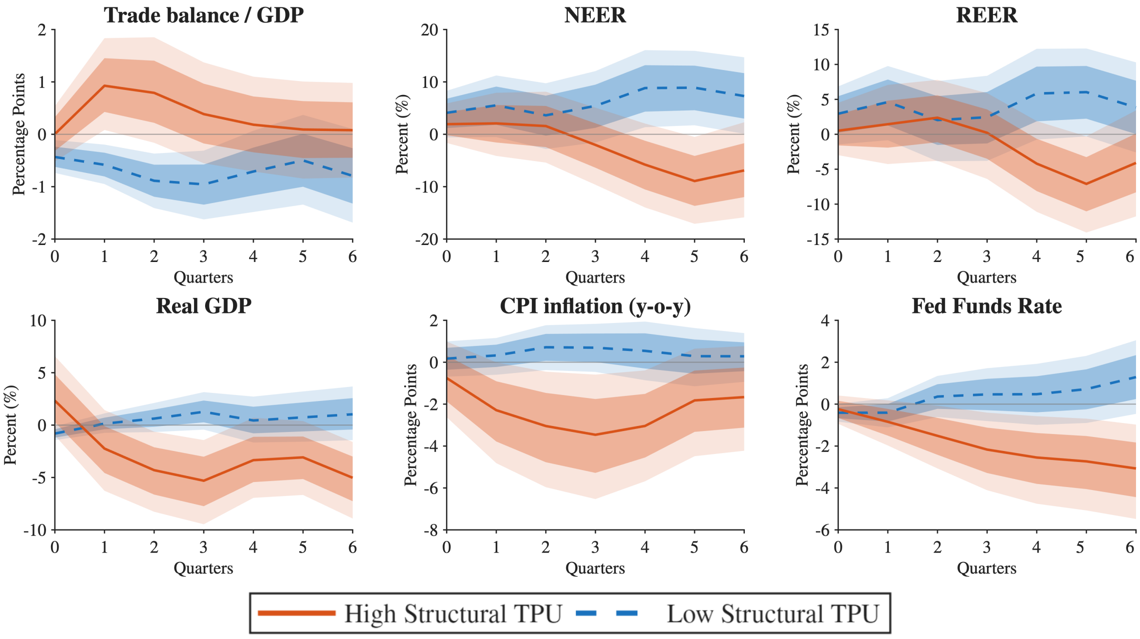
[20] In Online Appendix A.5.1, we replicate a set of state-dependent local projections with the "high S-TPU uncertainty state" identified as the top 40%, 20%, or top 10% of the S-TPU distribution. The results are qualitatively unchanged.

variable y_t, we estimate

$$y_{t+h} = \alpha_h + \beta_h \varepsilon_t^\tau + \beta_h^H H_t \varepsilon_t^\tau + \delta_h H_t + \sum_{j=1}^{4} \gamma_{j,h} y_{t-j} + u_{t+h} \tag{5}$$

The term $\delta_h H_t$ is an *uncertainty-state control*. Additionally, β_h represents the response in the low-uncertainty regime ($H_t = 0$) and $\beta_h + \beta_h^H$ the response in the high-uncertainty regime ($H_t = 1$).

Figure 10: Impulse responses of the exchange rate and other macroeconomic variables to an identified tariff shock across S-TPU states. A fall in the exchange rate is a depreciation



Notes: Impulse responses to an identified tariff shock under high (top 30% of the S-TPU distribution, solid orange) and low S-TPU state (bottom 70%, dashed blue). Shocks are normalized so that the median-shock local projection generates a 1 p.p. increase on impact in the trade-weighted tariff measure. The reported bands are 68% and 90% bands of the recentered pooled distribution of estimates, reflecting both uncertainty about the identified tariff shock series and sampling uncertainty. The sample covers U.S. quarterly data from 1990Q1 to 2025Q2. See Online Appendix A.5 for details.

Results Figure 10 shows that the main variables of interest exhibit sharply different dynamics across low- and high-S-TPU regimes. In states of *low* S-TPU, namely in a transparent and predictable trade-policy environment, tariffs deliver their standard textbook implications: a nominal and real exchange-rate appreciation, a mild increase in CPI inflation and a tightening of monetary policy. Furthermore, under low S-TPU, real GDP increases mildly. By contrast, in states of *elevated* S-TPU, the same tariff shock generates both a nominal and real depreciation, a contraction in both GDP and inflation, and a more accommodative monetary policy response. Notice also that the response of the trade-balance ratio differs across regimes: the trade balance deteriorates in low S-TPU states whereas it improves under high S-TPU.

Notably, the asymmetry across S-TPU states is specific to S-TPU: conditioning on the aggregate TPU index, which mixes structural and transitory components, eliminates it.[21,22] This result is consistent with the view that S-TPU captures the dimension of trade-policy uncertainty that is relevant for firms' decisions, whereas the aggregate TPU index is contaminated by volatility from transitory or inconsequential tariff announcements.

In the next section, we rationalize the S-TPU-based state-dependent pattern through a model with CARA utility and uncertainty about tariff persistence.

4 A Model of the Exchange Rate under Trade-Policy Uncertainty

We develop a dynamic equilibrium model of the exchange rate in which the *persistence* of the trade-policy regime is uncertain. An increase in the tariff *level* therefore shifts both the expected path and the *conditional variance* of future tariffs. The equilibrium effects of tariffs scale with the uncertainty about their persistence. In this context the exchange-rate response is state-dependent: tariffs appreciate the currency when tariff policy uncertainty is low, but may depreciate it when persistence uncertainty is sufficiently high.

Households Time is discrete and indexed by $t = 0, 1, \ldots$ The representative household has constant absolute risk aversion (CARA) utility over a composite consumption good:

$$U_0 = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Big(- \tfrac{1}{\gamma} \exp\{-\gamma C_t\} \Big), \qquad \gamma > 0 \tag{6}$$

[21]For brevity, we only report the set of results based on the S-TPU index. All results based on the aggregate TPU index are available upon request.

[22]Note that, since $STPU_t$ is itself estimated, H_t misclassifies quarters near the threshold, which attenuates β_h^H. Therefore, the estimated differential between states β_h^H is a lower bound on the true one, biasing the exercise against state dependence.

where γ is the coefficient of absolute risk aversion and, under CARA, of absolute prudence.[23] Aggregate consumption is a CES bundle of a home good and an imported good with import share ν, reflecting home bias in consumption, and trade elasticity $\eta > 0$,

$$C_t = \left[(1-\nu)^{1/\eta} C_{H,t}^{\frac{\eta-1}{\eta}} + \nu^{1/\eta} C_{F,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{7}$$

The model is expressed in real terms throughout, with the Home good as the *numeraire.* The Foreign economy (the rest of the world) is approximately closed, so its consumption basket effectively coincides with the Foreign good, and the Foreign price index reduces to the price of that single good. The price of the Foreign good in units of the numeraire is therefore the terms of trade, S_t. Imports are subject to an *ad valorem* tariff τ_t, so domestic consumers face a price of $(1+\tau_t)S_t$; tariff revenue is rebated lump sum. Let $\mathcal{G}_t(S_t, \tau_t)$ denote the price of the domestic consumption basket, equivalently the CPI-to-PPI ratio. The real exchange rate is the price of the Foreign consumption basket relative to the domestic one,

$$\mathcal{E}_t^r \equiv \frac{S_t}{\mathcal{G}_t}$$

Unless otherwise noted, lowercase letters represent log deviations from the symmetric zero-tariff steady state, at which $\bar{S} = \bar{\mathcal{G}} = \bar{\mathcal{E}}^r = 1$. Define the real exchange rate as $e_t^r \equiv s_t - g_t$, where an increase in s_t represents a deterioration in the terms of trade, while an *increase* in e_t^r represents a real *depreciation.*

Because domestic consumers pay the tariff-inclusive import price $(1+\tau_t)S_t$, to first order, the consumption price index satisfies:[24]

$$g_t = \nu(s_t + \tau_t), \qquad e_t^r = (1-\nu)s_t - \nu\tau_t \tag{8}$$

Demand Expenditure minimization subject to (7) yields the standard demand system:

$$C_{H,t} = (1-\nu)\,\mathcal{G}_t^{\eta}\,C_t, \qquad C_{F,t} = \nu\left(\frac{(1+\tau_t)S_t}{\mathcal{G}_t}\right)^{-\eta} C_t$$

[23] As is standard in CARA–Gaussian settings, consumption is unbounded below and negative realizations occur with positive probability; period utility (6) is well defined on the whole real line.

[24] Since $\mathcal{G}_t$ is the unit cost of the consumption bundle and domestic consumers face $(1+\tau_t)S_t$ on imports, Shephard's lemma implies that its elasticity with respect to the import price equals the import expenditure share ν.

Log-linearizing around the symmetric zero-tariff steady state and substituting the relative domestic price index from (8) obtains:

$$c_{H,t} = c_t + \eta\nu\,(s_t + \tau_t) \tag{9}$$

$$c_{F,t} = c_t - \eta(1-\nu)\,(s_t + \tau_t) \tag{10}$$

A rise in the tariff τ_t, for given terms of trade and aggregate consumption, lowers the demand for imports and raises the demand for domestic goods, with an elasticity increasing in η. This is the standard expenditure-switching channel in partial equilibrium. In general equilibrium, however, both c_t and s_t respond endogenously.

Tariff process We assume that the tariff is the sum of a persistent structural component $\tau_{S,t}$ and an *i.i.d.* transitory component $\varepsilon_{T,t}$:

$$\tau_t = \tau_{S,t} + \varepsilon_{T,t}, \qquad \varepsilon_{T,t} \overset{IID}{\sim} \mathcal{N}(0, \sigma_T^2) \tag{11}$$

The structural component follows an autoregressive process whose persistence is itself random and unknown one period ahead:

$$\tau_{S,t+1} = \rho_{t+1}\tau_{S,t} + \xi_{t+1}, \qquad \xi_{t+1} \overset{IID}{\sim} \mathcal{N}(0, \sigma_\xi^2) \tag{12}$$

where, conditional on date-t information,

$$\rho_{t+1} \overset{IID}{\sim} \mathcal{N}(\bar{\rho}, \sigma_S^2), \qquad \bar{\rho} \in (0,1) \tag{13}$$

For every t, the random variables ρ_{t+1}, ξ_{t+1}, and $\varepsilon_{T,t+1}$ are mutually independent and independent of date-t information.[25]

Structural trade-policy uncertainty From (13), we define *Structural Trade-Policy Uncertainty* (S-TPU) as the variance of tariff persistence:

$$\sigma_S^2 \;\equiv\; \mathrm{Var}_t(\rho_{t+1}) > 0 \tag{14}$$

[25]Notice that the empirical specification of Section 3.2.1 is the exact conditional reduced form of the tariff process (11)-(13). Assuming $\sigma_\xi^2 = 0$ and defining $u_{t+1} \equiv (\rho_{t+1} - \bar{\rho})\,\tau_{S,t}$, equation (12) reads $\tau_{S,t+1} = \bar{\rho}\,\tau_{S,t} + u_{t+1}$, where, conditional on date-t information, u_{t+1} is Gaussian with mean zero and variance $\tau_{S,t}^2\sigma_S^2$, i.e., an autoregression with fixed persistence and a heteroskedastic additive innovation, which is the specification estimated empirically. The index $STPU_t = \exp(2\sigma_{S,t})$ therefore measures $\mathrm{Var}_t(\tau_{S,t+1})$, the sufficient statistic for all conditional second moments in the theoretical model. The two specifications thus differ only in parameterization: the empirical model is the unrestricted version of the theoretical one, which additionally restricts the innovation variance to load on the squared tariff level $\tau_{S,t}^2$.

That is, uncertainty about the persistence of the current (observed) tariff stance. Note that the variance of tariff *persistence* σ_S^2 is an exogenous state of the economy that households know at the time of choosing the date-t allocations.[26]

Throughout we set $\sigma_\xi^2 = \sigma_T^2 = 0$, so that $\tau_t = \tau_{S,t}$ and the randomness of the persistence ρ_{t+1} is the *only* source of uncertainty in the model.[27]

Budget constraint Households trade two one-period real bonds. A home bond D_t pays a gross real return R_t in units of the consumption good. A foreign bond pays a gross real return R_t^* in units of the foreign good, whose value in units of the Home consumption aggregate is $\mathcal{B}_t \equiv \mathcal{E}_t^r B_t^*$. Home bonds are in zero net supply in equilibrium, so $\mathcal{B}_t$ is the country's net foreign asset position. The real budget constraint, in units of Home consumption, reads

$$C_t + D_t + \mathcal{B}_t + \Psi(\mathcal{B}_t) \leq \Omega_t + R_{t-1}\, D_{t-1} + R_{t-1}^* \, \frac{\mathcal{E}_t^r}{\mathcal{E}_{t-1}^r}\, \mathcal{B}_{t-1} \tag{15}$$

where Ω_t is real non-financial income (the endowment Y valued at the Home-good relative price plus the lump-sum rebate of tariff revenue) and $\Psi(\mathcal{B}_t)$ is the portfolio adjustment cost. In the symmetric steady state $\beta\bar{R} = 1$ and $\bar{R} = \bar{R}^*$, where $\bar{R}$ is the common steady-state gross real return; $r_t \equiv \log(R_t/\bar{R})$ is the deviation of the home real rate. Households face a strictly convex portfolio adjustment cost on foreign bond holdings, with the quadratic specification

$$\Psi(\mathcal{B}_t) = \frac{\psi}{2}\,\frac{(\mathcal{B}_t - \bar{\mathcal{B}})^2}{\bar{Y}}, \qquad \Psi(\bar{\mathcal{B}}) = \Psi'(\bar{\mathcal{B}}) = 0, \qquad \Psi''(\bar{\mathcal{B}}) = \frac{\psi}{\bar{Y}} > 0$$

We define the NFA position scaled by steady-state output as

$$b_t \equiv (\mathcal{B}_t - \bar{\mathcal{B}})/\bar{Y}$$

The marginal cost is exactly $\Psi'(\mathcal{B}_t) = \psi\, b_t$ in the scaled position b_t. We impose the zero-NFA steady state $\bar{\mathcal{B}} = 0$. The parameter $\psi > 0$ is a portfolio friction that induces stationarity in small open economy models with incomplete markets (Schmitt-Grohé and Uribe, 2003), and we set it small enough to leave the model's short-run dynamics essentially unaffected.

[26]The second moment of the tariff process reads: $\mathbb{E}_t\left[\tau_{S,t+j}^2\right] = \left(\bar{\rho}^2 + \sigma_S^2\right)^j \tau_{S,t}^2$. We therefore impose the parametric restriction $\bar{\rho}^2 + \sigma_S^2 < 1$ to ensure stability of the second moment.

[27]The general case $\sigma_\xi^2, \sigma_T^2 > 0$ adds constants to the wedges below and leaves every state-dependent term unchanged. Setting these variances to zero therefore isolates persistence uncertainty for expositional clarity.

Optimality conditions Let λ_t denote the Lagrange multiplier on the household budget constraint. Under CARA preferences, the first order condition for consumption reads: $\lambda_t = \exp\{-\gamma C_t\}$. Optimality with respect to the two bonds yields the corresponding real Euler equations, both of which hold exactly. For the home bond,

$$\exp\{-\gamma C_t\} = \beta R_t \, \mathbb{E}_t[\exp\{-\gamma C_{t+1}\}] \tag{16}$$

and for the foreign bond,

$$\underbrace{\exp\{-\gamma C_t\}\big(1 + \Psi'(\mathcal{B}_t)\big)}_{\substack{\text{marginal cost of} \\ \text{foreign bond}}} = \underbrace{\beta R_t^* \, \mathbb{E}_t\left[\exp\{-\gamma C_{t+1}\} \, \frac{\mathcal{E}_{t+1}^r}{\mathcal{E}_t^r}\right]}_{\substack{\text{marginal benefit of} \\ \text{foreign bond}}} \tag{17}$$

In the foreign Euler equation (17), the foreign real return is held fixed at $R_t^* = \bar{R}$, so that $r_t^* = 0$ throughout. The marginal cost of an extra unit of the foreign bond depends on the marginal portfolio adjustment cost $\Psi'(\mathcal{B}_t) = \psi b_t$. The marginal benefit is the expected discounted payoff, converted back into Home consumption units through the gross real exchange-rate change, $\frac{\mathcal{E}_{t+1}^r}{\mathcal{E}_t^r}$. Conditions (16)-(17) jointly determine how much the household saves in domestic and foreign bonds, and describe the marginal benefit of saving in each asset. When the future is uncertain - due to the unknown persistence of tariff actions - this marginal benefit is indeed higher and the household demands more bonds.[28] Notably, as is clear on the right-hand side of the Euler equations, the demand for domestic assets only responds to consumption risk, while foreign assets are sensitive to both consumption *and* currency risk.

4.1 Optimality in Log-linear Form

Throughout, we keep the Euler equations (16)-(17) exact. We log-linearize the remaining system conditions around a symmetric zero-tariff steady state and, as in Kalemli-Özcan et al. (2026), we characterize the equilibrium retaining the conditional second moments and dropping all cross terms that are quantitatively negligible.[29] We conjecture policy functions linear in the tariff and solve the system by the method of undetermined coefficients, evaluating the risk terms at the resulting loadings. To compute the *linear* response, we evaluate these loadings at the certainty benchmark, in which tariff persistence is deterministic and the entire future path is

[28] The convexity of the marginal utility of consumption $\exp\{-\gamma C_{t+1}\}$ determines that a mean-preserving spread in future consumption raises expected marginal utility.

[29] The retained second moments are of order $\sigma_S^2 \, \tau_{S,t}^2$, which we treat as non-negligible because σ_S^2 is large; terms of higher order $O(\sigma_S^4)$ are discarded.

known at the time of the shock. The certainty-equivalent responses of consumption and of the real exchange rate to a tariff shock are then summarized by the loadings:

$$\theta_c \equiv \left.\frac{\partial c_t}{\partial \tau_{S,t}}\right|_{\sigma_S^2=0} \qquad \theta_e \equiv \left.\frac{\partial e_t^r}{\partial \tau_{S,t}}\right|_{\sigma_S^2=0} \tag{18}$$

Online Appendix B.2.1 solves for both in terms of primitives and establishes that $\theta_e < 0$: in a benchmark with deterministic persistence, a tariff appreciates the real exchange rate, as in the textbook case.

Tariff shocks as volatility events After a tariff realization $\tau_{S,t}$, and because in (14) we established that tariff persistence is random, households do not know what fraction of today's tariff will survive into tomorrow. The observed tariff $\tau_{S,t}$ therefore shapes *both* the conditional mean and variance of the future tariff:

$$\mathbb{E}\left\{\tau_{S,t+1}|\tau_{S,t}\right\} = \bar{\rho}\,\tau_{S,t}, \qquad \mathrm{Var}\{\tau_{S,t+1}|\tau_{S,t}\} = \sigma_S^2\,\tau_{S,t}^2 \tag{19}$$

A tariff *level* shock is therefore not only a first-moment shock but also a tariff *volatility event*: the same increase in $\tau_{S,t}$ generates a wider distribution of future tariffs when its persistence is uncertain. Tariff volatility depends on the *interaction* between large S-TPU (σ_S^2) *and* the first-moment tariff shock ($\tau_{S,t}$). Note that the conditional variance in (19) vanishes when the tariff level (or σ_S^2) is zero.
Tariff volatility is the central margin of uncertainty in the model, and it determines the key conditional second moments - the volatility of future consumption, that of the real exchange rate, and the covariance of the two:

$$\mathrm{Var}_t(c_{t+1}) = \theta_c^2 \underbrace{\sigma_S^2\,\tau_{S,t}^2}_{\mathrm{Var}_t\left(\tau_{S,t+1}\right)} \qquad \mathrm{Var}_t(e_{t+1}^r) = \theta_e^2\sigma_S^2\,\tau_{S,t}^2 \qquad \mathrm{Cov}_t(c_{t+1}, e_{t+1}^r) = \theta_c\theta_e\sigma_S^2\,\tau_{S,t}^2$$

In what follows, we show that these three margins of uncertainty enter the Euler equations (16)-(17) and therefore play a pivotal role in determining the household's consumption and saving choices under uncertainty.

Precautionary wedge Under CARA with conditionally Gaussian consumption, the term inside the expectation in (16) is log-normal.[30] Taking logs of (16), normal-

[30]For Gaussian x_{t+1}, $\log \mathbb{E}_t \exp\{x_{t+1}\} = \mathbb{E}_t x_{t+1} + \frac{1}{2}\mathrm{Var}_t(x_{t+1})$.

izing $\bar{Y} = \bar{C} = 1$, we obtain:

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\gamma}\Big(r_t + \underbrace{\zeta_{c,t}}_{\substack{\text{precautionary}\\ \text{wedge}}}\Big)$$

$$\zeta_{c,t} = \underbrace{\frac{\gamma^2}{2}\,\mathrm{Var}_t(c_{t+1})}_{\text{Jensen}} = \frac{\gamma^2\theta_c^2}{2}\,\sigma_S^2\,\tau_{S,t}^2 \tag{20}$$

where the resulting equation is *exact* (not a first-order approximation) and c_t denotes the absolute deviation of consumption from its steady state value. The term $\zeta_{c,t}$ is labelled *precautionary wedge*, and it is a Jensen term, increasing in the conditional variance of future consumption: a higher variance raises expected future marginal utility, hence the marginal value of saving. A rise in $\zeta_{c,t}$ is thus isomorphic to an increase in the real interest rate. The strength of the precautionary response is governed by γ, which under CARA captures both *risk aversion* and *prudence* - each channel raises the precautionary wedge separately.

Currency risk wedge The same steps applied to the foreign-bond Euler equation (17) - with (c_{t+1}, e^r_{t+1}) conditionally Gaussian and $\log(1+\psi b_t) \simeq \psi b_t$ for $\psi \to 0$ - deliver, after substituting (20), the modified Uncovered Interest Parity (UIP) condition:[31]

$$e^r_t = \mathbb{E}_t e^r_{t+1} - r_t + \underbrace{\chi_{e,t}}_{\substack{\text{currency-risk}\\ \text{wedge}}} \tag{21}$$

where the deviation from uncovered interest parity $\chi_{e,t}$ is the *currency-risk wedge*. A higher $\chi_{e,t}$ raises the impact depreciation required to induce households to hold foreign bonds. The exchange rate therefore depreciates on impact and is expected to appreciate subsequently. We can decompose the currency-risk wedge into a Jensen term and a hedging term:

$$\begin{aligned}\chi_{e,t} &= \underbrace{\tfrac{1}{2}\,\mathrm{Var}_t\big(e^r_{t+1}\big)}_{\text{Jensen}} - \underbrace{\gamma\,\mathrm{Cov}_t\big(c_{t+1},\, e^r_{t+1}\big)}_{\text{hedging}} \\ &= \theta_e\big(\tfrac{1}{2}\theta_e - \gamma\,\theta_c\big)\,\sigma_S^2\,\tau_{S,t}^2 \end{aligned} \tag{22}$$

The Jensen term reflects the convexity of the foreign bond's payoff in e^r_{t+1}, so that a more volatile real exchange rate raises its expected value - and hence the impact

[31] The equilibrium studied is the $\psi \to 0$ limit of the stationary economy, with $\psi > 0$ arbitrarily small guaranteeing stationarity of b_t without affecting the impact responses.

depreciation. The hedging term reflects how that payoff *covaries* with consumption. A higher covariance means that the bond pays off when marginal utility is low, so it hedges poorly and $\chi_{e,t}$ falls, lowering the impact depreciation the household requires to hold the asset. The parameter γ enters the currency risk wedge linearly, through the hedging term, so both the sign of $\chi_{e,t}$ and its comparative static in γ depend on the certainty-equivalent loadings.

Total uncertainty wedge We have so far introduced two key deviations in the household's Euler equations that reflect adjustments to tariff uncertainty - the precautionary wedge and the currency-risk wedge. Adding the two, we obtain the *total uncertainty wedge*:

$$W(\tau_{S,t};\ \sigma_S^2)\ \equiv\ \zeta_{c,t} + \chi_{e,t}\ =\ \tfrac{1}{2}\,\kappa^2\,\sigma_S^2\,\tau_{S,t}^2\ \geq\ 0; \qquad \kappa \equiv \gamma\theta_c - \theta_e \tag{23}$$

Notably, the total uncertainty wedge is a function of the tariff $\tau_{S,t}$, and scales with uncertainty over tariff persistence σ_S^2 - the only source of risk in the model - up to the coefficient κ.

Real income Real non-financial income Ω_t (inclusive of tariff rebate) in deviation from the zero-tariff steady state reads:

$$\omega_t = -\nu s_t \tag{24}$$

A terms-of-trade deterioration, a rise in s_t, lowers the value of domestic goods (relative to the consumption basket) and lowers real income.

Net foreign assets Log-linearizing the budget constraint in (15) around the zero-NFA steady state, and noting that portfolio adjustment costs are second order, yields

$$b_t = \bar{R}\,b_{t-1} + \underbrace{\omega_t - c_t}_{\equiv\, tb_t}$$

where the trade balance tb_t is defined as real non-financial income net of consumption. Using (24), the NFA position is therefore given by

$$b_t = \bar{R}\,b_{t-1} - \nu s_t - c_t \tag{25}$$

For given pre-determined external position b_{t-1}, a terms-of-trade deterioration ($s_t > 0$) lowers real income and, holding consumption fixed, worsens the trade balance and the current NFA position; a fall in consumption, $c_t < 0$, improves it.

Export demand Let y_t^* denote exogenous foreign output in deviation from steady state. Foreign demand for the Home good in log-linear form is

$$x_t = \eta\, s_t + y_t^* \tag{26}$$

A deterioration in the terms of trade increases export demand with elasticity η.

Market clearing The domestic good can be used for domestic consumption or exported. Market clearing, log-linearized around the symmetric zero-tariff steady state, requires:

$$y_t = (1-\nu)\; c_{H,t} + \nu\; x_t \tag{27}$$

Substituting the demand for Home goods (9) and the export demand (26) into (27) yields:

$$y_t = (1-\nu)c_t + \eta\,\nu(2-\nu)s_t + \eta\,\nu(1-\nu)\tau_{S,t} + \nu y_t^* \tag{28}$$

4.2 Equilibrium in the Endowment Economy

The terms of trade The Home economy receives a fixed endowment and the Foreign economy has fixed output, so we set $y_t = y_t^* = 0$ in the market-clearing condition (28). Solving for the terms of trade yields:

$$s_t = -A\left(c_t + \eta\nu\,\tau_{S,t}\right), \qquad A \equiv \frac{1-\nu}{\eta\,\nu(2-\nu)} \tag{29}$$

The terms of trade are the margin of adjustment that clears the Home-good market against a fixed supply. *Ceteris paribus*, higher consumption or a higher tariff raise demand for the Home good, so its relative price rises and the terms of trade improve.

Open-economy Euler equation Substituting (29) into (8) yields the real exchange rate in terms of consumption and the tariff:

$$e_t^r = -\Phi\, c_t - \frac{1}{2-\nu}\,\tau_{S,t}, \qquad \Phi \equiv (1-\nu)A = \frac{(1-\nu)^2}{\eta\,\nu(2-\nu)} \tag{30}$$

Notice that, for given consumption, an increase in tariff appreciates the real exchange rate. Substituting (30) into (21) yields a single consumption Euler equation for the small open economy:

$$(\gamma + \Phi)\,\mathbb{E}_t \Delta c_{t+1} = \underbrace{-\frac{1}{2-\nu}\,\mathbb{E}_t \Delta \tau_{S,t+1}}_{\text{expected tariff path}} + \underbrace{W(\tau_{S,t};\ \sigma_S^2)}_{\text{uncertainty wedge}} \tag{31}$$

Equation (31) separates the two forces driving consumption. The first term is the expected tariff path, which pins down consumption growth under *certainty equivalence*. The second is the uncertainty wedge $W(\tau_{S,t};\ \sigma_S^2) = \zeta_{c,t} + \chi_{e,t}$, which collects the two risk wedges derived above: the precautionary wedge, arising on the intertemporal saving margin, and the currency risk wedge, arising on the currency margin. Notably, the currency risk wedge has an ambiguous sign on its own, but the sum $W_t \equiv \zeta_{c,t} + \chi_{e,t} > 0$ by equation(23). Intuitively, a rise in W_t induces precautionary saving and delays consumption.

The coefficient $(\gamma + \Phi)$ is the effective inverse elasticity of intertemporal substitution in the open economy. It exceeds the parameter γ by a terms-of-trade feedback:

$$\Phi = \frac{(1-\nu)^2}{\eta\nu(2-\nu)}.$$

This terms-of-trade feedback component captures the fact that along a rising consumption path, the terms of trade improve over time, reducing the return on foreign saving in units of Home consumption and thereby dampening the incentive to shift consumption into the future. The effective intertemporal elasticity, $1/(\gamma + \Phi)$, is therefore strictly lower than its closed-economy counterpart, $1/\gamma$. The prudence parameter γ enters both sides of (31). On the one hand, a higher γ lowers the effective intertemporal response coefficient $1/(\gamma + \Phi)$, dampening the consumption response to any given uncertainty wedge. On the other hand, it strengthens precautionary savings and the coefficient κ, magnifying the wedge itself (23). For sufficiently high γ, the latter effect dominates, and higher values of γ raise the precautionary response on impact.

Present value of future consumption The economy's intertemporal budget constraint determines the present discounted value of the consumption path. Iterating (25) forward, imposing transversality and $b_{-1} = 0$, combining with (29) and (13), yields:

$$\Lambda \sum_{k \geq 0} \beta^k\, \mathbb{E}_0\, c_k = \frac{\nu(1-\nu)}{2-\nu} \sum_{k \geq 0} \beta^k\, \bar{\rho}^k \tau_{S,0}, \qquad \Lambda \equiv 1 - \nu A = \frac{\eta(2-\nu) - (1-\nu)}{\eta(2-\nu)} \tag{32}$$

Note that only the first moment of tariffs enters (32): uncertainty does not affect the present value of future consumption, it only redistributes consumption across times via a precautionary motive, with consumption lower on impact and higher going forward.[32]

4.3 The effects of tariff shocks under S-TPU

We now compute the impact responses of the real exchange rate, consumption, and the trade balance to a structural tariff shock under S-TPU. The general-equilibrium response combines the two conditions derived above: the open-economy Euler equation (31) sets the slope of the expected consumption path, whereas the intertemporal budget constraint (32) pins down its level.

Uncertainty enters the equilibrium through the *uncertainty wedge* W_t, which summarizes the effect of tariff-policy risk on the general-equilibrium allocations. Notably, the wedge tilts the slope of the expected consumption path in (31) but does *not* modify its present value: households postpone consumption rather than forgo it. In response to higher tariffs, consumption thus falls on impact and precautionary saving rises. For a given output endowment and domestic bonds in zero net supply, higher saving must be absorbed by the rest of the world, translating one-for-one into a domestic trade balance surplus via accumulated net foreign assets.
In general equilibrium, the real exchange rate movement consistent with this adjustment operates through both the goods and the asset market. In the goods market, the relative price of domestic goods falls - a real exchange rate *depreciation* - which induces foreign agents to absorb the domestic goods no longer consumed at home. In the asset market, the excess demand for saving lowers the domestic real interest rate for a given return on foreign assets: by the UIP condition (21), holding foreign bonds at a lower home rate requires an expected future *appreciation*, which can be delivered only by an *impact depreciation*.
A tariff shock therefore also operates as an uncertainty event, captured by the wedge W_t. The wedge responds to the first-moment disturbance $\tau_{S,t}$ and is scaled by S-TPU, the uncertainty about tariff *persistence* σ_S^2. The transmission of tariffs to the economy thus features a non-linear, *state-dependent*, component that varies with the size of the shock and with the prevailing level of S-TPU. The following proposition formalizes this result for the real exchange rate.

[32] A well-defined permanent-income solution requires $\Lambda > 0$, i.e. $\eta > \frac{1-\nu}{2-\nu}$.

Proposition 1 (State-dependent exchange-rate response). *Consider a positive structural tariff shock. The impact response of the real exchange rate is*

$$e_0^r = \underbrace{\theta_e\, \tau_{S,0}}_{\substack{\textit{expenditure-switching} \\ \textit{channel (appreciation)}}} + \underbrace{K(\sigma_S^2)\, \sigma_S^2\, \tau_{S,0}^2}_{\substack{\textit{state-dependent precautionary} \\ \textit{channel (depreciation)}}} \tag{33}$$

where $K(\sigma_S^2)$ depends positively on the uncertainty about persistence σ_S^2:

$$K(\sigma_S^2) = \frac{\beta\,\Phi}{(\gamma+\Phi)\left(1-\beta(\bar{\rho}^2+\sigma_S^2)\right)}\,\frac{1}{2}\kappa^2 \tag{34}$$

Online Appendix B.2.1 derives θ_e, and κ in terms of primitives and establishes $\theta_e < 0$ and $\kappa > 0$, hence $K > 0$. Two cases follow.

(i) Certainty equivalence ($\sigma_S^2 \to 0$). *The state-dependent channel vanishes and the tariff appreciates the real exchange rate for every shock size, $e_0^r = \theta_e\, \tau_{S,0} < 0$.*

(ii) Structural trade-policy uncertainty ($\sigma_S^2 > 0$). *The tariff shock depreciates the real exchange rate, $e_0^r > 0$, if and only if it exceeds the depreciation threshold*

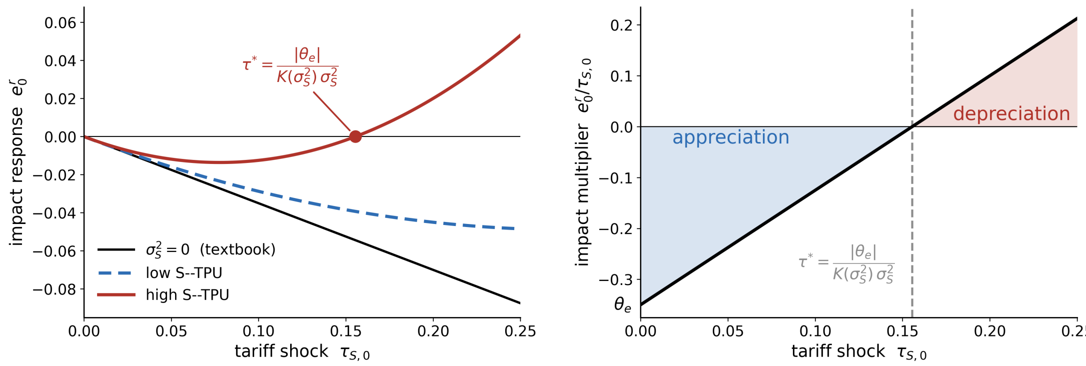
$$\tau_{S,0} \;>\; \tau_{S,0}^*\left(\sigma_S^2\right) \;\equiv\; \frac{|\theta_e|}{K(\sigma_S^2)\,\sigma_S^2}, \qquad \frac{\partial \tau_{S,0}^*}{\partial \sigma_S^2} \;<\; 0. \tag{35}$$

Proof. See Online Appendix. □

Equation (33) decomposes the impact response of the real exchange rate into a *expenditure-switching* channel, which appreciates the real exchange rate, and a *state-dependent precautionary* channel, which depreciates it. The first effect captures the standard textbook goods (currency) expenditure-switching response to a tariff shock, with a marginal appreciation effect of $\theta_e < 0$ per unit of tariff. The second effect arises whenever the future tariff schedule is uncertain and households engage in precautionary saving behaviour. A rise in demand for assets is reflected in a portfolio adjustment on foreign bonds. By the UIP condition in (21), the ensuing fall in relative returns translates into a real *depreciation* on impact (followed by an expected appreciation) that makes households willing to hold the larger position. The effect of impact depreciation grows with S-TPU uncertainty and with the size of the shock itself.

Figure 11 illustrates Proposition 1. Panel (a) plots the impact response of the exchange rate e_0^r against the size of the structural tariff shock $\tau_{S,0}$. Under certainty, only the expenditure-switching channel operates: the response schedule (black line) is a straight line through the origin with negative slope $\theta_e < 0$, and the real exchange

Figure 11: State-dependent transmission of a tariff shock to the real exchange rate.



(a) Impact response (b) Impact multiplier

Notes. Illustrative figure. Panel (a) plots the impact response e_0^r against the size of the tariff shock $\tau_{S,0}$ for three uncertainty states: certainty equivalence, $\sigma_S^2 = 0$ (solid black); low S-TPU (dashed); and high S-TPU (solid orange). The marked point on the high-S-TPU schedule is $\tau_{S,0}^*$, at which e_0^r changes sign. Panel (b) plots the impact multiplier $e_0^r/\tau_{S,0} = \theta_e + K(\sigma_S^2)\,\sigma_S^2\,\tau_{S,0}$ against $\tau_{S,0}$. The intercept is $\theta_e < 0$ and the slope is $K(\sigma_S^2)\,\sigma_S^2 > 0$; the vertical dashed line marks the depreciation threshold $\tau_{S,0}^*$ of (35), at which the multiplier crosses zero. Shaded areas indicate the appreciation region (blue, left) and the depreciation region (orange, right).

rate appreciates in proportion to the shock. Under S-TPU, the *state-dependent* precautionary channel is also active, depreciating the exchange rate non-linearly. The impact response is then the sum of the two channels and is therefore convex, with curvature $2K(\sigma_S^2)\,\sigma_S^2 > 0$ inherited from the precautionary channel. Notably, for small shocks the expenditure-switching channel dominates and the response is close to its certainty-equivalence counterpart, while for large shocks, above the depreciation threshold $\tau_{S,0}^*$, the precautionary channel takes over. Holding the size of the shock fixed, a higher σ_S^2 raises $K(\sigma_S^2)\,\sigma_S^2$ both directly and through $K(\sigma_S^2)$, so the precautionary channel becomes stronger and the response schedule more convex. Consequently, the higher the S-TPU, the lower the depreciation threshold and the narrower the range of tariff shocks over which the currency appreciates.

Panel (b) plots the impact multiplier $e_0^r/\tau_{S,0}$ against the size of the tariff shock under S-TPU. The precautionary term is quadratic in the tariff, so per unit of tariff it vanishes as $\tau_{S,0} \to 0$ and the intercept is the certainty-equivalent appreciation $\theta_e < 0$. As the shock grows, the schedule rises with slope $K(\sigma_S^2)\,\sigma_S^2$ and crosses zero at the depreciation threshold $\tau_{S,0}^*$ of (35): shocks to its left lie in the appreciation region, shocks to its right in the depreciation region.

Consumption and trade balance Next we turn to the equilibrium response of consumption and trade balance to a tariff shock.

Proposition 2 (Consumption and the trade balance)**.** *The impact responses of consumption and the trade balance to a positive tariff shock are*

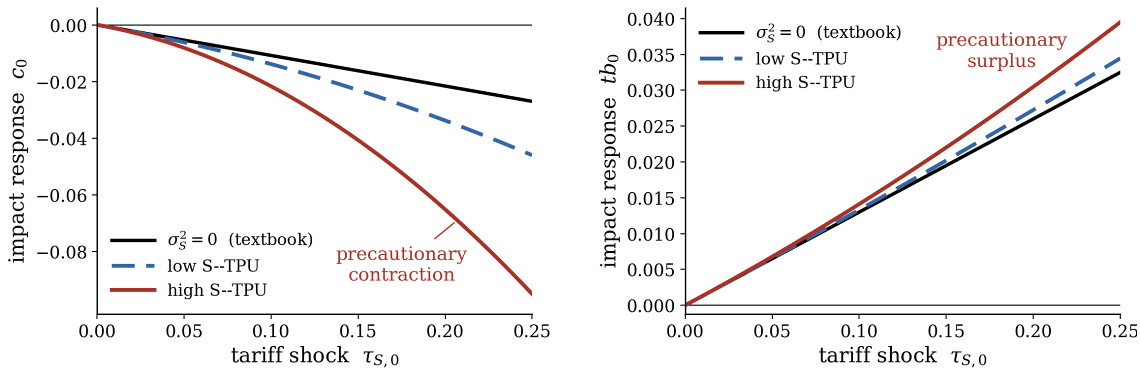
$$c_0 = \theta_c\,\tau_{S,0} - \underbrace{\frac{K}{\Phi}\,\sigma_S^2\,\tau_{S,0}^2}_{\substack{\textit{precautionary}\\ \textit{channel}}}, \qquad tb_0 = \left[-\Lambda\,\theta_c + \frac{\nu(1-\nu)}{2-\nu}\right]\tau_{S,0} + \underbrace{\frac{\Lambda\,K}{\Phi}\,\sigma_S^2\,\tau_{S,0}^2}_{\substack{\textit{precautionary}\\ \textit{channel}}}. \tag{36}$$

Consequently, S-TPU lowers consumption and improves the trade balance,

$$\frac{\partial c_0}{\partial \sigma_S^2} = -\frac{\tau_{S,0}^2}{\Phi}\,\frac{\partial\big(K\sigma_S^2\big)}{\partial \sigma_S^2} = -\frac{\tau_{S,0}^2\,K}{\Phi}\,\frac{1-\beta\bar{\rho}^2}{1-\beta\left(\bar{\rho}^2+\sigma_S^2\right)} \;\le\; 0, \qquad \frac{\partial tb_0}{\partial \sigma_S^2} = -\Lambda\,\frac{\partial c_0}{\partial \sigma_S^2} \;\ge\; 0.$$

Proof. See Online Appendix. □

Figure 12: Impact responses of consumption and the trade balance to a structural tariff shock.



(a) Consumption (b) Trade balance

Notes. Illustrative figure. Panel (a) plots the impact response of consumption against the size of the tariff shock $\tau_{S,0}$. Panel (b) plots the impact response of the trade balance against $\tau_{S,0}$.

Proposition 2 decomposes the impact responses of consumption and the trade balance into a certainty-equivalent component - linear in the tariff - and a *precautionary channel*. The precautionary channel lowers consumption and improves the trade balance, and both effects grow with the interaction $\sigma_S^2\,\tau_{S,0}^2$. This is the quantity counterpart of the portfolio adjustment behind Proposition 1; by equation (25), the accumulation of domestic savings that depreciates the currency is the same flow that appears as an improvement in the trade balance. Figure 12 plots the impact responses of consumption and trade balance in (36) against the tariff shock for three levels of S-TPU. Relative to the linear certainty-equivalent benchmark, S-TPU bends consumption downward in Panel (a) and the trade balance upward in Panel (b), with the gap widening in the tariff size because the precautionary term scales with the square of the tariff $\tau_{S,0}^2$.

To summarize, tariff uncertainty induces households to cut current consumption and increase precautionary saving. With output fixed, the contraction in consumption generates a trade balance surplus, which households invest in foreign assets. In general equilibrium, the real exchange rate depreciates, shifting expenditure away from foreign toward domestic goods, and allowing an increase in domestic saving. Tariff shocks therefore operate as *adverse demand* shocks, consistent with the empirical evidence.

5 Conclusions

We have shown that, in U.S. data after 1990, import tariff shocks transmit as negative demand shocks, and generate a persistent depreciation of the U.S. dollar, overturning the textbook prediction of currency appreciation through expenditure-switching. We have argued that a key to understanding this result lies in *structural* trade-policy uncertainty (S-TPU): the uncertainty agents face about the *persistence* of the trade-policy regime in place. Agents observe the tariff level currently in place, but the persistence of the tariff stance is itself random. A tariff increase therefore shifts not only the expected path of future tariffs but also their conditional variance, in proportion to S-TPU and to the (squared) tariff stance itself, endogenously generating an increase in uncertainty that triggers a precautionary saving channel.

Our paper makes four contributions. First, we propose a narrative-dominance identification strategy for tariff shocks in a Bayesian VAR on U.S. quarterly data, combining a sign restriction on real imports with historical-contribution restrictions at well-documented narrative episodes. A positive tariff shock contracts real activity, generates an S-shaped response of CPI inflation, improves and then deteriorates the trade balance ratio, induces monetary accommodation, and persistently depreciates the nominal and real U.S. dollar effective exchange rate. In a nutshell, a positive tariff shock transmits like a negative aggregate demand shock, in that it simultaneously lowers activity and inflation.

Second, we construct a novel measure of S-TPU within a state-space stochastic-volatility model of tariff rates. Unlike the aggregate TPU index of Caldara et al. (2020), which is constructed from a univariate approach, S-TPU rises around episodes of genuine regime change and remains muted around inconsequential ("noisy") tariff announcements.

Third, we document that the transmission of tariff shocks is state-dependent in S-TPU: the textbook implications prevail when S-TPU is low, while the same shock generates a real exchange rate depreciation when S-TPU is high. The asymmetry vanishes when conditioning on the aggregate TPU index, suggesting that structural - not noise-driven - uncertainty governs the macroeconomic transmission of tariff shocks.

Fourth, we build a dynamic equilibrium model of a small open economy with incomplete international financial markets, CARA preferences, and random persistence of the tariff regime that rationalizes this evidence. Because of tariff persistence risk, a sufficiently large tariff enacted under elevated S-TPU is, in itself, an endogenous uncertainty event. In that state, a prudent household responds with precautionary saving, which, for given output, induces a trade balance improvement and an exchange rate depreciation. Above a threshold, this precautionary channel dominates the conventional expenditure-switching channel and overturns the sign of the exchange-rate response.

Taken together, our results show that the textbook association between tariffs and currency appreciation is neither a robust empirical regularity nor a general theoretical implication of dynamic open-economy models. More generally, once agents face uncertainty about the persistence of the trade-policy regime, S-TPU becomes a key determinant of the macroeconomic effects of tariff shocks.

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Online Appendix

Tariffs, Uncertainty, and the Exchange Rate

Alfonso Merendino and Tommaso Monacelli

Contents

A Empirical Appendix

A.1 Data

Below we provide more details on the data employed in the BVAR estimation.

Nominal and real effective exchange rate measures As the main effective exchange rate indicators, we consider the *nominal* and *real* effective exchange rate for the United States from the Bank for International Settlements (BIS), computed against the BIS "narrow" basket of major trading partners: Australia, Canada, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, Hong Kong SAR, South Korea, Singapore, Chinese Taipei, and the euro area. Mexico is additionally included in the real index only.[33] Both indices are geometric weighted averages of bilateral exchange rates, with the real index additionally adjusted by relative consumer prices in the comparator economies. These indices are designed to reflect developments in global trade by using time-varying weighting patterns.[34] Data are monthly series, which we aggregate to quarterly frequency using simple averages and then transform into natural logs. For both the nominal and the real effective exchange rate, an increase corresponds to an appreciation.

Weighted-import tariff rate Our preferred trade-policy measure is the trade-weighted U.S. import tariff rate - we label it *WIT1*. Following the logic in Franconi and Hack (2026), we construct this series as the ratio of customs duties to dutiable imports. More precisely, customs duties are measured using FRED series *B235RC1Q027SBEA*. Dutiable imports are constructed as total goods imports from FRED series *A255RC1Q027SBEA* multiplied by the average share of dutiable goods in total imported goods, where the latter is computed using the U.S. International Trade Commission DataWeb. This construction implies that our series differs slightly from that in Schmitt-Grohé and Uribe (2025) - labeled *WIT2* - who instead compute the tariff rate as the ratio of U.S. import customs duties to the total value of goods imports. The WIT1 measure has a simple interpretation: it captures the average tariff burden effectively applied to the subset of imports that is actually subject to duties. Compared with WIT2, based on total imports, this construction is better aligned with the actual incidence of tariffs, since it isolates the portion of trade flows on which duties are in fact levied.

[33] For details, see `https://data.bis.org/topics/EER`

[34] The weights are derived from manufacturing trade flows and capture both direct bilateral trade and third-market competition.

Trade restrictiveness index (TRI) To complement the average tariff measure, we also use the Trade Restrictiveness Index (TRI) from Schmitt-Grohé and Uribe (2025), available at `https://www.columbia.edu/~mu2166/import_tariff/`. The TRI summarizes the overall restrictiveness of the tariff structure by combining information on tariff rates, import shares, and import demand elasticities into a single scalar measure. Let τ_{it} denote the ad valorem tariff on good i at time t, s_{it} the import share of good i, and ε_i the absolute value of the import demand elasticity. Following Schmitt-Grohé and Uribe, the welfare-equivalent uniform tariff, or Trade Restrictiveness Index, is defined as

$$\text{TRI}_t = \left(\frac{\sum_i s_{it}\varepsilon_i \tau_{it}^2}{\sum_i s_{it}\varepsilon_i} \right)^{1/2}$$

Figure 1 compares the TRI with our benchmark weighted-import tariff measure and the alternative weighted-import tariff measure of Schmitt-Grohé and Uribe (2025) over the full post-1990 sample. Figure 2 zooms in on quarter-on-quarter changes around the narrative-event window.

Other data sources We summarize all the remaining data description in Table 3. The displayed variables are obtained from FRED, maintained by the Federal Reserve Bank of St. Louis, or from the ECB data portal; identifiers are in italic letters.

A.2 Narrative evidence by event

In the main text, we identify tariff episodes that satisfy the three criteria in Section 2.3: narrative clarity (C1), a material movement in τ_t (C2), and sign consistency (C3). This appendix documents those episodes. We cover the two baseline events, 2018Q4 and 2025Q2, and the two additional events included in the extended set, 2019Q3 and 2019Q4.[35]

For each date, we rely, where relevant, on official records from (i) Federal Register notices, (ii) USTR releases, (iii) White House presidential actions, (iv) WTO records, and (v) European Commission records. We then corroborate the official record with contemporaneous coverage from major policy and financial news outlets (e.g., Reuters and The Wall Street Journal).

[35] The extended set includes more modest or goods-specific tariff measures. We therefore use these dates only in the robustness exercise reported in Online Appendix A.3.

Table 3: Macroeconomic data

Variable	Data identifier and details
CPI inflation	*CPIAUCSL*. Percent change from year ago, seasonally adjusted. Quarterly data.
Real GDP	*GDPC1*. Levels in natural log, seasonally adjusted. Quarterly data.
Federal funds rate	*DFF*. Percent, not seasonally adjusted. Quarterly data.
Trade balance	$(EXPGS - IMPGS)\,/\,GDP \times 100$, where $EXPGS$ are exports and $IMPGS$ imports in billions of dollars. GDP is nominal GDP. Trade balance is expressed in percent of nominal GDP, seasonally adjusted annual rate. Quarterly data.
Real private investment	*GPDIC1*. Levels in natural log, seasonally adjusted annual rate. Quarterly data.
EA real GDP	*CLV10MNACB1GQSCAEA20Q*. Chain-linked volumes (millions of euro), seasonally adjusted. Levels in natural log. Quarterly data.
EA HICP inflation	*I10_CPI*. Harmonised index of consumer prices, percent change from year ago. Monthly data aggregated to quarterly averages.
Treasury Yield 10-year	*DGS10*. Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity, Quoted on an Investment Basis. Percent, not seasonally adjusted. Quarterly data.
EA 3-month Euribor	*FM.M.U2.EUR.RT.MM.EURIBOR3MD_.HSTA* (ECB Data Portal), 3-month Euribor, historical close. Percent. Monthly data, averaged to quarterly frequency.

Notes: Macroeconomic data used in the empirical work in the main text and appendix. Data identifiers refer to FRED series codes unless otherwise noted.

2018Q4: Section 301 List 3 Effective September 24, 2018, the USTR finalized the third Section 301 action against China, imposing an additional 10% *ad valorem* duty on approximately \$200 billion of Chinese imports, (Office of the U.S. Trade Representative, 2018a,b) with duties being collected mostly in 2018Q4. List 3 was the central escalation of the bilateral tariff cycle initiated earlier that year. The WIT1 weighted tariff rate rises by 1.70 percentage points in 2018Q4, a move more than 1.8 standard deviations above the sample mean. Several newspapers reported the new tariff round[36], and the Guardian explicitly frames it as an escalation of the U.S.-China trade war[37].

Other tariff actions from the same U.S.-China trade-war cycle could also be

[36]Schlesinger and Salama, *The Wall Street Journal*, September 2018, `https://www.wsj.com/articles/trump-to-lay-out-line-on-china-trade-1537213209`

[37]Kuo and *Reuters*, *The Guardian*, September 2018, `https://www.theguardian.com/world/2018/sep/24/new-us-tariffs-on-china-take-effect-with-no-compromise-in-sight`

considered as candidate shocks. In particular, two prominent actions occurred in 2018Q2: the initial Section 232 steel and aluminum tariffs and the original Section 301 determination. However, we do not classify 2018Q2 as a narrative shock because the realized increase in τ_t is small and does not correspond to a clear tariff innovation. Nor does it appear to anticipate the larger tariff increase observed in 2018Q4.

2025Q2: "Liberation Day" On April 2, 2025, Executive Order 14257 imposed an additional *ad valorem* duty "on all imports from all trading partners," starting at a 10% baseline rate with country-specific reciprocal surcharges layered on top (Executive Office of the President, 2025). It is the broadest tariff increase in the postwar U.S. applying a baseline duty across trading partners and a wide range of products. The WIT1 weighted tariff rate rises unexpectedly by 9.31 percentage points in the quarter, around ten standard deviations above the sample mean. This event ignited worldwide fears of a trade war[38] and of a global economic recession[39]. The 2025Q2 observation is the main anchor of the baseline date set.

Other tariff actions around the same episode could also be considered as candidate shocks. In particular, the IEEPA tariffs on Chinese imports announced in February 2025 appear in 2025Q1. We do not classify 2025Q1 as a narrative shock because the realized increase in τ_t is modest relative to the April 2 package and does not represent an anticipation of the broader 2025Q2 "Liberation Day" tariff increase.

2019Q3: Section 301 List 4A Effective September 1, 2019, USTR modified the Section 301 action, raising the additional duty on approximately $112 billion of Chinese imports from 10% to 15% (Office of the U.S. Trade Representative, 2019a,c). List 4A extended coverage to essentially all remaining Chinese imports and completed the bilateral escalation begun in 2018[40]. The WIT1 weighted tariff rate rises by a considerable 1.26 percentage points in the quarter. Note that the measure is more modest than the broad-based tariff increases in the baseline set. We therefore do not treat 2019Q3 as a baseline narrative shock, but retain it in the extended date set.

[38] French, *Reuters*, April 2025, `https://www.reuters.com/markets/us/wall-street-futures-tailspin-tariffs-fuel-recession-fears-2025-04-03/`

[39] Sweney, *The Guardian*, April 2025, `https://www.theguardian.com/business/2025/apr/04/imf-warns-of-significant-risk-to-global-economy-from-trump-tariffs-as-markets-slide`

[40] Mauldin and Deng, *The Wall Street Journal*, September 2019, `https://www.wsj.com/articles/trump-administration-goes-ahead-with-new-tariffs-on-chinese-products-11567337797`

2019Q4: WTO-authorized Airbus countermeasures Two distinct policy actions contribute to the 2019Q4 increase. In October 2019, the WTO Dispute Settlement Body authorized the United States to impose countermeasures on up to $7.5 billion of annual EU imports, in response to a finding of WTO-inconsistent subsidies to Airbus (Office of the U.S. Trade Representative, 2019b; European Commission, 2021). Acting on this, USTR imposed an additional 10% duty on large civil aircraft and a 25% duty on a range of agricultural and industrial EU products, effective October 18, 2019[41]. The Airbus countermeasures constitute a regional, dispute-specific tariff shock. Layered on top, 2019Q4 also captures the full-quarter incidence of the List 4A duties, whose September 1 effective date places only one month of new collections in Q3. Together the two actions raise the WIT1 weighted tariff rate by 1.39 percentage points in the quarter. The 2019Q4 observation enters the extended set as a joint narrative restriction reflecting the simultaneous incidence of a WTO-authorized regional countermeasure against the EU and the continuation of the Section 301 escalation against China.

A.3 Robustness of BVAR estimates

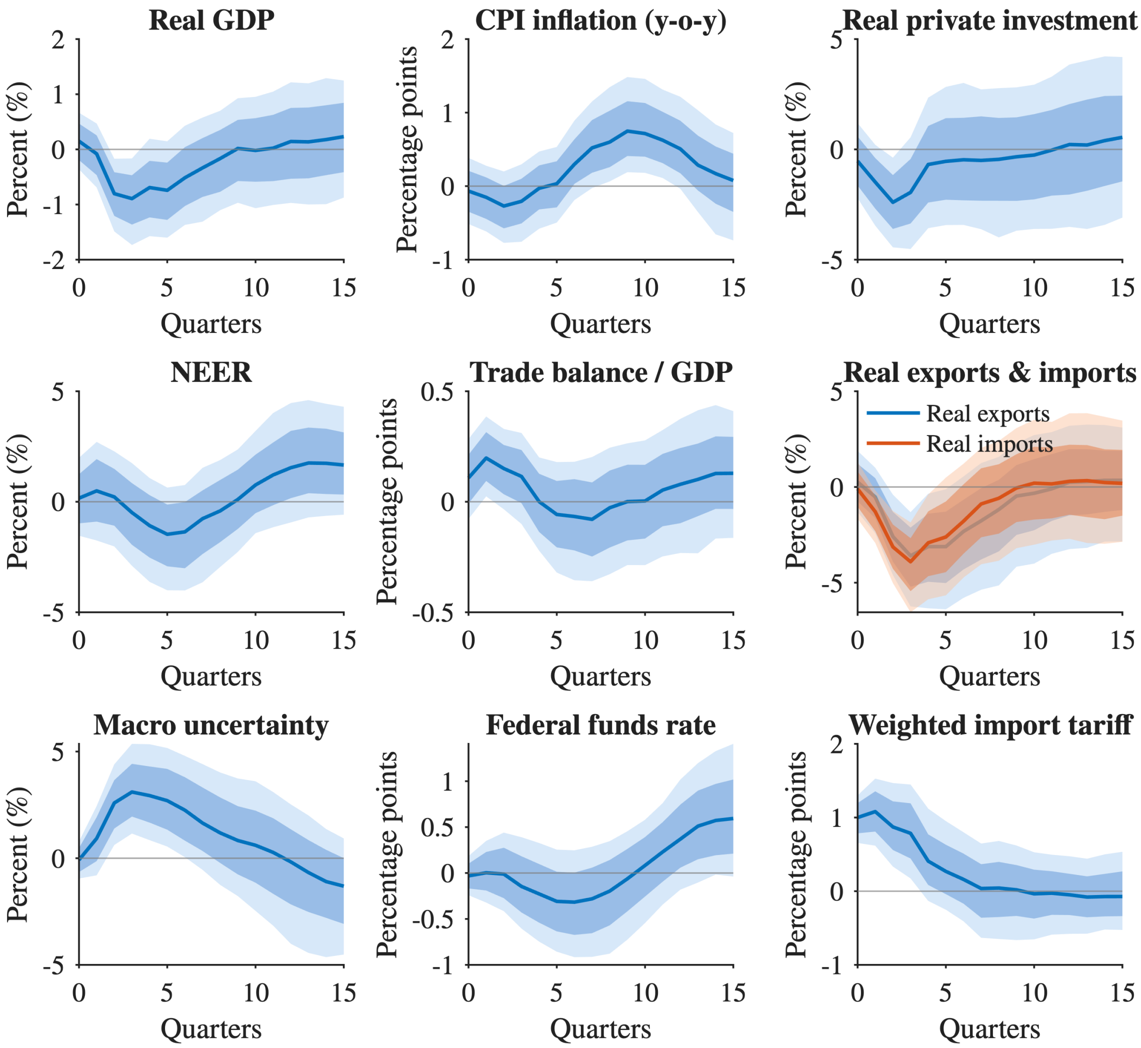
A.3.1 Robustness to additional narrative dates

To assess whether our baseline findings depend on the particular choice of tariff event dates, this appendix section re-estimates the BVAR of Section 2 using an *extended* narrative approach. In addition to the baseline episodes, the extended set incorporates the 2019Q3 implementation of Section 301 List 4A tariffs and the 2019Q4 WTO-authorized countermeasures related to the Airbus dispute (see panel B of Table 1).

Figures 13 and 14 report the estimated impulse responses of the NEER and the other macroeconomic variables for the long sample (1990Q1-2025Q2) and the short sample (2002Q1-2025Q2), respectively. Similarly, Figure 15 presents the estimated impulse responses of the REER for the long and short samples. Across both specifications, the responses of the exchange rate and the other macroeconomic variables are quantitatively very similar to the baseline estimates, indicating that the main findings are robust to the inclusion of these additional tariff episodes.

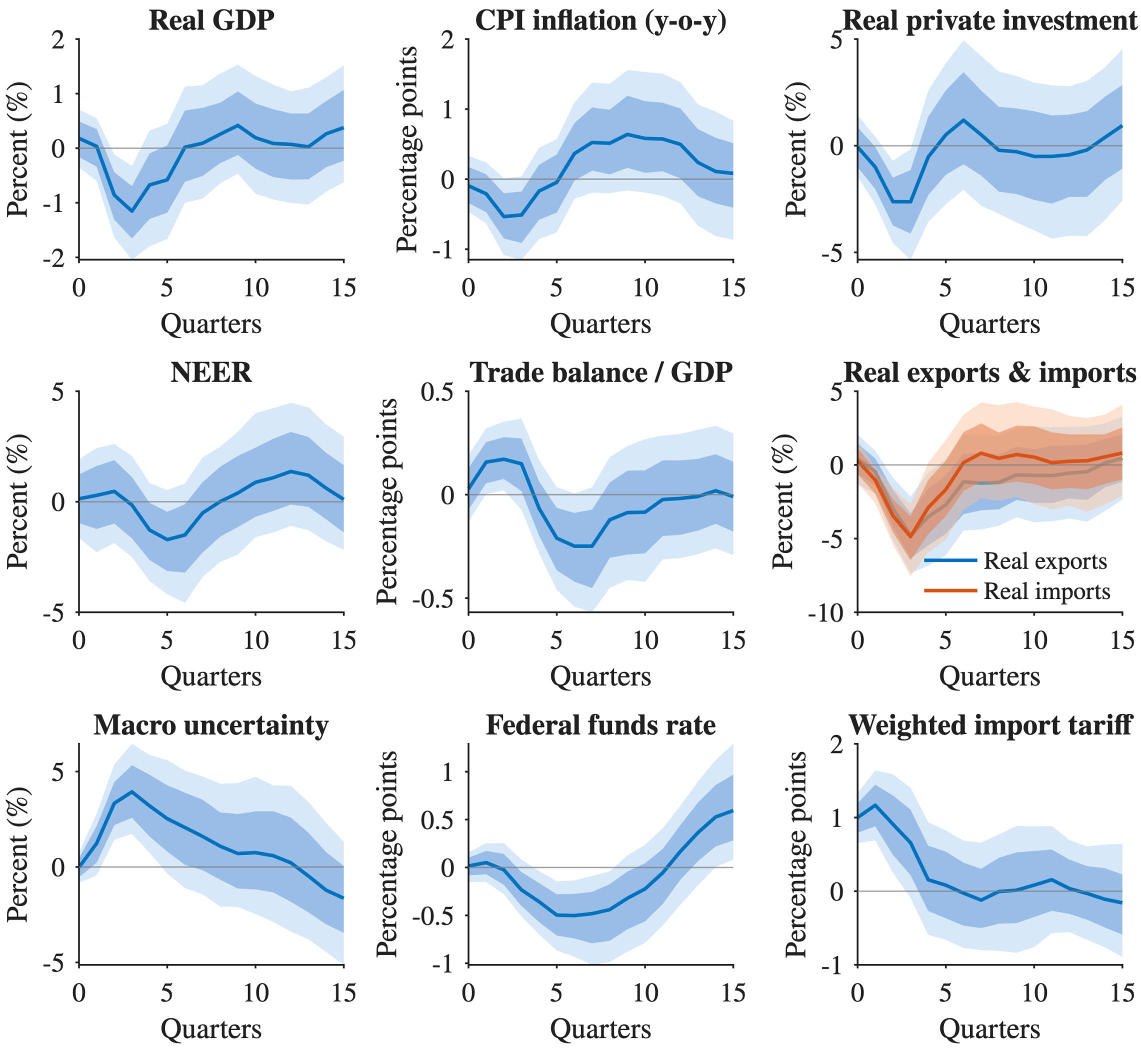
[41] *Reuters*, October 2019, https://www.reuters.com/article/wto-aircraft-usa/ustr-confirms-u-s-tariffs-to-hit-certain-eu-goods-on-oct-18-idUSL2N2722A4

Figure 13: *Extended dates.* Estimated impulse responses of NEER and other macroeconomic variables to a 1 p.p. weighted-import tariff shock. A fall in the exchange rate is a depreciation.



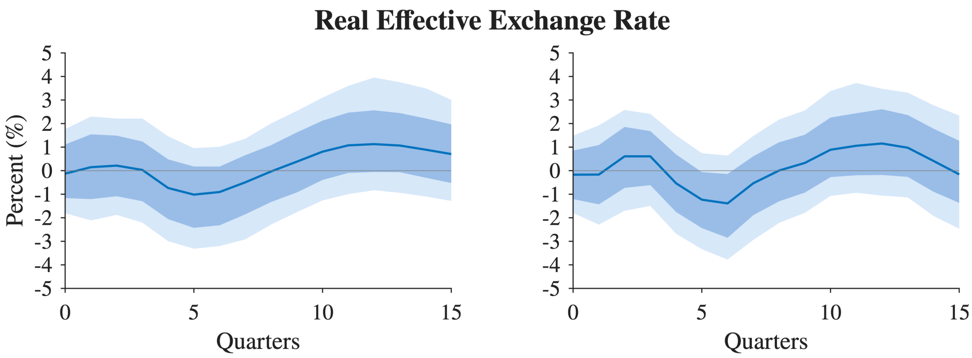
Notes: The sample considered covers U.S. indicators with quarterly frequency from 1990Q1 to 2025Q2. For more information, see the note to Figure 3.

Figure 14: *Extended dates.* Estimated impulse response of NEER and other macroeconomic variables to a 1 p.p. weighted-import tariff shock. A fall in the exchange rate is a depreciation.



Notes: The sample considered covers U.S. indicators with quarterly frequency from 2002Q1 to 2025Q2. For more information, see the note to Figure 3.

Figure 15: *Extended dates.* Estimated impulse responses of the real effective exchange rate (REER) to a 1 p.p. shock to the weighted import tariff. A fall in the exchange rate is a depreciation.



(a) 1990–2025 (b) 2002–2025

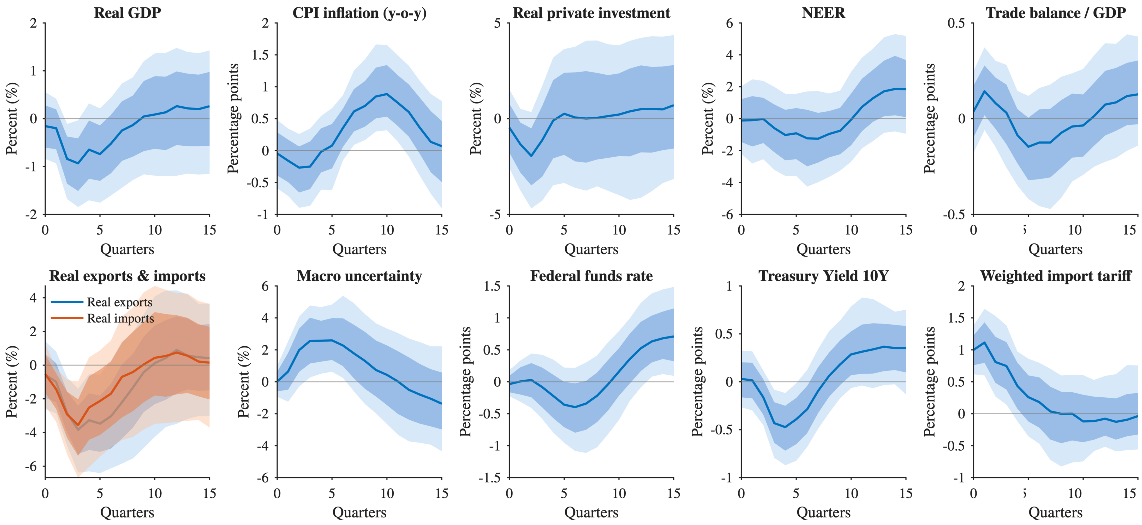
Notes: The figure shows the estimated impulse response of the real effective exchange rate (REER) to a 1 p.p. shock to the weighted import tariff. Panel (a) reports results for the 1990Q1-2025Q2 sample, while panel (b) reports results for the 2002Q1-2025Q2 sample. For further details, see the note to Figure 3. A fall in the exchange rate is a depreciation.

A.3.2 Robustness to additional financial variables

To assess whether the identified tariff shock confounds contemporaneous financial disturbances, this appendix section augments the BVAR of Section 2 with the ten-year Treasury yield. In the baseline system the exchange rate is the only asset price: a disturbance originating in financial markets has no dimension of its own, so its variation is necessarily absorbed by the rest of the system, including the candidate tariff shock. The concern is particularly relevant for April 2025, when equities, Treasuries, and the dollar declined together. Including a second, forward-looking asset price gives such disturbances a dimension of their own and makes the dominance restriction more demanding, since the tariff shock must now dominate the contribution of an additional competing (financial) shock.

Figure 16 reports the estimated impulse responses from the augmented specification. The responses of the nominal exchange rate and the other macroeconomic variables are qualitatively unchanged from the baseline estimates of Figure 3, and the response of the ten-year yield to the tariff shock mirrors that of the exchange rate. The main findings are therefore robust to the inclusion of an additional financial variable.

Figure 16: Estimated impulse response of NEER, the ten-year U.S. Treasury yield, and other macroeconomic variables to a 1 p.p. weighted-import tariff shock. A fall in the exchange rate is a depreciation.



Notes: The sample considered covers U.S. indicators with quarterly frequency from 1990Q1 to 2025Q2. For more information, see the note to Figure 3.

A.4 Measuring structural trade-policy uncertainty

We measure structural trade-policy uncertainty as the conditional volatility of innovations to the persistent component of U.S. trade policy. Observed tariffs combine movements in a persistent policy regime with transitory tariff wedges. The decomposition is not observed directly and is recovered from a state-space stochastic-volatility model for the tariff rate.

A.4.1 Model calibration

We calibrate the state-space model from Section 3.2.1 using the values in Table 4.

The calibration assigns high persistence to the structural tariff (ρ_S) and low persistence to the transitory component (ρ_T). It also makes structural volatility smooth and persistent, through a lower η_S and a higher $\rho_{\sigma S}$, while allowing transitory volatility to absorb short-run abrupt movements through a higher η_T and a lower $\rho_{\sigma T}$. Identification of structural trade-policy uncertainty therefore comes from the maintained distinction between a slow-moving policy regime and a short-lived transitory tariff.[42] In a robustness check available upon request, we calibrate all

[42]We assess the sensitivity of the filtered series to the persistence of the transitory blocks by

Table 4: Stochastic-volatility model calibration

Symbol	Value	Description
ρ_S	0.975	Persistence of the structural component $\tau_{S,t}$
ρ_T	0.200	Persistence of the transitory component $\tau_{T,t}$
$\rho_{\sigma S}$	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	Volatility of innovations to $\sigma_{S,t}$
η_T	0.900	Volatility of innovations to $\sigma_{T,t}$
$\bar{\sigma}_S$	-2.00	Long-run mean of structural log-SD
$\bar{\sigma}_T$	-2.00	Long-run mean of transitory log-SD

parameters but let the model estimate ρ_T and η_T. We find that while η_T is close to the calibrated value, the estimated persistence ρ_T is higher than the calibrated value - a posterior median for ρ_T of 0.770 against a calibration of 0.200. The estimated S-TPU is nonetheless quantitatively close to the baseline, and the identified peaks are unvaried.

A.4.2 Model filtering

Given the calibrated parameters, we recover the latent states with a bootstrap particle filter applied to the standardized WIT1 tariff series. The procedure follows the particle-filtering logic of Born and Pfeifer (2014), adapted to the state-space stochastic-volatility system described above.

The filter uses the tariff rate as the only observation. At each date t, the algorithm works with a cloud of 100,000 particles, each representing a possible value of the unobserved state vector - the state vector contains the persistent tariff component and the two log-volatility states, $\{\tau_{S,t}, \sigma_{S,t}, \sigma_{T,t}\}$. For each particle, the tariff observation pins down the transitory component residually:

$$\tau_{T,t} = \tau_t - \tau_{S,t}. \tag{37}$$

Each particle is then weighted by the likelihood of the implied transitory tariff $\tau_{T,t}$ under its calibrated AR(1) law of motion. In particular, particles that imply transitory tariff movements consistent with the calibrated transitory process receive higher weight, while particles that imply unlikely movements receive lower weight. The weighted particle cloud is then systematically resampled in a bootstrap from 100,000 particles.

re-estimating the model under (i) $\rho_T \in \{0.20, 0.30\}$ with $\rho_{\sigma,T} = 0.50$, (ii) $\rho_{\sigma,T} \in \{0.20, 0.30\}$ with $\rho_T = 0.50$, and (iii) both lowered jointly to $\{0.20, 0.20\}$ and $\{0.30, 0.30\}$. The identified peaks in the estimated S-TPU series are unvaried.

At each date t, the reported filtered state is the median across the resampled particle cloud, following the convention in the Born and Pfeifer (2014) routines. Let $\widehat{\sigma}_{S,t|t}$ and $\widehat{\sigma}_{T,t|t}$ denote the filtered median estimates of the structural and transitory tariff log-volatilities, respectively. We define structural trade-policy uncertainty as the corresponding filtered variance estimate for innovations to the persistent tariff component:

$$STPU_t = \exp\left(2\widehat{\sigma}_{S,t|t}\right). \tag{38}$$

Because the particle filter is run on the standardized tariff series, this variance is converted back to tariff-level units by multiplying it by the squared standard deviation of WIT1 over the filtering window.

A.5 State-dependent local projections

This Appendix section complements the state-dependent evidence in the main text with the operational details of the local-projection exercise. We estimate state-dependent local projections (Jordà (2005), Ramey and Zubairy (2018)) of the macroeconomic variables on a series of narrative-identified tariff shocks, conditioning on the regime of structural trade-policy-uncertainty (S-TPU).

The regressor that enters the local projection is the structural tariff shock of each accepted posterior draw:[43]

$$\varepsilon_t^{\tau} \;=\; e_1' \left[B\right]^{-1} u_t, \qquad u_t \;=\; y_t - c - \sum_{j=1}^{p} A_j\, y_{t-j} \tag{39}$$

where u_t is the reduced-form innovation implied by the draw of the BVAR coefficients $(c, A_1, \ldots, A_p)$, and $B = \text{chol}\left(\Sigma_u\right) Q$ is the corresponding structural impact matrix of Section 2.2, with its columns reordered so that the column labelled as the tariff shock by the identifying restrictions is first.[44] Since $u_t = B\varepsilon_t$ by construction, inverting the impact matrix recovers the structural innovations, $\varepsilon_t = B^{-1}u_t$, and the selection vector e_1 extracts the tariff shock.

Following Section 3.3, let $H_t = \mathbf{1}\{STPU_t > p_{70}\}$ denote the high-uncertainty indicator and ε_t^{τ} the narrative tariff shock, for each horizon $h = 0, \ldots, 6$ and response variable y_t we estimate

$$y_{t+h} \;=\; \alpha_h \;+\; \beta_h\, \varepsilon_t^{\tau} \;+\; \beta_h^{H}\, H_t\, \varepsilon_t^{\tau} \;+\; \delta_h\, H_t \;+\; \sum_{j=1}^{4} \gamma_{j,h}\, y_{t-j} \;+\; u_{t+h} \tag{40}$$

[43]To lighten notation, we do not index each variable to the single draw d in what follows.

[44]Throughout, $\text{chol}(\cdot)$ denotes the lower-triangular Cholesky factor, i.e. $\Sigma_u = \text{chol}(\Sigma_u)\,\text{chol}(\Sigma_u)'$.

with four lags of the dependent variable, an LP intercept α_h, and a state-level component $\delta_h H_t$ that absorbs the direct effect of the high-uncertainty regime on the level of y_{t+h}. In what follows, we label the response of the dependent variable to a tariff shock at horizon h as Θ_h. In particular, $\Theta_h \equiv \beta_h$ identifies the response in the low-uncertainty regime ($H_t = 0$) and $\Theta_h \equiv \beta_h + \beta_h^H$ the response in the high-uncertainty regime ($H_t = 1$, the top 30% of the distribution in the baseline).

The shock ε_t^τ entering (40) is estimated in the first-stage BVAR, which delivers not a single shock series but a whole set of N_d admissible ones (one for each accepted posterior draw and rotation). Running the projection on a single series and reporting its LP standard errors would treat the shock as known data and thereby understate the true uncertainty (the generated-regressor problem of Pagan (1984)). The neglected uncertainty has two sources: posterior uncertainty about the reduced-form parameters $(A_1, \ldots, A_p, c, \Sigma_u)$, and set-identification uncertainty about the rotation Q that maps them into the structural shock.

We carry both sources into the projection by re-estimating (40) on every admissible draw d, using that draw's own shock series $\{\varepsilon_t^{\tau,(d)}\}$ from (39). From each run, we estimate $\widehat{\Theta}_h(d)$ of the impulse-response coefficient together with its Newey-West HAC sampling variance $V_h(d)$.[45] We represent each draw's within-draw sampling distribution by Gaussian simulation, drawing S values

$$\widetilde{\Theta}_h^{(d,s)} \sim \mathcal{N}\big(\widehat{\Theta}_h(d),\, V_h(d)\big), \qquad s = 1, \ldots, S$$

independently across (d, s). Pooling the $(N_d \times S)$ realisations $\{\widetilde{\Theta}_h^{(d,s)}\}$ yields, for each horizon h and S-TPU state, a single predictive distribution whose dispersion realises the law of total variance,

$$\underbrace{\mathrm{Var}\big(\widetilde{\Theta}_h\big)}_{\text{total}} = \underbrace{\mathrm{Var}_d\big(\mathbb{E}[\widetilde{\Theta}_h \mid d]\big)}_{\text{between: identification}} + \underbrace{\mathbb{E}_d\big(\mathrm{Var}[\widetilde{\Theta}_h \mid d]\big)}_{\text{within: LP sampling}}. \tag{41}$$

The plotted line is the median-shock point estimate $\widehat{\Theta}_h^\star$, obtained by re-estimating (40) once on the across-draw median of the identified shock series. The shaded 68% and 90% bands are Hall-recentered quantiles of the pooled predictive distribution: each quantile q_α of $\{\widetilde{\Theta}_h^{(d,s)}\}$ is shifted by $\widehat{\Theta}_h^\star - \mathrm{med}\{\widetilde{\Theta}_h^{(d,s)}\}$, so that the recentered band median coincides with $\widehat{\Theta}_h^\star$ while the bands inherit the asymmetry of the pooled distribution.

All responses are expressed per 1 p.p. impact on the weighted import tariff: we

[45] Standard errors are computed with Newey-West corrections, allowing for serial correlation over the horizon of the local projection. We set the truncation lag equal to the horizon, $L = h$.

divide every per-draw impulse response by the same denominator, the impact tariff response of the median-shock projection, which puts all draws on one comparable footing, discards no draw, and avoids the ratio-distribution blow-up that arises when a draw's own on-impact response is near zero.

One assumption deserves emphasis. The tariff shock is identified from a single, linear BVAR whose coefficients and impact matrix are constant over the sample, yet the local projection lets its transmission differ across S-TPU regimes. We are thus assuming that the identification and on-impact propagation of the shock do not themselves depend on the regime, even though its dynamic effects do. A fully nonlinear treatment, in the spirit of the regime-dependent (smooth transition) VAR of Caggiano et al. (2014), in which shocks are identified and propagated within each state, would relax this assumption. However, this specification would come at the cost of tractability and transparency. We therefore retain the simpler two-step design, as is standard in the state-dependent LP literature, and read the estimates as regime-specific responses to a common, linearly identified shock.

A.5.1 Robustness of state-dependent estimates

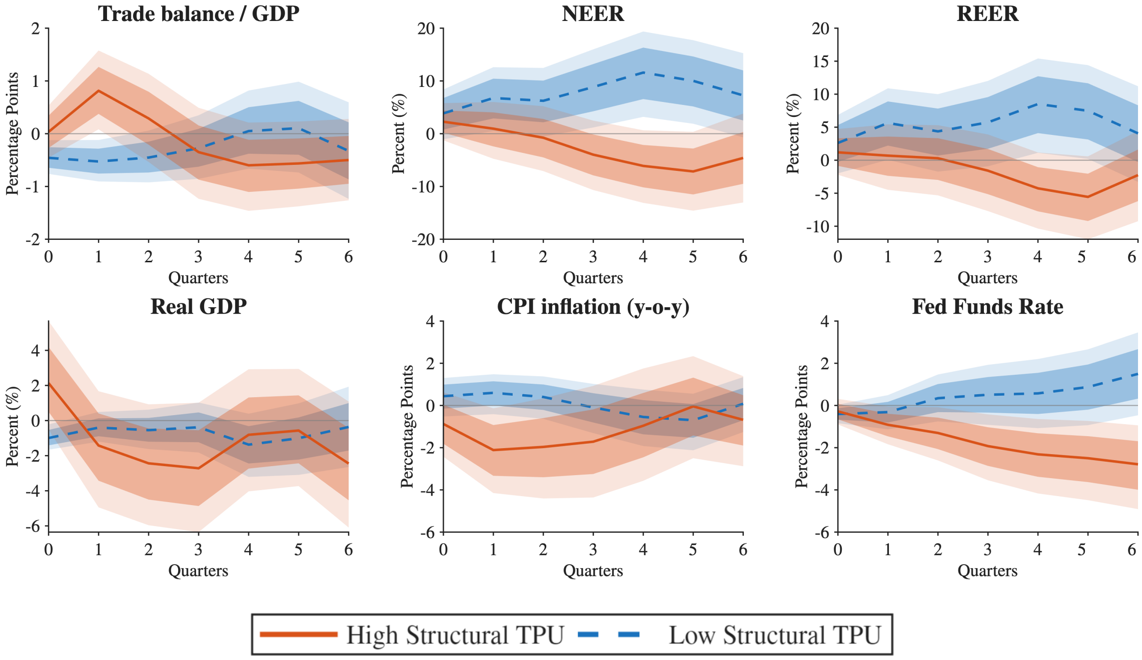
We assess whether the state-dependent responses depend on the cutoff used to define the high-$STPU_t$ state. We re-estimate (5) using three alternative cutoffs: the top 40%, 20%, and 10% of the $STPU_t$ distribution.[46] Formally, for $q \in \{60, 80, 90\}$, we define

$$H_t^{(q)} = \mathbf{1}\{STPU_t > p_q\},$$

and replace H_t in (5) with $H_t^{(q)}$. Figures 17, 18, and 19 report the corresponding results. The state dependence of the responses is robust across the alternative cutoffs.

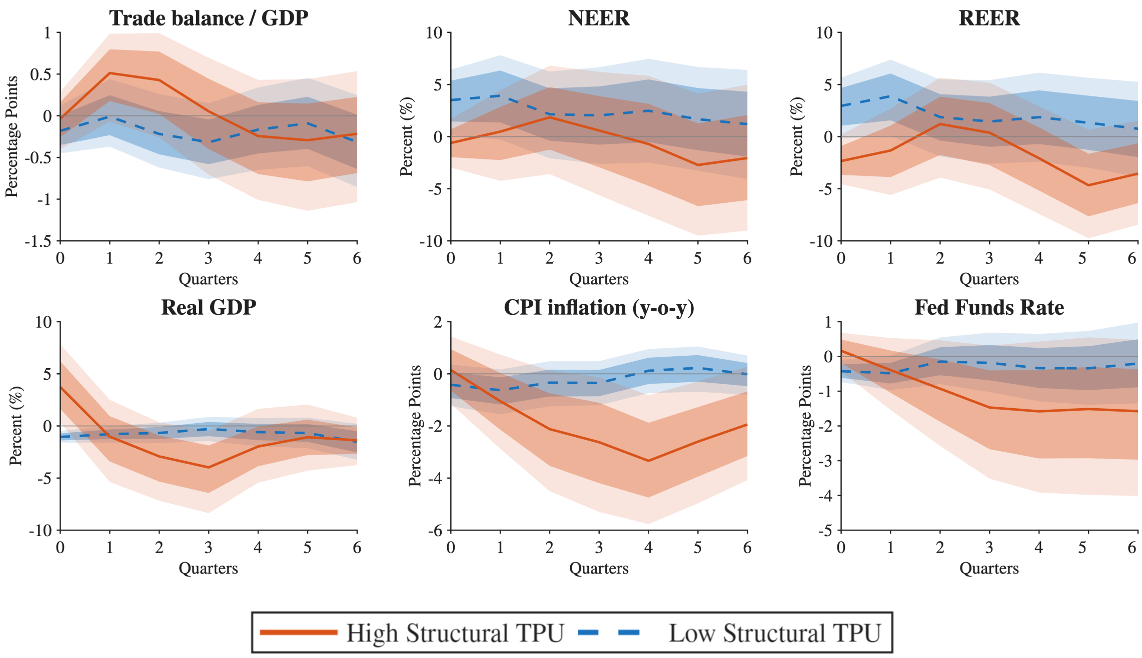
[46] See Figure 10 and the corresponding notes for details on the baseline specification, variables, shock normalization, and construction of the confidence bands.

Figure 17: State-dependent impulse responses: high S-TPU state in the top 40%



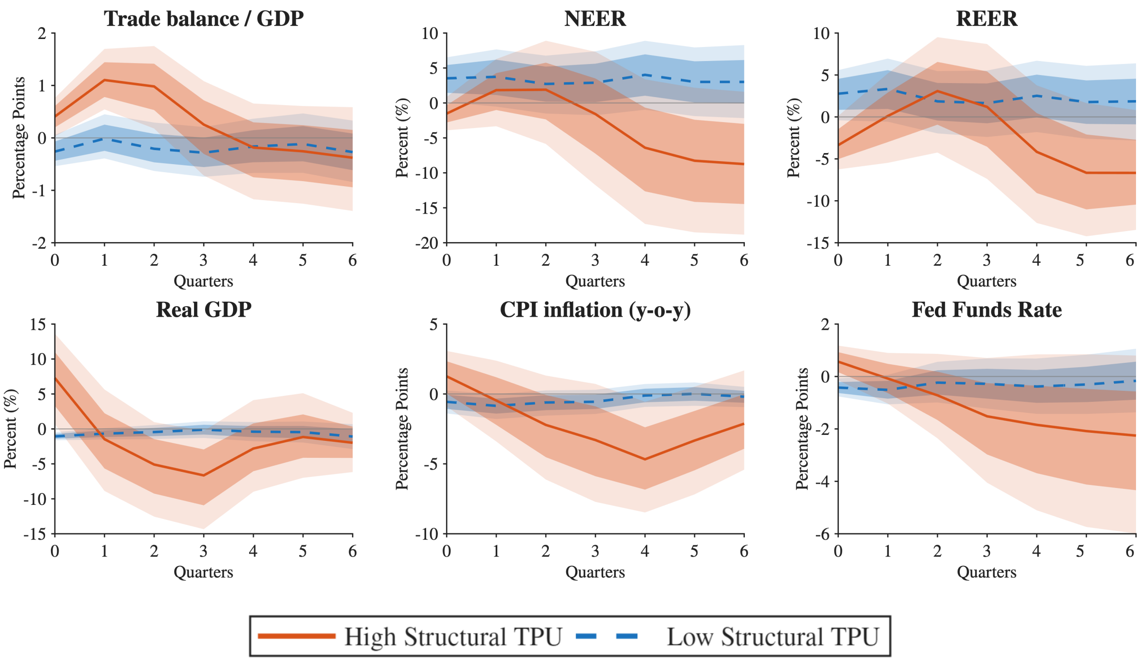
Notes: For details, see Figure 10.

Figure 18: State-dependent impulse responses: high S-TPU state in the top 20%



Notes: For details, see Figure 10.

Figure 19: State-dependent impulse responses: high S-TPU state in the top 10%



Notes: For details, see Figure 10.

B Model appendix

B.1 Proofs of Propositions 1 and 2

This appendix proves the two propositions of Section 4 and collects the results on which they rest: the certainty-equivalent loadings θ_c and θ_e and the adjustment to the consumption path induced by uncertainty. In what follows we use the main-text constants $\Phi = (1-\nu)^2/[\eta\nu(2-\nu)]$ and $\Lambda \equiv 1-\nu A = [\eta(2-\nu)-(1-\nu)]/[\eta(2-\nu)] > 0$, the risk loading $\kappa \equiv \gamma\theta_c - \theta_e$ of (23). We also state the assumption briefly introduced in footnote 26:

Assumption B.1 (Mean-square stability of the tariff process)**.** $\mu_2 \equiv \mathbb{E}_t\rho_{t+1}^2 = \bar{\rho}^2 + \sigma_S^2 < 1$.

Lemma B.1 (Second moment of the tariff)**.** *Under* (12)–(13) *with* $\sigma_\xi^2 = 0$, $\mathbb{E}_t\tau_{S,t+1}^2 = \mu_2\,\tau_{S,t}^2$ *and* $\mathbb{E}_0\tau_{S,k}^2 = \mu_2^k\tau_{S,0}^2$ *for* $k \geq 0$.

Proof. $\tau_{S,t+1}^2 = \rho_{t+1}^2\tau_{S,t}^2$ with $\tau_{S,t}$ known at t and $\mathbb{E}_t\rho_{t+1}^2 = \mu_2$. Iterating, $\tau_{S,k} = \big(\prod_{j=1}^{k}\rho_j\big)\tau_{S,0}$ with $\{\rho_j\}$ i.i.d., so $\mathbb{E}_0\tau_{S,k}^2 = \mu_2^k\tau_{S,0}^2$. □

B.1.1 Proof of Proposition 1

With $b_{-1} = 0$, impact consumption is $c_0 = \theta_c \tau_{S,0} + x_0$ (Lemma B.3) and the date-0 wedge is $W_0 = \frac{1}{2}\kappa^2 \sigma_S^2 \tau_{S,0}^2$ by (23). By Lemma B.1 the whole expected sequence of wedges is proportional to W_0, $\mathbb{E}_0 W_k = \mu_2^k W_0$. Hence, under Assumption B.1, (48) gives

$$x_0 = -\frac{\beta}{\gamma + \Phi} W_0 \sum_{k \geq 0} (\beta\mu_2)^k = -\frac{\beta W_0}{(\gamma + \Phi)(1 - \beta\mu_2)}, \tag{42}$$

Substituting c_0 into the real-exchange-rate relation (30),

$$e_0^r = -\Phi c_0 - \tfrac{1}{2-\nu}\tau_{S,0} = \theta_e \tau_{S,0} - \Phi x_0 = \theta_e \tau_{S,0} + K \sigma_S^2 \tau_{S,0}^2,$$

with $\theta_e = -\Phi\theta_c - \frac{1}{2-\nu} < 0$ and $K = \dfrac{\beta \Phi \kappa^2}{2(\gamma + \Phi)(1 - \beta\mu_2)}$, which is (34). Since $\kappa > 0$ by Lemma B.2 and $1 - \beta\mu_2 > 0$ by Assumption B.1, $K > 0$. The two cases follow. □

B.1.2 Proof of Proposition 2

By Lemma B.3 with $b_{-1} = 0$, $c_0 = \theta_c \tau_{S,0} + x_0$; with $\frac{\beta}{(\gamma+\Phi)(1-\beta\mu_2)} W_0 = \frac{K}{\Phi}\sigma_S^2 \tau_{S,0}^2$,

$$c_0 = \theta_c \tau_{S,0} - \frac{K}{\Phi}\sigma_S^2 \tau_{S,0}^2, \qquad \frac{K}{\Phi} = \frac{\beta \kappa^2}{2(\gamma + \Phi)(1 - \beta\mu_2)} \;>\; 0.$$

From the balance-of-payments identity (25) at $t = 0$ with $b_{-1} = 0$, $tb_0 = -\nu s_0 - c_0$; by the terms of trade (29), $-\nu s_0 = \nu A(c_0 + \eta\nu\tau_{S,0})$ with $A\eta\nu = \frac{1-\nu}{2-\nu}$, so

$$tb_0 = (\nu A - 1)c_0 + \tfrac{\nu(1-\nu)}{2-\nu}\tau_{S,0} = -\Lambda c_0 + \tfrac{\nu(1-\nu)}{2-\nu}\tau_{S,0},$$

and substituting c_0 gives (36). For the comparative statics, K depends on σ_S^2 through $\mu_2 = \bar{\rho}^2 + \sigma_S^2$, so that

$$\frac{\partial\big(K\sigma_S^2\big)}{\partial \sigma_S^2} = K \frac{1 - \beta\bar{\rho}^2}{1 - \beta\mu_2} \;>\; 0,$$

from which

$$\frac{\partial c_0}{\partial \sigma_S^2} = -\frac{K}{\Phi}\frac{1 - \beta\bar{\rho}^2}{1 - \beta\mu_2}\tau_{S,0}^2 \leq 0, \qquad \frac{\partial tb_0}{\partial \sigma_S^2} = \frac{\Lambda K}{\Phi}\frac{1 - \beta\bar{\rho}^2}{1 - \beta\mu_2}\tau_{S,0}^2 \geq 0,$$

using $\Lambda > 0$. □

B.2 Results used in the proofs

B.2.1 Certainty-equivalent loadings

Iterating the flow constraint (25) forward from date t with $\beta\bar{R} = 1$, imposing transversality, and using $\omega_t = -\nu s_t$ together with the terms of trade (29) (so that $\nu \cdot A\eta\nu = \nu(1-\nu)/(2-\nu)$), the economy's intertemporal budget constraint at any date t reads

$$\Lambda \sum_{k\geq 0} \beta^k \, \mathbb{E}_t c_{t+k} = \bar{R}\, b_{t-1} + \frac{\nu(1-\nu)}{2-\nu} \sum_{k\geq 0} \beta^k \, \mathbb{E}_t \tau_{S,t+k}, \tag{43}$$

of which (32) is the case $t = 0$, $b_{-1} = 0$.

Lemma B.2 (Certainty-equivalent loadings). *Under certainty equivalence ($\sigma_S^2 = 0$) the equilibrium is*

$$c_t^{CE} = \theta_c \, \tau_{S,t} + \frac{(1-\beta)\bar{R}}{\Lambda} \, b_{t-1}^{CE}, \qquad e_t^{r,CE} = \theta_e \, \tau_{S,t} - \Phi \, \frac{(1-\beta)\bar{R}}{\Lambda} \, b_{t-1}^{CE}, \tag{44}$$

with $\theta_e \equiv -\Phi\theta_c - \frac{1}{2-\nu}$ and

$$\theta_c = \frac{1}{(2-\nu)(1-\beta\bar{\rho})} \left[\frac{(1-\beta)\nu(1-\nu)}{\Lambda} - \frac{\beta(1-\bar{\rho})}{\gamma + \Phi} \right]. \tag{45}$$

The risk loading $\kappa = \gamma\theta_c - \theta_e$ of (23) equals $(\gamma + \Phi)\theta_c + \frac{1}{2-\nu}$ and satisfies

$$\kappa = \frac{1-\beta}{(2-\nu)(1-\beta\bar{\rho})} \left[1 + \frac{\nu(1-\nu)(\gamma+\Phi)}{\Lambda} \right] > 0, \qquad \theta_e = -\frac{\Phi\,\kappa + \frac{\gamma}{2-\nu}}{\gamma + \Phi} \; < \; 0, \tag{46}$$

and κ is strictly increasing in prudence, with $\partial\kappa/\partial\gamma = \frac{(1-\beta)\,\nu(1-\nu)}{(2-\nu)(1-\beta\bar{\rho})\,\Lambda} > 0$.

Proof. Set $W \equiv 0$ in (31). Since $\mathbb{E}_t \tau_{S,t+k} = \bar{\rho}^k \tau_{S,t}$,

$$(\gamma + \Phi)\big(\mathbb{E}_t c_{t+k+1}^{CE} - \mathbb{E}_t c_{t+k}^{CE}\big) = -\tfrac{1}{2-\nu}\big(\bar{\rho}^{k+1} - \bar{\rho}^k\big)\tau_{S,t} = \tfrac{(1-\bar{\rho})\,\bar{\rho}^k}{2-\nu}\, \tau_{S,t},$$

and cumulating from $k = 0$, $\mathbb{E}_t c_{t+k}^{CE} = c_t^{CE} + \frac{1-\bar{\rho}^k}{(2-\nu)(\gamma+\Phi)}\, \tau_{S,t}$. Inserting this into (43) and using $\sum_{k\geq 0} \beta^k \bar{\rho}^k = \frac{1}{1-\beta\bar{\rho}}$ and $\sum_{k\geq 0} \beta^k (1-\bar{\rho}^k) = \frac{\beta(1-\bar{\rho})}{(1-\beta)(1-\beta\bar{\rho})}$,

$$\Lambda \left[\frac{c_t^{CE}}{1-\beta} + \frac{\beta(1-\bar{\rho})\,\tau_{S,t}}{(2-\nu)(\gamma+\Phi)(1-\beta)(1-\beta\bar{\rho})} \right] = \bar{R}\, b_{t-1}^{CE} + \frac{\nu(1-\nu)}{2-\nu}\, \frac{\tau_{S,t}}{1-\beta\bar{\rho}}.$$

Solving for c_t^{CE} delivers the first equality in (44) with θ_c as in (45); the second follows from (30). The wealth term $(1-\beta)\bar{R}\, b_{t-1}^{CE}/\Lambda$ is the annuity value of the predetermined external position, is known at $t-1$, and therefore drops out of every date-t conditional moment.

For (46), substitute (45) into $\kappa = (\gamma+\Phi)\theta_c + \frac{1}{2-\nu}$:

$$\kappa = \frac{1}{(2-\nu)(1-\beta\bar{\rho})}\left[\frac{(1-\beta)\nu(1-\nu)(\gamma+\Phi)}{\Lambda} - \beta(1-\bar{\rho}) + (1-\beta\bar{\rho})\right],$$

and note that $-\beta(1-\bar{\rho}) + (1-\beta\bar{\rho}) = 1-\beta$, which gives the stated expression; it is strictly positive because $\Lambda > 0$. Inverting, $\theta_c = \big(\kappa - \frac{1}{2-\nu}\big)/(\gamma+\Phi)$, and substituting into $\theta_e = -\Phi\theta_c - \frac{1}{2-\nu}$,

$$\theta_e = -\frac{\Phi\kappa - \frac{\Phi}{2-\nu} + \frac{\gamma+\Phi}{2-\nu}}{\gamma+\Phi} = -\frac{\Phi\kappa + \frac{\gamma}{2-\nu}}{\gamma+\Phi} \;<\; 0,$$

both terms in the numerator being strictly positive. Finally $\partial\kappa/\partial\gamma$ follows by inspection of (46). □

B.2.2 The uncertainty adjustment

Lemma B.3 (Uncertainty adjustment)**.** *Let $\Delta b_t \equiv b_t - b_t^{CE}$ denote the excess net foreign asset position relative to the certainty-equivalent economy, and let the date-t wedge in (31) be of the form $W_t = w\,\tau_{S,t}^2$ for a constant $w \geq 0$ - as it is possible to verify. Under Assumption B.1 and $b_{-1} = 0$, the equilibrium consumption path splits as $c_k = c_k^{CE} + x_k$, with c_k^{CE} the certainty-equivalent path of Lemma B.2, and*

$$x_t = -\frac{\beta\,W_t}{(\gamma+\Phi)\,(1-\beta\mu_2)} + \frac{(1-\beta)\,\bar{R}}{\Lambda}\,\Delta b_{t-1}, \qquad \Delta b_t = \bar{R}\,\Delta b_{t-1} - \Lambda\,x_t, \qquad \Delta b_{-1} = 0. \tag{47}$$

In particular, at $t = 0$,

$$x_0 = -\frac{\beta}{\gamma+\Phi}\sum_{j\geq 0}\beta^j\,\mathbb{E}_0 W_j = -\frac{\beta\,W_0}{(\gamma+\Phi)(1-\beta\mu_2)} \;<\; 0 \qquad \textit{whenever } \sigma_S^2 > 0,\ \tau_{S,0} \neq 0, \tag{48}$$

and $\sum_{k\geq 0}\beta^k\mathbb{E}_0 x_k = 0$: uncertainty redistributes consumption across dates without altering its present value.

Proof. Subtracting the certainty-equivalent system from (31), the common tariff terms cancel and the drift of $\{x_k\}$ obeys

$$(\gamma+\Phi)\big(\mathbb{E}_t x_{t+1} - x_t\big) = W_t, \tag{49}$$

with $W_t = w\,\tau_{S,t}^2$ measurable with respect to date-t information. The level of x_t

is pinned down by (43), whose right-hand side involves the tariff only through $\mathbb{E}_t \tau_{S,t+k} = \bar{\rho}^k \tau_{S,t}$, identical in the two economies; differencing therefore gives

$$\sum_{k \geq 0} \beta^k \, \mathbb{E}_t x_{t+k} = \frac{\bar{R} \, \Delta b_{t-1}}{\Lambda}, \tag{50}$$

using $\Lambda > 0$. Condition (50) holds at every date and state, which is what delivers the policy function in (47) rather than the date-0 value of x_0 alone.

Cumulating (49) and using $\mathbb{E}_t W_{t+j} = \mu_2^j W_t$ (Lemma B.1),

$$\mathbb{E}_t x_{t+k} = x_t + \frac{W_t}{\gamma + \Phi} \frac{1 - \mu_2^k}{1 - \mu_2}, \qquad k \geq 0,$$

finite for every k because $\mu_2 < 1$. Substituting into (50) and using $\frac{1}{1-\beta} - \frac{1}{1-\beta\mu_2} = \frac{\beta(1-\mu_2)}{(1-\beta)(1-\beta\mu_2)}$,

$$\frac{x_t}{1-\beta} + \frac{\beta \, W_t}{(\gamma+\Phi)(1-\beta)(1-\beta\mu_2)} = \frac{\bar{R} \, \Delta b_{t-1}}{\Lambda},$$

which is (47); the accumulation equation for Δb_t follows by differencing (25) across the two economies. Setting $t = 0$ with $\Delta b_{-1} = 0$ gives the second equality in (48), negative whenever $W_0 > 0$. The first equality in (48) is the equivalent forward-sum representation: cumulating (49) in $\mathbb{E}_0$ and substituting into (50) at $t = 0$ with $\sum_{k \geq j+1} \beta^k = \beta^{j+1}/(1-\beta)$,

$$\frac{x_0}{1-\beta} + \frac{1}{(\gamma+\Phi)(1-\beta)} \sum_{j \geq 0} \beta^{j+1} \, \mathbb{E}_0 W_j = 0,$$

the interchange of summation being valid because $W_j \geq 0$ and $\sum_j \beta^j \mathbb{E}_0 W_j = W_0/(1-\beta\mu_2) < \infty$ under Assumption B.1. □

Setting $\mathbb{E}_0 W_j = 0$ for $j \geq 1$ in (48) recovers the one-time-risk expression $x_0 = -\beta W_0/(\gamma+\Phi)$. The amplification factor is $(1-\beta\mu_2)^{-1} = \left[1 - \beta(\bar{\rho}^2 + \sigma_S^2)\right]^{-1}$, and not $(1-\beta\bar{\rho}^2)^{-1}$: persistence uncertainty raises the second moment of ρ above $\bar{\rho}^2$ and thereby the persistence of the wedge itself.

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