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TARIFF STAGGERING

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ABSTRACT

Using a panel of U.S. imports and customs duties at the HS 6-digit level, we document that in a typical quarter about 20 percent of tariffs rise, 20 percent fall, and 60 percent remain unchanged. Motivated by these facts, we develop a model of staggered tariff setting and embed it in a dynamic open-economy framework. Staggering changes the dynamics of the cross-sectional mean tariff, generating hump-shaped macroeconomic responses to tariff shocks. Staggering also overturns the Razin–Svensson trade- balance neutrality result for permanent tariff increases, because the gradual adjustment of the mean tariff creates an anticipation effect that induces agents to front-load net imports. Inherited tariff dispersion has first-order macroeconomic effects, allowing tariff harmonization to be studied with linear approximation methods. We find that eliminating tariff dispersion while holding the mean tariff unchanged has effects akin to a transitory tariff cut in an economy without staggering.

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1 Introduction

Studies of the macroeconomic effects of tariffs often assume a single uniform tariff. In the data, however, tariffs vary significantly not only over time but also across goods. In any given period, policymakers select some product lines and change their dutiability status, leave the tariffs of other dutiable product lines unchanged, raise tariffs on some dutiable goods, and lower tariffs on others. How is this pattern reflected in the distribution of import tariffs across goods and over time? What are the macroeconomic effects of this form of tariff adjustment? And what are the consequences of eliminating tariff dispersion through tariff harmonization?

To address these questions, we begin by analyzing tariff movements in a panel of U.S. imports of goods and customs duties at a quarterly frequency from 1990:Q1 to 2026:Q1 at the HTS 6-digit product level. We document four features of U.S. tariff policy. First, on average, about 75 percent of imports are dutiable. Second, in a typical quarter, about 60 percent of dutiable product lines experience no change in their tariff rates. Third, conditional on being dutiable, a tariff spell lasts an average of four quarters. Fourth, among dutiable product lines whose tariff rates do change, roughly half experience increases and half decreases. Taken together, these patterns point to a staggered process of tariff adjustment.

Motivated by these empirical regularities, we develop a model of staggered import tariff setting. In each period, the government resets the import tariff on a randomly selected fraction $1 - \theta$ of goods, while the remaining fraction θ retain their previous-period tariffs. The reset tariff follows an exogenous stochastic process. We show that tariff staggering alters the law of motion of the cross-sectional mean tariff, the variable whose macroeconomic effects are typically studied in the related literature. Specifically, staggering raises the order of its autoregressive representation by one. Thus, if the reset tariff follows an AR(1) process with persistence ρ , the cross-sectional mean tariff follows an AR(2) process with first-lag coefficient $\theta + \rho$ and second-lag coefficient $-\theta\rho$. By contrast, absent staggering, the cross-sectional mean tariff coincides with the reset tariff and therefore follows the same AR(1) process.

We then test the empirical implications of this prediction. We show that in U.S. data, the preferred autoregressive representation of the reset tariff rate is an AR(1) process. Tariff staggering then implies that the mean tariff rate should follow an AR(2) process. We test this prediction and establish that the preferred autoregressive representation for the mean tariff is indeed AR(2). Furthermore, we show that the hypothesis that the estimated coefficients of this AR(2) process are equal to the coefficients predicted by the staggering model cannot be rejected at conventional confidence levels. These findings imply that studies that abstract from tariff staggering and represent tariff policy with a single uniform rate should specify

that rate as an AR(2), rather than the commonly assumed AR(1), if they are to capture equilibrium dynamics. This result is important because, as we show in this paper, the assumed tariff process materially affects the transmission of tariff shocks.

We embed tariff staggering in a dynamic open economy model. We keep the scale of the model small, but make an effort to ensure that imports enter the economy in a roundabout way, to reflect the fact that imports serve as inputs at all stages of the production process from the most upstream level down to final absorption.

The economy features an import sector consisting of a continuum of importers, each of which combines a variety of imported material with a corresponding variety of labor to produce a differentiated import good. This stage of production captures the labor services required to make imported materials suitable for use in domestic production or final consumption, such as customs clearance, transportation, and distribution. A competitive firm then combines the differentiated import goods into a composite import good, which it sells to final-good producers and consumers. Final-good firms operate in two sectors: one produces a nontradable good sold only domestically, and the other produces an exportable good sold only in foreign markets. Households consume the composite import good and the nontradable good and supply differentiated labor to all three sectors.

We show that tariff staggering and the additional propagation mechanism it invokes produces hump-shaped responses in endogenous variables, with important implications for forecasts at business-cycle horizons. For example, following a tariff increase that improves the trade balance on impact, a model that ignores staggering predicts a deterioration at every subsequent horizon, whereas a model that incorporates staggering predicts further improvements over the next several quarters.

Tariff staggering also has important implications for the macroeconomic effects of reforms that permanently reduce the mean tariff. A classic result in open-economy macroeconomics, emphasized by Razin and Svensson (1983) and Calvo (1987), is that, unlike a temporary tariff cut, a permanent tariff cut has no effect on the trade balance, even though it may increase both imports and exports and thereby make the economy more open to trade. The intuition is that a permanent tariff cut lowers the relative price of imports by the same amount today and in the future, leaving intertemporal relative prices unchanged. Optimizing households therefore have no incentive to reallocate domestic absorption across time. Under tariff staggering, by contrast, a permanent reduction in the reset tariff is incorporated only gradually into the mean tariff. Because imports are expected to become progressively cheaper, households postpone imported purchases, generating an anticipatory effect on the trade balance. In particular, we show that a permanent tariff cut initially improves the trade balance as agents anticipate that an increasing number of product lines will face lower tariffs

over time.

The proposed tariff-staggering model provides a convenient framework for studying the quantitative effects of tariff harmonization. This is important because tariff reforms typically involve reductions not only in the mean tariff but also in the cross-sectional dispersion of tariffs. An important question in international economics is how tariff harmonization, that is, a reduction in dispersion that leaves the mean tariff unchanged, affects imports, exports, the current account, and the domestic economy. As we demonstrate, inherited tariff dispersion has first-order effects. To illustrate this result, we consider a reform that eliminates the tariff dispersion observed in the United States in 2025:Q2, the quarter of the so-called Liberation Day tariff increases, while preserving its cross-sectional mean. We find that, despite leaving the mean tariff unchanged, harmonization has effects similar to those set in motion by a transitory cut in the tariff rate in an economy without staggering. The intuition is that, when tariffs are dispersed, importers shift purchases toward goods subject to below-average tariffs, making the effective tariff lower than the mean tariff. As dispersion gradually disappears under harmonization, these opportunities diminish, raising the effective tariff toward the uniform-tariff level. Consequently, during the transition, the effective tariff is below its post-harmonization steady-state level. Imports, exports, and domestic absorption therefore converge to their steady-state levels from above, while the trade balance converges from below. There is a key distinction between tariff harmonization in the presence of staggering and a transitory tariff cut in a uniform-tariff economy. This is because tariff dispersion introduces a cross-sectional misallocation of imports and labor that is welfare decreasing and, by construction, absent in the uniform-tariff economy.

The present investigation relates to three strands of research in macroeconomics and international economics. First, our formulation of tariff policy draws on the literature on staggered price adjustment, particularly the models of price setting developed by Calvo (1983), Yun (1996), and Woodford (2003), and the large literature that followed. Our analysis of tariff harmonization is related to Yun (2005), who studies optimal monetary policy in a New Keynesian model with relative price dispersion. Beyond the fact that our analysis concerns tariffs rather than nominal prices, the source of staggering also differs. In New Keynesian models, staggered price adjustment reflects frictions faced by private firms. In our setting, staggered tariff adjustment may instead reflect political and administrative constraints faced by policymakers. Following a change in trade-policy objectives, governments may find it difficult to replace the inherited tariff schedule all at once and may therefore implement reforms progressively across product lines. We do not model these constraints explicitly but interpret them as a possible source of the staggered tariff adjustment documented in the data.

Second, the paper relates to the international-trade literature that seeks to summarize a dispersed tariff structure with a uniform tariff under a specified metric. In particular, it is connected to work on trade restrictiveness indices (TRI) that characterizes, approximates, and measures welfare-equivalent uniform tariffs (Anderson and Neary, 1994; Feenstra, 1995; Kee, Nicita, and Olarreaga, 2009; and Irwin, 2010). We complement this literature by providing a model of how the type of tariff dispersion observed in the data can arise and evolve, embedding this mechanism in a dynamic general-equilibrium framework, and studying its implications for macroeconomic adjustment.

Third, we contribute to the growing literature on the measurement and macroeconomic effects of tariff shocks. Recent work constructs measures of tariff shocks suitable for aggregate time-series analysis (Boer and Rieth, 2024; den Besten et al., 2026; Schmitt-Grohé and Uribe, 2025, 2026). In the present study, we show that tariff staggering creates a macroeconomically meaningful distinction between innovations to tariff policy, represented by the reset tariff in our model, and movements in the cross-sectional mean tariff.

The dynamic effects of tariff harmonization in general equilibrium has been less studied. Alessandria and Avila (2023) examine Colombia’s 1989–1993 tariff liberalization, which included a reduction in tariff dispersion, through the lens of a dynamic model with export frictions. Our approach contributes by showing that the proposed tariff staggering framework permits the analysis of the effects of reforms that alter tariff dispersion to be studied using first-order perturbation methods.

Finally, the paper contributes to the rapidly growing literature on the short-run effects of tariff shocks and their implications for monetary policy (Amiti et al., 2024; Auclert et al., 2025; Auray et al., 2022, 2024; Barattieri et al., 2021; Bergin and Corsetti, 2023; Bianchi and Coulibaly, 2025; Costinot and Werning, 2025; Cuba-Borda et al., 2025; Erceg et al., 2023; Ferrante et al., 2026; Itskhoki and Mukhin, 2025; Werning et al., 2025). Much of this literature represents tariff policy using a single aggregate tariff rate. Our analysis complements this approach by examining the implications of allowing movements in the mean tariff to reflect, in part, changes in the cross-sectional distribution of tariffs.

The remainder of the paper is organized as follows. Section 2 presents empirical evidence on tariff staggering. Section 3 develops a model of staggered tariff adjustment, shows how it affects the laws of motion of the cross-sectional mean tariff, and estimates the time paths and laws of motion of the variables governing U.S. import tariff policy. Section 4 embeds this tariff process in a dynamic general equilibrium model of an open economy. Section 5 studies the macroeconomic effects of transitory and permanent tariff changes. Section 6 studies tariff harmonization. Section 7 concludes.

2 Evidence on Tariff Staggering

We use data on U.S. imports of goods and customs duties at a quarterly frequency from 1990:Q1 to 2026:Q1 at the HTS 6-digit product level. We obtain the data from USITC DataWeb (U.S. International Trade Commission, 2026) and use Harmonized System correspondence tables from the United Nations Statistics Division (2026) to track product codes across revisions of the classification. Appendix A provides more details on the construction of the data we use. We impose a balanced panel. This results in a panel containing 4,022 import goods each quarter. The data covers 92 percent of imports on average and at least 88 percent in each quarter. It also represents 97 percent of total duties on average and at least 91 percent of duties in each quarter.

We measure the import tariff rate of product i in period t , as the ratio of custom duties to imports. Formally, letting m_{it} denote the value of imports of product i in period t and d_{it} duties on product i in period t , the import tariff rate on good i in period t , denoted τ_{it} , is given by

$$\tau_{it} = \frac{d_{it}}{m_{it}}.$$

Let τ_t denote the cross-sectional mean tariff in period t . We construct a fixed-weight measure of the mean tariff as

$$\tau_t = \sum_i \omega_i \tau_{it}, \quad (1)$$

where ω_i is the 2006 import share of product i , that is, $\omega_i = \frac{1}{4} \sum_{j=1}^4 m_{i2006:Qj} / m_{2006:Qj}$, where $m_{i2006:Qj}$ denotes imports of good i in 2006:Qj and $m_{2006:Qj} = \sum_i m_{i2006:Qj}$, for $j = 1, \dots, 4$, denotes total imports in 2006:Qj. We use 2006 import shares as fixed weights because 2006 is near the midpoint of the sample, is unaffected by either the global financial crisis or the COVID-19 pandemic, and falls within a period of comparatively stable U.S. tariff policy.

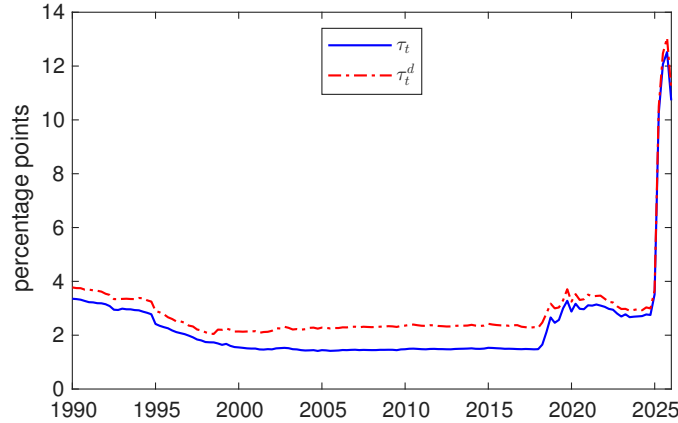
We also construct the cross-sectional mean tariff conditional on the good being dutiable. Specifically, let τ_t^d denote the fixed-weight cross-sectional mean tariff rate on dutiable goods in period t , again using 2006 import shares as weights. Then τ_t^d is given by

$$\tau_t^d = \sum_i \frac{\omega_i}{\omega_t} \tau_{it} \mathcal{I}(\tau_{it} > 0), \quad (2)$$

where $\omega_t = \sum_i \omega_i \mathcal{I}(\tau_{it} > 0)$ is the sum of 2006 import shares of goods that are dutiable in period t , and $\mathcal{I}(\cdot)$ is an indicator function.

Figure 1 displays the cross-sectional mean tariff rates τ_t and τ_t^d , over the period 1990:Q1 to 2026:Q1. Over this period, the mean of τ_t is 2.3 percent, and the mean of τ_t^d is 2.9 percent. The sample spans periods of trade liberalization, relatively stable tariffs, and a

Figure 1: Cross-Sectional Mean Tariff Rates: United States, 1990:Q1 to 2026:Q1



Notes. The cross-sectional fixed-weight mean tariff rates, τ_t and τ_t^d , are calculated using the formulas given in (1) and (2). The data are a balanced quarterly panel constructed by the authors from product-level data on imports and import duties obtained from USITC DataWeb, together with Harmonized System correspondence tables from the United Nations Statistics Division. The panel contains 4,022 product lines at the HTS 6-digit level and spans the period 1990:Q1 to 2026:Q1.

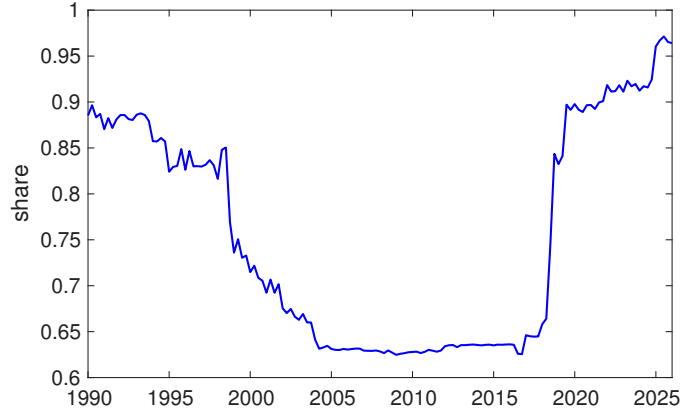
return to protectionism. At the beginning of the sample, τ_t stood at about 3.5 percent. As a consequence of a number of trade agreements, especially NAFTA and the Uruguay Rounds, τ_t declines, reaching about 1.5 percent by the late 1990s. It stays at approximately that level until 2018, when the first Trump administration shifts U.S. trade policy toward protectionism. Between 2018 and 2019, τ_t rises to close to 3 percent and remains near that level during much of the Biden administration. The second Trump administration intensifies protectionist measures, raising τ_t dramatically to above 10 percent starting in 2025:Q2, with a peak of 12.5 percent at the end of 2025. The tariff rate on dutiable goods, τ_t^d , displays a similar pattern, with, of course, a higher mean level.

We now look under the hood, to see how changes in the mean tariff are distributed across individual product lines. We define the dutiable share as the share of imports of goods subject to a positive import tariff rate. We continue to use 2006 import shares as weights. Letting s_t denote the dutiable share in period t , we have that

$$s_t = \sum_i \omega_i \mathcal{I}(\tau_{it} > 0). \quad (3)$$

Figure 2 displays the dutiable share, s_t , over the period 1990:Q1 to 2026:Q1. It shows that in a typical quarter the majority of imports are subject to import duties. On average across time 75 percent of imports are dutiable. At the beginning of the sample, the dutiable

Figure 2: The Share of Dutiable Goods: United States, 1990:Q1 to 2026:Q1



Notes. The dutiable share, s_t , is the share of goods subject to a positive import tariff and is calculated using the formula given in equation (3). The data to calculate s_t is described in the notes to Figure 1.

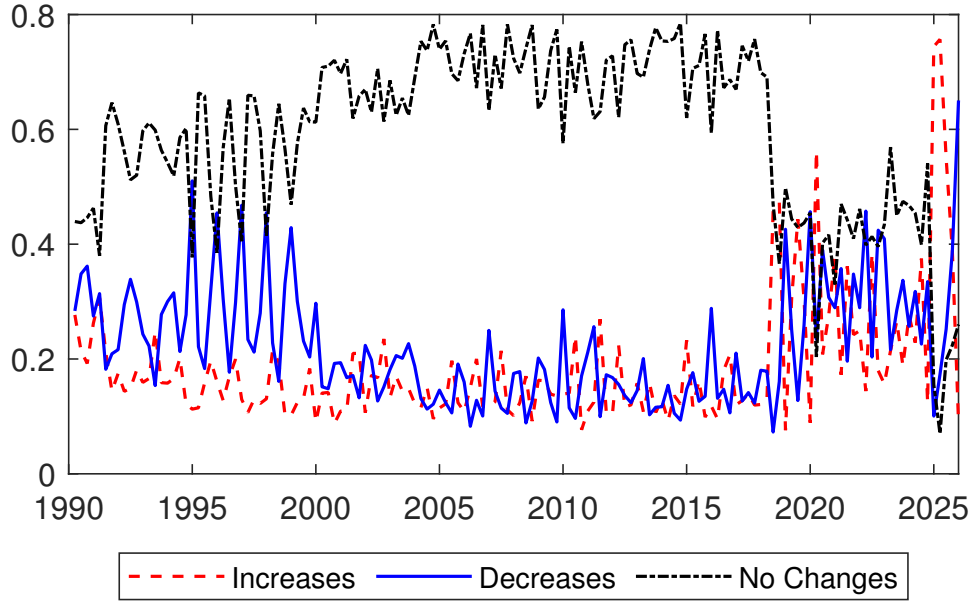
share was close to 90 percent, but then, in line with the broader process of U.S. trade liberalization described above, declined steadily over the following 15 years. By 2004, the dutiable share had fallen below 65 percent and remained at that level until 2017. As the United States returned to protectionist trade policy in 2018, the dutiable share rose sharply. The first Trump administration imposed tariffs on a large number of previously duty-free goods bringing the dutiable share back to 90 percent, the value observed at the beginning of the sample. The second Trump administration brought the dutiable share even higher to 95 percent, leaving just 5 percent of U.S. imports duty free.

Viewed jointly, Figures 1 and 2 suggest that the 1990s were a period of trade liberalization along both the intensive and extensive margins of tariff policy: the average tariff conditional on dutiability and the dutiable share both declined significantly. From roughly 2004 to 2017, tariff policy was comparatively stable, with a low average tariff and a large share of imports entering duty free. The tariff increases introduced by the first Trump administration in 2018 operated through both margins. The tariff increases introduced by the second Trump administration in 2025 operated primarily through the intensive margin: tariff rates rose sharply, while the dutiable share increased only modestly, almost by necessity, as it was already close to one hundred percent.

2.1 Tariff Adjustment Across Product Lines

We now analyze the observed behavior of tariffs within the group of dutiable goods. Figure 3 displays the time paths of the shares of tariff increases, tariff cuts, and no tariff changes among dutiable goods. Because τ_{it} is constructed from data on duties and imports, it may

Figure 3: Shares of Dutiable Product Lines with Tariff Decreases, Increases, and No Changes: United States, 1990:Q1 to 2026:Q1



Notes. See notes to Figure 1.

be affected by measurement error or by changes in the composition of imports, either across products within a product line or across source countries for a given individual product. We therefore need to take a stand on what constitutes a tariff change, that is, on when $\tau_{it} \neq \tau_{i,t-1}$. We classify a tariff movement as a change if its absolute value is at least 0.1 percentage points. A smaller movement is also classified as a tariff change if it involves a change in dutiability status, that is, a movement from zero to a positive tariff or from a positive tariff to zero. Individual product lines are weighted by their 2006 import shares.

Among all dutiable product lines, around 20 percent experience tariff increases from one quarter to the next, 20 percent experience tariff cuts, and 60 percent remain unchanged. Figure 3 shows that the fluidity of tariff rates within the dutiable set is not confined to particular episodes, but is present throughout the sample. In most quarters, the set of product lines experiencing tariff increases, the set experiencing tariff cuts, and the set experiencing no tariff changes are all quantitatively relevant. Thus, in a given period, the government does not simply adjust all tariffs in the same direction, but instead tends to increase some tariffs, decrease others, and leave still others unchanged.

The tariff cuts of the period 1994–2000 and the tariff hike of the first Trump administration are noteworthy. During the first of these two periods, the average tariff fell, triggered by the cuts under NAFTA and the Uruguay Round. Understandably, as is evident in Fig-

Table 1: Average Number and Duration of Tariff Spells

	Unconditional	Conditional on Dutiable	Conditional on Duty Free
Average number of spells	46	45	1
Average duration (quarters)	5	4	41

Notes. Weighed averages using import shares of 2006. U.S. quarterly data from 1990:Q1 to 2026:Q1.

ure 3, the share of tariff cuts increased.¹ However, the shares of tariff increases and of no tariff changes continued to be sizable. Similarly, during the first Trump administration, the average tariff increased, and, as a result, there was an uptick in the share of product lines with tariff increases. Yet, the share of tariff cuts also increased during this episode. The share of product lines with no tariff change fell, of course, but remained sizable.

2.2 Tariff Spells and Duration

Table 1 reports the weighted average number and duration of complete tariff spells, both unconditionally and conditional on dutiability status. A tariff spell is defined as an interval during which the tariff rate on a particular product line remains unchanged.² Over the sample period, 1990:Q1–2026:Q1, the weighted average number of spells is 46 per product line, and their average duration is 5 quarters. Most spells occur while products are dutiable: Conditional on being dutiable, the average number of spells is 45 per product line, with an average duration of 4 quarters. Duty-free spells are much rarer but substantially longer. The average product line experiences only 1 duty-free spell, but this spell lasts an average of 41 quarters.

Taken together, the empirical evidence presented here suggests three relevant features of U.S. tariff policy. First, conditional on being dutiable, tariff rates are fluid: in a typical quarter, substantial fractions of product lines experience tariff increases, tariff cuts, or no change. Second, the majority of product lines is dutiable in any given quarter. Third, a positive tariff remains in place for about one year, on average, before being reset, whereas a duty-free product line retains a zero tariff for about ten years.

These patterns motivate modeling tariff policy as a staggered process in which tariff adjustments occur asynchronously across product lines and in both directions.

¹The ups and downs in the share of tariff cuts between 1994 and 2000 are likely related to the staged implementation of tariff reductions under NAFTA and the Uruguay Round commitments, many of which took effect at the beginning of calendar years.

²The initial and terminal spells are excluded because their durations are censored.

3 Staggered Tariff Adjustment

Motivated by the evidence in section 2, we propose a model with staggered tariff policy inspired by formulations of price setting in the tradition of Calvo (1983). This section develops the tariff-setting mechanism, characterizes the dynamics of the cross-sectional mean tariff, and disciplines the tariff process using U.S. data.

3.1 A Model of Tariff Staggering

The government sets import tariffs in a staggered fashion. For simplicity, we focus on the case in which all import goods are dutiable. In the notation of section 2, this assumption implies that $s_t = 1$ for all t . We assume that in each period, a randomly selected fraction θ of imported-good varieties retains its previous tariff, τ_{it-1} , while the remaining fraction $1 - \theta$ is assigned a newly set tariff, denoted $\tilde{\tau}_t$, which is assumed to follow an exogenous stochastic process.

For any real number k , let

$$\mathcal{T}_t(k) \equiv \int_0^1 (1 + \tau_{it})^k di$$

denote the k th cross-sectional moment of the gross tariff, $1 + \tau_{it}$. Staggered tariff setting implies the recursive law of motion for $\mathcal{T}_t(k)$

$$\mathcal{T}_t(k) = \theta \mathcal{T}_{t-1}(k) + (1 - \theta)(1 + \tilde{\tau}_t)^k. \quad (4)$$

The cross-sectional mean of gross import tariffs, denoted $1 + \tau_t$, satisfies $1 + \tau_t \equiv \mathcal{T}_t(1)$ and thus evolves according to

$$1 + \tau_t = \theta(1 + \tau_{t-1}) + (1 - \theta)(1 + \tilde{\tau}_t). \quad (5)$$

For a given autoregressive process for the reset tariff $\tilde{\tau}_t$, tariff staggering raises the autoregressive order of the mean tariff τ_t by one. To see this, suppose that the reset tariff follows the AR(1) process

$$\tilde{\tau}_t - \tilde{\tau} = \rho_{\tilde{\tau}}(\tilde{\tau}_{t-1} - \tilde{\tau}) + \sigma_{\tilde{\tau}}\epsilon_t^{\tilde{\tau}}, \quad (6)$$

where $\epsilon_t^{\tilde{\tau}}$ distributes i.i.d. $\mathcal{N}(0, 1)$, and $\rho_{\tilde{\tau}} \in [0, 1)$, $\sigma_{\tilde{\tau}} > 0$, and $\tilde{\tau} > 0$ are parameters. Then, combining this expression with equation (5), which links the reset tariff with the mean tariff, gives

$$\tau_t - \tilde{\tau} = (\theta + \rho_{\tilde{\tau}})(\tau_{t-1} - \tilde{\tau}) - \theta\rho_{\tilde{\tau}}(\tau_{t-2} - \tilde{\tau}) + (1 - \theta)\sigma_{\tilde{\tau}}\epsilon_t^{\tilde{\tau}}. \quad (7)$$

Thus, when the reset tariff $\tilde{\tau}_t$ follows an AR(1) process, the cross-sectional mean tariff, τ_t , follows an AR(2) process. If $\theta > 0$, $\rho_{\tilde{\tau}} \in (0, 1)$, and $\theta + \rho_{\tilde{\tau}} > 1$, which, as we will see shortly, is the case of greatest empirical interest, the response of the cross-sectional mean tariff to a $\tilde{\tau}_t$ shock is hump-shaped.

3.2 Estimating the Tariff-Staggering Process

We now take the predicted relationship between the reset tariff and the cross-sectional mean tariff to the data and show that, among the autoregressive specifications, an AR(1) process for the reset tariff and an AR(2) process for the cross-sectional mean tariff are the most empirically relevant ones. This result is important because, as explained above, the dynamics of the cross-sectional mean tariff shape the aggregate effects of tariff shocks, and because the vast majority of quantitative studies of the macroeconomic effects of tariff shocks assume a uniform tariff governed by an AR(1) process.

We begin by calibrating θ , the parameter governing the degree of tariff inertia. According to the model of tariff staggering presented above, the expected duration of any tariff τ_{it} is given by $(1 - \theta) \sum_{j=1}^{\infty} j\theta^{j-1} = 1/(1 - \theta)$ quarters. In section 2, we showed that the average duration of tariffs on dutiable goods is 4 quarters (see Table 1). The implied value of θ is therefore 0.75.³

With the observed time series of the average tariff for dutiable goods and an estimate for θ in hand, we can back out the time series of the reset tariff rate $\tilde{\tau}_t$ using equilibrium condition (5). The formula is

$$\tilde{\tau}_t = \frac{\tau_t - \theta\tau_{t-1}}{1 - \theta}.$$

In the context of the present model of tariff staggering, the empirically relevant measure of τ_t is the tariff rate on dutiable goods, which in the empirical analysis of section 2 is denoted τ_t^d and is plotted in Figure 1.

Assuming an autoregressive process for $\tilde{\tau}_t$, we test its order. In Appendix B, we compare AR(0), AR(1), and AR(2) specifications using the AIC, the BIC, and nested F -tests. All three procedures select the AR(1) specification. The estimated autoregressive coefficient of

³One might be tempted to compare the fraction of dutiable product lines with unchanged tariffs, about 0.60 in Figure 3, with the value of $\theta = 0.75$ implied by the average spell duration of four quarters reported in Table 1, and conclude that the two findings are inconsistent. However, they need not be. If the probability of tariff adjustment differs across product lines, the average expected spell duration is $E[1/(1 - \theta_i)]$, where θ_i denotes the probability that the tariff on product line i remains unchanged. By Jensen's inequality, $E[1/(1 - \theta_i)] \geq 1/(1 - E[\theta_i])$, with strict inequality if adjustment probabilities differ across product lines. Thus, an average fraction of unchanged tariffs of 0.60 implies a lower bound on the average expected spell duration of $1/(1 - 0.60) = 2.5$ quarters, but is entirely consistent with an average duration of four quarters. Nevertheless, a model with a common adjustment probability $\theta = 0.75$ cannot reproduce both empirical findings exactly.

the AR(1) specification is 0.62, and the estimated standard deviation of the innovation is 2.3. Accordingly, we set $\rho_{\tilde{\tau}} = 0.62$ and $\sigma_{\tilde{\tau}} = 2.3$, with tariffs expressed in percentage points.

Given that the reset tariff $\tilde{\tau}_t$ is estimated to follow an AR(1) process, the tariff staggering model predicts that the cross-sectional mean tariff, τ_t , should follow an AR(2) process. We now test this prediction using the time series τ_t^d . In Appendix B, we compare four specifications for the autoregressive representation of τ_t , AR(0), AR(1), AR(2), and AR(3), using the AIC, the BIC, and nested F -tests. All three procedures favor the AR(2) specification, lending support to the model's prediction.

The estimated coefficients on the first and second lags of the AR(2) process of τ_t are 1.395 and -0.511 , respectively. Their theoretical counterparts are $\theta + \rho_{\tilde{\tau}} = 0.75 + 0.62 = 1.37$ and $-\theta\rho_{\tilde{\tau}} = -0.75 \times 0.62 = -0.465$. In Appendix B, we show that the hypotheses that the estimated coefficients of the AR(2) process equal their theoretical counterparts cannot be rejected at conventional significance levels, either individually or jointly.

These results imply that models that abstract from tariff staggering should specify the assumed uniform import tariff as an AR(2) process, rather than follow the common practice of using an AR(1) specification, if they are to capture equilibrium dynamics accurately up to first order.

4 Tariff Staggering in General-Equilibrium

We now embed the staggered tariff model developed in section 3 in a dynamic open economy model. Following a common practice in the recent related literature, we assume that the economy is small to isolate the domestic transmission of tariff policy shocks (Auclert, Rognlie, and Straub, 2025; Bianchi and Coulibaly, 2025; Monacelli, 2025; and Werning, Lorenzoni, and Guerrieri, 2025). This assumption should be interpreted as holding foreign prices and interest rates fixed, rather than as a literal characterization of the size of the U.S. economy. Consequently, the analysis abstracts from terms-of-trade effects, foreign retaliation, and feedback through world interest rates.

The economy features three sectors. The first, called the import sector, consists of a continuum of importers that combine labor with imported materials to produce differentiated import goods. A competitive firm in this sector combines the differentiated import goods into a composite import good. The second sector produces exportable goods, and the third produces nontradable goods. Firms in the latter two sectors use labor and the composite import good as inputs. Households consume the composite import good and the nontradable good and supply labor to each of the three sectors.

4.1 The Import Sector

Each period $t \geq 0$, there is a continuum of importers indexed by $i \in [0, 1]$. Importer i combines labor of variety i , denoted h_{it}^m , with imported material of variety i , denoted m_{it} , to produce a differentiated import good, denoted z_{it} . This formulation captures the idea that imported materials may not be directly usable in domestic production. Rather, making them available as productive inputs may require domestic labor services associated with activities such as customs clearance, transportation, warehousing, handling, processing, assembly, and distribution. The production technology is

$$z_{it} = e^{a_t^m} (h_{it}^m)^\alpha (m_{it})^{1-\alpha},$$

where a_t^m is an exogenous sector-specific productivity shock, and $\alpha \in (0, 1)$ is a parameter. Importers behave competitively. Their demands for labor and imported materials satisfy

$$\alpha \frac{p_{it}^z z_{it}}{h_{it}^m} = w_{it}^m \quad (8)$$

and

$$(1 - \alpha) \frac{p_{it}^z z_{it}}{m_{it}} = p_{it}^m, \quad (9)$$

where p_{it}^z denotes the relative price of import good i , w_{it}^m denotes the wage paid to labor of variety i , and p_{it}^m denotes the domestic price of imported material of variety i . All prices and wages are expressed in units of the exportable good. In equilibrium, these firms make zero profits and price at marginal cost,

$$p_{it}^z = A e^{-a_t^m} (w_{it}^m)^\alpha (p_{it}^m)^{1-\alpha}, \quad (10)$$

where $A \equiv \alpha^{-\alpha} (1 - \alpha)^{-(1-\alpha)}$.

A competitive representative firm aggregates the differentiated import goods into a composite import good, denoted z_t , using the technology

$$z_t = \left[\int_0^1 z_{it}^{1-1/\eta} di \right]^{1/(1-1/\eta)},$$

where $\eta > 0$ is a parameter. Profit maximization implies the following demand function for import good i :

$$z_{it} = \left(\frac{p_{it}^z}{p_t^z} \right)^{-\eta} z_t, \quad (11)$$

with

$$p_t^z = \left[\int_0^1 (p_{it}^z)^{1-\eta} di \right]^{1/(1-\eta)}. \quad (12)$$

The variable p_t^z satisfies $p_t^z z_t = \int_0^1 p_{it}^z z_{it} di$. The firm makes zero profits, so p_t^z is the unit price of the composite import good z_t .

4.2 The Exportable and Nontradable Sectors

There is an exportable sector, denoted x , and a nontradable sector, denoted n . In each sector $s \in \{x, n\}$, a representative firm uses labor, h_t^s , and the composite import good, z_t^s , denoting the quantity of this good used in sector s , to produce a final good, y_t^s , according to

$$y_t^s = e^{a_t^s} F^s(h_t^s, z_t^s), \quad (13)$$

where a_t^s is an exogenous sector-specific productivity shock, and F^s is assumed to be increasing, concave, and homogeneous of degree one. The first-order conditions for profit maximization are

$$p_t^s e^{a_t^s} F_1^s(h_t^s, z_t^s) = w_t^s \quad (14)$$

and

$$p_t^s e^{a_t^s} F_2^s(h_t^s, z_t^s) = p_t^z. \quad (15)$$

Because F^s is linearly homogeneous, these firms make zero profits in equilibrium.

4.3 Households

There is a continuum of identical households with preferences over consumption, c_t , and sector-specific labor, h_t^x , h_t^n , and h_t^m . The representative household's lifetime utility function is

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, h_t^x, h_t^n, h_t^m),$$

where $\beta \in (0, 1)$ is the subjective discount factor, U is the period utility function, assumed to be increasing in its first argument, decreasing in all other arguments, and concave, and E_t is the expectations operator conditional on information available in period t .

Labor employed in the import sector is a composite of the differentiated labor varieties,

$$h_t^m = \left[\int_0^1 (h_{it}^m)^{1+1/\eta_h} di \right]^{1/(1+1/\eta_h)},$$

where $\eta_h > 0$ is a parameter. Conditional on h_t^m , the household chooses the supply of each labor variety to maximize labor income. The resulting variety-specific labor supply is

$$h_{it}^m = \left(\frac{w_{it}^m}{w_t^m} \right)^{\eta_h} h_t^m, \quad (16)$$

where

$$w_t^m \equiv \left[\int_0^1 (w_{it}^m)^{1+\eta_h} di \right]^{1/(1+\eta_h)} \quad (17)$$

satisfies $\int_0^1 w_{it}^m h_{it}^m di = w_t^m h_t^m$. Thus, w_t^m can be interpreted as the wage rate per unit of composite labor supplied to the import sector.

The final consumption good, c_t , is a linearly homogeneous composite of consumption of the composite import good, denoted c_t^z , and consumption of the nontradable good, denoted c_t^n ,

$$c_t = C(c_t^z, c_t^n). \quad (18)$$

Given c_t , the household chooses c_t^z and c_t^n to minimize expenditure, $p_t^z c_t^z + p_t^n c_t^n$, subject to (18). The optimality condition associated with this problem is

$$\frac{C_1(c_t^z, c_t^n)}{C_2(c_t^z, c_t^n)} = \frac{p_t^z}{p_t^n}, \quad (19)$$

and the unit cost of consumption, denoted p_t^c , satisfies

$$p_t^c c_t = p_t^z c_t^z + p_t^n c_t^n. \quad (20)$$

Households have access to an internationally traded bond that pays the real interest rate r_t , expressed in units of the exportable good, when held from period t to period $t+1$. They also receive a lump-sum transfer g_t from the government. Letting f_t denote the household's debt position, its sequential budget constraint is

$$f_{t-1} + p_t^c c_t = w_t^x h_t^x + w_t^n h_t^n + w_t^m h_t^m + g_t + \frac{f_t}{1+r_t}. \quad (21)$$

The household chooses processes for c_t , h_t^x , h_t^n , h_t^m , and f_t , to maximize its lifetime utility function subject to the above sequential budget constraint and to a borrowing limit that prevents it from engaging in Ponzi schemes. Letting $\beta^t \lambda_t$ denote the Lagrange multiplier on this constraint, the first-order conditions associated with the household's optimization problem are

$$-\frac{U_{h^x}(c_t, h_t^x, h_t^n, h_t^m)}{U_c(c_t, h_t^x, h_t^n, h_t^m)} = \frac{w_t^x}{p_t^c}, \quad (22)$$

$$\frac{U_{h^x}(c_t, h_t^x, h_t^n, h_t^m)}{U_{h^n}(c_t, h_t^x, h_t^n, h_t^m)} = \frac{w_t^x}{w_t^n}, \quad (23)$$

$$\frac{U_{h^x}(c_t, h_t^x, h_t^n, h_t^m)}{U_{h^m}(c_t, h_t^x, h_t^n, h_t^m)} = \frac{w_t^x}{w_t^m}, \quad (24)$$

$$U_c(c_t, h_t^x, h_t^n, h_t^m) = p_t^c \lambda_t, \quad (25)$$

and

$$\lambda_t = \beta(1 + r_t)E_t \lambda_{t+1}. \quad (26)$$

4.4 The Government

The government imposes import tariffs τ_{it} on imported materials m_{it} and rebates the resulting tariff revenue to households. Its period-by-period budget constraint is

$$\int_0^1 \tau_{it} p_{it}^{m*} m_{it} di = g_t, \quad (27)$$

where p_{it}^{m*} denotes the world price of imported material i in units of the exportable good. Tariff rates follow the staggered adjustment process introduced in section 3.1.

4.5 Aggregation and Equilibrium

We normalize the world prices of imported materials and the world price of the exportable good to one,

$$p_{it}^{m*} = p_t^x = 1.$$

We assume that the law of one price holds for all tradable goods. This implies, in particular, that the domestic relative price of imported materials equals the corresponding gross tariff rate,

$$p_{it}^m = 1 + \tau_{it}. \quad (28)$$

In equilibrium, the relative price of the composite import good, p_t^z , satisfies (see Appendix C.1 for a proof)

$$p_t^z = A e^{-a_t^m} (w_t^m)^\alpha \left[(1 + \tau_t) D_t(\zeta)^{\frac{1}{\zeta}} \right]^{1-\alpha}, \quad (29)$$

where, for any real k ,

$$D_t(k) \equiv \frac{\mathcal{I}_t(k)}{(1 + \tau_t)^k}, \quad (30)$$

and

$$\zeta \equiv \frac{(1-\eta)(1-\alpha)(1+\eta_h)}{1+\eta_h-\alpha(1-\eta)} < 1. \quad (31)$$

The factor $D_t(\zeta)$ is a tariff dispersion term. In the absence of tariff dispersion, that is, when $\tau_{it} = \tau_t$ for all i , $D_t(\zeta) = 1$, and the equation for the equilibrium price of p_t^z is the same as in an economy with a uniform tariff. As we show in Appendix C.2, for $\eta > 0$, we have that the dispersion factor $D_t(\zeta)^{1/\zeta}$ in equation (29) is less than one. The intuition for $D_t(\zeta)^{1/\zeta} < 1$ is that when tariffs are cross-sectionally dispersed, importers favor varieties with below-average tariffs, lowering the price of the composite import good relative to an environment with a uniform tariff equal to the average tariff in the environment with tariff dispersion. Put differently, because $[(1+\tau_t)D_t(\zeta)^{1/\zeta}] < (1+\tau_t)$, tariff dispersion acts like a reduction in the mean tariff.

The dispersion factor $D_t(\zeta)^{1/\zeta}$ is strictly increasing in ζ in the presence of tariff dispersion. Since ζ is decreasing in the elasticity of substitution η , the price-reducing effect of tariff dispersion becomes stronger as imported varieties become more substitutable. Intuitively, greater substitutability allows producers of the composite import good to shift more easily toward varieties subject to lower tariffs, thereby reducing production costs. This relationship is particularly transparent when $\alpha = 0$, that is, when the production of z_{it} takes only imported materials as inputs, in which case $\zeta = 1 - \eta$.

To find aggregate employment in the import sector, h_t^m , multiply optimality condition (8) by h_{it}^m and then integrate the resulting expression over i . Then use the zero-profit condition in the sector producing the composite import good, $p_t^z z_t = \int_0^1 p_{it}^z z_{it} di$, and the fact that $w_t^m h_t^m = \int_0^1 w_{it}^m h_{it}^m di$, to obtain

$$\frac{w_t^m h_t^m}{p_t^z z_t} = \alpha, \quad (32)$$

which says that the standard Cobb–Douglas labor-share condition holds in aggregate in the import sector, despite wage dispersion.

Aggregate imports, m_t , are defined as $m_t \equiv \int_0^1 p_{it}^{m*} m_{it} di = \int_0^1 m_{it} di$. In Appendix C.3, we show that

$$\frac{\left[(1+\tau_t) \frac{D_t(\zeta)}{D_t(\zeta-1)} \right] m_t}{p_t^z z_t} = (1-\alpha). \quad (33)$$

Because in the absence of tariff dispersion, $D_t(k) = 1$ for any k , we have that in this case equilibrium condition (33) has the interpretation that the cost share of imports is equal to $1 - \alpha$. In Appendix C.4, we show that, in the presence of tariff dispersion, the factor $D_t(\zeta)/D_t(\zeta-1) < 1$. Thus, $\left[(1+\tau_t) \frac{D_t(\zeta)}{D_t(\zeta-1)} \right] < (1+\tau_t)$, or in words, given the cross-sectional mean tariff τ_t , cross-sectional tariff dispersion acts like a reduction in the mean tariff.

Market clearing for the composite import good and for nontradable goods requires, respectively,

$$z_t = z_t^x + z_t^n + c_t^z \quad (34)$$

and

$$y_t^n = c_t^n. \quad (35)$$

Combining the household's budget constraint (21), the government's budget constraint (27), the market-clearing conditions (34) and (35), and the fact that all firms make zero profits, yields the country's resource constraint

$$f_{t-1} = y_t^x - m_t + \frac{f_t}{1 + r_t}. \quad (36)$$

Finally, following Schmitt-Grohé and Uribe (2003), we assume that the country interest rate, r_t is the sum of an exogenous world interest rate, denoted r_t^* and a debt elastic country premium. Specifically, r_t satisfies

$$1 + r_t = 1 + r_t^* + \Gamma(e^{-f_t + \bar{f}} - 1), \quad (37)$$

where $\Gamma > 0$ and $\bar{f}$ are parameters.

We are now ready to define a competitive equilibrium.

Definition 1 (Competitive Equilibrium) *A competitive equilibrium is a set of processes $y_t^x, y_t^n, h_t^x, h_t^n, z_t^x, z_t^n, w_t^x, w_t^n, p_t^x, p_t^n, p_t^z, c_t, c_t^z, c_t^n, h_t^m, w_t^m, m_t, f_t, \lambda_t, z_t, r_t, \tau_t$, and $\mathcal{T}_t(k)$ and $D_t(k)$, for $k \in \{\zeta, \zeta - 1\}$, satisfying (5), (18)–(20), (22)–(26), (29), (32)–(37); (13)–(15), for $s = x, n$; and (4) and (30), for $k = \zeta, \zeta - 1$, given the exogenous processes a_t^s , $s = x, n, m$, r_t^* , and $\tilde{\tau}_t$, the normalization $p_t^x = 1$, the initial debt position f_{-1} , and the initial tariff moments τ_{-1} and $\mathcal{T}_{-1}(k)$, for $k = \zeta, \zeta - 1$.*

To characterize the dynamics implied by the tariff staggering model, we adopt a numerical approach.

4.6 Functional Forms

We adopt the following functional forms for preferences, production technologies, and aggregation technologies: The assumed period utility function is CRRA in consumption and isoelastic in sectoral labor,

$$U(c, h^x, h^n, h^m) = \frac{c^{1-\kappa} - 1}{1 - \kappa} - \frac{\psi_x(h^x)^{1+v}}{1 + v} - \frac{\psi_n(h^n)^{1+v}}{1 + v} - \frac{\psi_m(h^m)^{1+v}}{1 + v},$$

Table 2: Structural Parameters

Parameter	Value	Description
α	0.15	Labor share, imports
α_x	0.80	Labor share, exports
α_n	0.94	Labor share, nontradables
β	$1.04^{-1/4}$	Discount factor
κ	2	Risk aversion
v	1	Inverse labor-supply elasticity
ψ_x	8.79	Labor weight, exports
ψ_n	3.63	Labor weight, nontradables
ψ_m	2.49	Labor weight, imports
ξ	0.10	Import consumption share
η	1.63	Import-variety elasticity
η_h	6	Labor-variety elasticity
Γ	0.0001	Debt-premium elasticity
$\bar{f}$	-2.45	Steady-state external debt
r^*	$1.04^{1/4} - 1$	World interest rate
θ	0.75	Tariff inertia
$\tilde{\tau}$	0.029	Steady-state reset tariff
$\rho_{\tilde{\tau}}$	0.62	Reset-tariff persistence
$\sigma_{\tilde{\tau}}$	0.023	Reset-tariff volatility

Note. The time unit is one quarter.

where κ, v , and $\psi_s > 0$, for $s = x, n, m$ are parameters. The consumption aggregator takes the Cobb-Douglas form

$$C(c^z, c^n) = (c^z)^\xi (c^n)^{1-\xi},$$

with $\xi \in (0, 1)$. The production functions F^s for $s = x, n$ are both Cobb-Douglas,

$$F^s(h^s, z^s) = (h^s)^{\alpha_s} (z^s)^{1-\alpha_s},$$

with $\alpha_s \in (0, 1)$.

4.7 Calibration

Table 2 summarizes the calibration of the model. We set the time unit to one quarter. We denote the steady-state value of a variable by removing its time subscript.

The parameters governing the tariff process are taken from the estimation performed in section 3. In particular, we set $\theta = 0.75$, $\rho_{\tilde{\tau}} = 0.62$, and $\sigma_{\tilde{\tau}} = 0.023$. We set the steady-state

import tariff and reset tariff to 2.9 percent, $\tau = \tilde{\tau} = 0.029$ to match the mean tariff observed in our sample.

We set employment in the nontradable sector to 70 percent of total employment, $h^n/h = 0.7$, where $h \equiv h^n + h^m + h^x$. We divide the remaining employment equally between the exportable and import sectors, setting $h^x/h = h^m/h = 0.15$. These values reflect the greater labor intensity of the nontradable sector relative to the exportable and import sectors. We set expenditure on the composite import good to 10 percent of total consumption expenditure, $p^z c^z / (p^n c^n + p^z c^z) = 0.1$, a value consistent with estimates for the United States.

To calibrate the sectoral production functions, we use estimates from Goldberg and Campa (2010). They report that imported inputs account for 3 percent of the total cost of producing nontradable goods in the United States and 10 percent of the total cost of producing tradable goods. We double these shares to account for the fact that our model abstracts from capital and domestic intermediate inputs. The resulting parameter values are $\alpha_n = 0.94$ and $\alpha_x = 0.80$. There is less direct evidence on the labor intensity of the domestic processing and distribution activities that transform imported materials into usable import goods.

There is less direct evidence on the labor intensity of the domestic processing and distribution activities that transform imported materials into usable import goods. We set $\alpha = 0.15$, a relatively small value reflecting the view that most of the cost of a usable import good is embodied in the imported materials themselves.

We assume that the steady-state value of the world interest rate is 4 percent per year, $r^* = 1.04^{1/4} - 1$. We also assume that the subjective discount factor equals the steady-state world market discount factor, $\beta = 1/(1 + r^*)$.

We set the elasticity of substitution across labor types in the import sector, η_h , to 6, consistent with the firm-level labor-supply elasticity estimated by Lamadon, Mogstad, and Setzler (2022) in U.S. administrative data.

To calibrate the elasticity of substitution across import varieties in the production of the composite import good, η , we first derive the price elasticity of variety-specific imports, m_{it} , holding aggregate variables constant, which we denote $\varepsilon_m \equiv -\partial \ln m_{it} / \partial \ln(1 + \tau_{it})$. In Appendix D, we show that

$$\varepsilon_m = 1 - \zeta, \tag{38}$$

where ζ is a decreasing function of η , as can be seen from equation (31). Thus, the more substitutable are the differentiated import goods, z_{it} , in the production of the composite import good, z_t , the more responsive are imports of the corresponding materials, m_{it} , to changes in their tariffs. Fajgelbaum et al. (2020) use granular U.S. data on imports and import tariffs for 2018 to estimate a nested import-demand system. They obtain an elasticity

of substitution across imported goods of 1.53, which we interpret as the empirical counterpart of ε_m . Accordingly, we set $\varepsilon_m = 1.53$. Equations (31) and (38) then imply $\eta = 1.63$.

We set the inverse of the intertemporal elasticity of consumption substitution, κ , to 2, and the inverse of the Frisch elasticities of the sectoral labor supplies, v , to one. These are standard values in the related literature.

To determine the level of net external debt in the steady-state, $\bar{f}$, we target a steady-state trade-balance-to-output ratio, $(y^x - m)/(p^c c + y^x - m)$, of -3 percent, which is in line with the mean observed in the United States over the period 1990:Q1 to 2026:Q1. Finally, following Schmitt-Grohé and Uribe (2003), we set the debt elasticity of the country premium to 0.0001, a small value that ensures the stationarity of the net external debt in equilibrium.

5 Macroeconomic Effects of Tariff Staggering

We established in section 3 that tariff staggering alters the dynamic properties of the cross-sectional mean tariff, τ_t . In this section, we show that tariff staggering affects the response to tariff shocks of all macroeconomic variables of interest. To this end, we approximate the equilibrium dynamics up to first-order.⁴

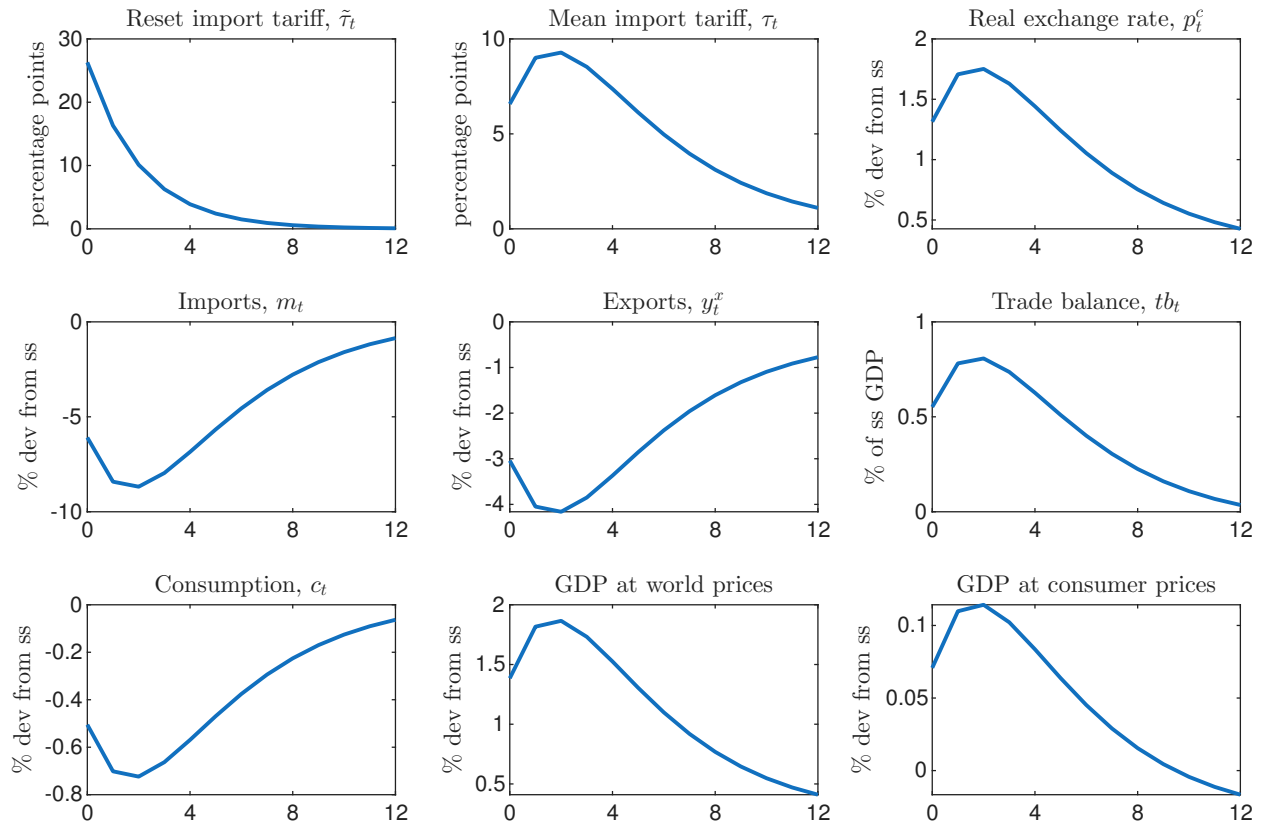
5.1 A Transitory Tariff Shock

Consider a tariff shock of the magnitude observed in the United States in the second quarter of 2025, when the Trump administration implemented sweeping tariff reforms. We recover the reset-tariff innovation, $\sigma_{\tilde{\tau}} \tilde{\epsilon}_t^{\tilde{\tau}}$, from the reset-tariff series computed in section 3, using the AR(1) specification in equation (6) and the estimated persistence parameter, $\rho_{\tilde{\tau}}$. In 2025:Q2, this innovation was 26.3 percentage points, that is $\sigma_{\tilde{\tau}} \tilde{\epsilon}_t^{\tilde{\tau}} = 0.263$ for $t = 2025.25$. Figure 4 displays the impulse responses to an innovation of this magnitude in $\tilde{\tau}_t$.

The shock generates hump-shaped responses in the cross-sectional mean tariff, τ_t , and in all endogenous variables. Because of tariff staggering, the innovation of 26.3 percentage points in $\tilde{\tau}_t$ initially applies to only a fraction $1 - \theta$ of tariffs, so the mean tariff increases by only $(1 - \theta) \times 26.3 = 6.6$ percentage points on impact. Thereafter, the mean tariff continues to rise as long as the reset tariff exceeds the previous quarter's mean. This rising phase eventually ends because the reset tariff declines monotonically, falling below the mean in finite time. Figure 4 shows that τ_t peaks at 9.3 percentage points above its steady-state level

⁴Up to first-order, the tariff dispersion terms $D_t(k)$ for $k = \zeta, \zeta - 1$, are zero unconditionally, so tariff staggering affects the equilibrium dynamics exclusively through its effect on the mean tariff, τ_t . Inherited tariff dispersion has transitory first-order effects. We study these effects in section 6 in the context of tariff harmonization.

Figure 4: Impulse Responses to a Positive Tariff Shock



Note. The innovation is a 26.3-percentage-point increase in $\tilde{\tau}_t$.

two quarters after the shock. Beginning in quarter 3, the reset tariff remains below the mean tariff, causing the latter to decline gradually toward its steady-state level.

Staggering also increases the persistence of the mean tariff. Recall that in the absence of staggering ($\theta = 0$), the mean tariff equals the reset tariff ($\tau_t = \tilde{\tau}_t$) and therefore inherits its persistence. With staggering ($\theta > 0$), the mean tariff adjusts more slowly. This is evident in Figure 4: after 8 quarters, the reset tariff, $\tilde{\tau}_t$, is close to its steady-state level, whereas the mean tariff, τ_t , remains more than 3 percentage points above its steady-state level.

The tariff shock makes the country more expensive relative to the rest of the world (i.e., it causes an appreciation of the real exchange rate). This is shown in the top right panel of Figure 4, which displays the price of the consumption good relative to world prices. The real exchange rate appreciates by 1.3 percent on impact and then continues to appreciate for a couple of quarters, before returning gradually to its pre-shock level. The reason why the response of p_t^c mimics the response of τ_t is that the production of consumption goods uses imported materials, so the tariff changes are passed through to consumption prices.

The tariff increase generates a contraction in imports of about 6 percent on impact. The decline is due to two factors. First, the tariff makes imports more expensive so firms substitute labor for imported materials and households substitute nontraded goods for import goods. Second, because the tariff hike is transitory, it pays for economic agents to postpone purchases of imported goods. Imports continue to fall after the shock, because the mean tariff continues to increase making imported goods increasingly more expensive. Imports reach a trough two quarters after the shock, at which point they are 9 percent below steady state. Exports also fall, as imported materials used in the production of exportable goods become more expensive as a result of the higher tariff.

The trade balance improves by about half a percentage point of steady-state GDP on impact. The improvement in the trade balance is due to the fact that agents expect the increase in the tariff to be transitory and thus find it optimal to postpone the net absorption of traded goods.

The tariff increase lowers consumption spending (bottom left panel). Because consumption goods are produced in part with imported inputs, which are temporarily expensive due to the tariff increase, households substitute intertemporally away from current consumption spending.

As is well known, the response of GDP to a transitory tariff increase depends on the balance between two forces: a contractionary intertemporal-substitution effect and an expansionary expenditure-switching effect. Their relative strengths is governed by the intertemporal and intratemporal elasticities of substitution in consumption, which in our calibration equal 1/2 and 1, respectively. Under this calibration, the expenditure-switching effect dom-

inates quantitatively. The bottom middle and right panels of Figure 4 show the impulse responses of gross domestic product at world prices, $p_t^c c_t + y_t^x - m_t$, and at consumer prices, $(p_t^c c_t + y_t^x - m_t)/p_t^c$. By both measures, output expands after the tariff increase.

The intuition is as follows. The transitory increase in tariffs causes households to postpone absorption, which tends to depress output (the intertemporal substitution effect). It also induces households to substitute away from imported goods and toward nontraded goods, which tends to boost aggregate activity (the expenditure switching effect). As explained above, in the present calibration the latter effect dominates. The predicted increase in output is thus dictated by what happens with value added in the nontraded sector, which is the most labor intensive sector in the economy. The increase in tariffs induces firms to substitute away from imported materials and towards labor. In turn, the increased demand for labor pushes the wage in the nontraded sector up. Both of these effects cause labor income in the nontraded sector, which accounts for the bulk of value added in this economy, to go up.

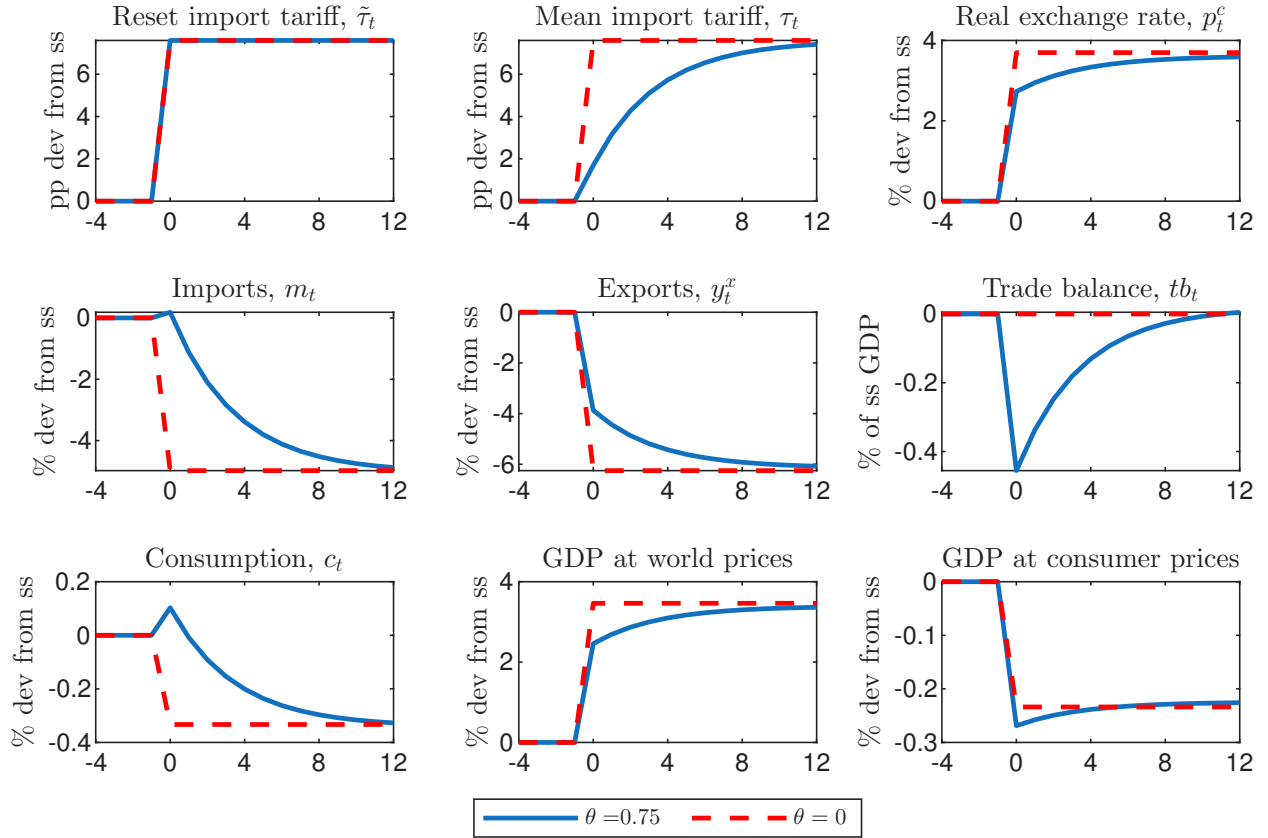
5.2 A Permanent Tariff Increase

Tariff shocks are typically a mix of transitory and permanent components. We just considered a transitory shock. We now study the economy's adjustment to a permanent increase in the reset tariff. Specifically, we consider a permanent increase in the reset tariff $\tilde{\tau}_t$ from its original steady state of 2.9 percent to 10.5 percent, which is the cross-sectional mean tariff observed in the second quarter of 2025. The shock takes place in period 0. The new steady-state tariff level is, of course, also 10.5 percent.

Figure 5 depicts the equilibrium dynamics unleashed by this tariff shock. All variables are expressed in deviations from the low-tariff steady state. The cross-sectional mean tariff rate τ_t increases gradually from its initial value of 2.9 percent to its long-run value of 10.5 percent. The reason is that even though the reset tariff is constant and equal to 10.5 percent, it is applied to a random fraction $1 - \theta$ of product lines each quarter, causing a gradual adjustment in the cross-sectional mean tariff. This sluggish increase in the mean tariff introduces an anticipatory effect that households take into account in their spending decisions, as we analyze next.

The increase in tariffs raises the price of imported materials faced by importers, causing a fall in imports. The long-run decline in imports is about 5 percent. Exporters use the imported composite good as an intermediate input, which is now increasingly more expensive. As a result, they become less competitive in international markets, and exports fall gradually to a lower steady-state level. The decline in exports is significant, about 6 percent.

Figure 5: A Permanent Tariff Increase



Notes. The figure depicts the adjustment to a permanent increase in $\tilde{\tau}_t$ from 2.9 percent to 10.5 percent taking place in period 0. Variables are expressed in deviations from their low-tariff steady state levels.

The central result of this experiment concerns the trade balance. Tariff staggering breaks the Razin–Svensson result that a permanent tariff increase leaves the trade balance unchanged. With staggering, forward-looking households anticipate that the mean tariff, and hence the relative price of imports, will continue to rise, giving them an incentive to frontload absorption. The trade balance consequently deteriorates on impact and then gradually returns to its steady-state level as the mean tariff approaches its new long-run value. By contrast, when tariff staggering is absent ($\theta = 0$), the cross-sectional mean tariff (and thus the relative price of imports) jumps immediately to its new permanent level. There is then no change in the relative price of imports between the present and the future, so households have no incentive to shift absorption across time. The trade balance therefore remains unchanged, as in Razin and Svensson (1983).

Consumption initially increases, as households frontload expenditure on imported goods, but then falls gradually to a lower steady-state level.

The response of GDP depends on the price at which it is measured. GDP measured at world prices expands, both during the transition and in the new steady state. In the long run, there is no intertemporal-substitution effect because the tariff is constant. The long-run increase in GDP at world prices therefore reflects the expenditure-switching effect: the higher relative price of imports induces substitution away from imported goods and toward nontradable goods, increasing activity in the labor-intensive nontradable sector.

By contrast, GDP measured at consumer prices falls. The permanent tariff increase raises the price of the domestic consumption basket relative to world prices, generating a sizable real appreciation. Deflating GDP by this higher consumer price more than offsets the increase in GDP measured at world prices, so GDP measured at consumer prices declines.

6 Tariff Harmonization

Tariff reforms often involve not only a reduction in the average tariff, but also a reduction in the dispersion of import tariffs across product lines. Two cases in point are Colombia’s trade reform of 1989–1993, which reduced the cross-sectional standard deviation of import tariffs by about two thirds (see Alessandria and Avila, 2023), and the U.S. trade liberalization of the 1990s, which, through a series of trade agreements, reduced the cross-sectional standard deviation of import tariffs by about one fourth (see Schmitt-Grohé and Uribe, 2026).

In this section, we characterize the effects of tariff harmonization predicted by the tariff-staggering model. This characterization is facilitated by the fact that in this framework inherited cross-sectional tariff dispersion has first-order effects on macroeconomic aggregates.

To see this, log-linearize equation (4) around the steady state to obtain

$$\widehat{\mathcal{T}}_t(k) = \theta \widehat{\mathcal{T}}_{t-1}(k) + (1 - \theta) k \widehat{\tau}_t,$$

where $\widehat{\mathcal{T}}_t(k) \equiv \ln \mathcal{T}_t(k) - k \ln(1 + \widetilde{\tau})$ and $\widehat{\tau}_t \equiv \ln(1 + \widetilde{\tau}_t) - \ln(1 + \widetilde{\tau})$ denote the log-deviations of $\mathcal{T}_t(k)$ and $1 + \widetilde{\tau}_t$ from their steady-state values. Since $1 + \tau_t = \mathcal{T}_t(1)$, we have that

$$\hat{\tau}_t = \theta \hat{\tau}_{t-1} + (1 - \theta) \widehat{\tau}_t,$$

where $\hat{\tau}_t \equiv \ln(1 + \tau_t) - \ln(1 + \widetilde{\tau})$ denotes the log-deviation of $1 + \tau_t$ from its steady-state value. Subtracting k times the second expression from the first expression gives

$$\widehat{\mathcal{T}}_t(k) - k \hat{\tau}_t = \theta [\widehat{\mathcal{T}}_{t-1}(k) - k \hat{\tau}_{t-1}].$$

From the definition of the tariff dispersion factor of order k given in (30), we have that $\widehat{\mathcal{T}}_t(k) - k \hat{\tau}_t = \widehat{D}_t(k)$, where $\widehat{D}_t(k)$ is the log-deviation of $D_t(k)$ from steady state. Thus, we can write the above expression as

$$\widehat{D}_t(k) = \theta \widehat{D}_{t-1}(k).$$

This expression says that up to first order, the tariff dispersion factor follows a deterministic path converging back to its steady state value of one. It follows that in the absence of inherited tariff dispersion, $\widehat{D}_{-1}(k) = 0$, tariff dispersion has no effect up to first order.

However, a nondegenerate initial tariff distribution, $\widehat{D}_{-1}(k) \neq 0$, will in general cause transitional dynamics up to first order. This type of dynamics are the focus of the present analysis. This property of the model allows us, using the same computational tools employed thus far, to characterize the dynamics of an economy that starts from an empirically plausible cross-sectional distribution of import tariffs and converges to a steady state with a uniform tariff. We refer to this experiment as tariff harmonization.

The tariff harmonization experiment we study here asks what are the predicted effects of removing the tariff dispersion observed after the tariff hike of 2025:Q2 (Liberation Day). To isolate the effects of tariff harmonization, the counterfactual experiment we consider is as follows. We assume that the reset tariff, $\widetilde{\tau}_t$, and the mean tariff, τ_t , are both constant at 10.5 percent, the tariff level observed in 2025:Q2, that is, $\widetilde{\tau}_t = \tau_t = \tau_{t-1} = 0.105$, for $t \geq 0$. By equilibrium condition (5), the mean tariff then remains at its steady state value during the entire transition. We set the initial tariff dispersion measures, $\mathcal{T}_{-1}(\zeta)$ and $\mathcal{T}_{-1}(\zeta - 1)$ at the values observed in 2025:Q2, which we compute from our panel of import tariffs at the

HTS 6-digit level.

Figure 6 displays the model’s predicted dynamics following this tariff harmonization experiment. By construction, both the reset tariff and the mean tariff remain at their steady-state values throughout the transition.

The bottom row of the figure displays the dynamics of the two tariff dispersion wedges, $D_t(\zeta)^{1/\zeta}$ and $D_t(\zeta)/D_t(\zeta - 1)$. Both wedges lie below their common steady-state value of one at the start of the tariff harmonization and then converge monotonically to one. The elimination of tariff dispersion is qualitatively similar to that of transitory cut in the tariff rate in an economy without tariff staggering. Intuitively, dispersion induces importers to shift purchases toward goods subject to tariffs below the mean. The effective tariff they pay is therefore lower than the mean tariff. As dispersion gradually disappears under harmonization, these opportunities diminish, raising the effective tariff paid by importers.

Thus, when harmonization is announced, economic agents understand that the effective tariff, inclusive of the dispersion wedge, is temporarily below its long-run level. This means the domestic price of imports is below its long-run level initially and along the entire transition. The temporarily lower price of imported goods induces agents to substitute intertemporarily and increase imports above their long-run level. Throughout the transition, exporters face costs of imported materials below those that will prevail in the long run. For this reason, exports converge to their long-run level from above.

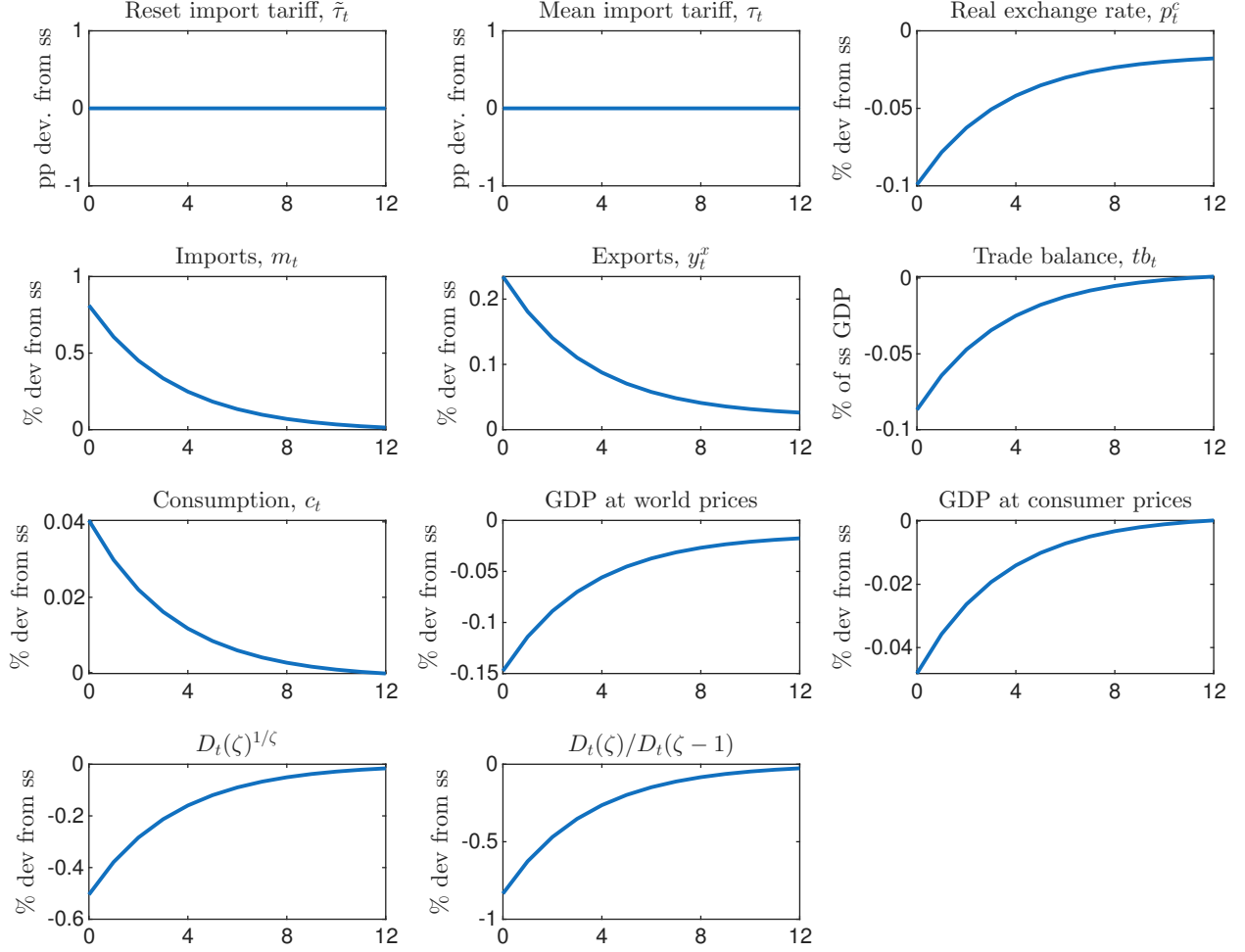
Domestic absorption, which in the model is given by consumption, converges from above to its uniform-tariff steady state. This is because households take advantage that along the transition the price of consumption is lower than in the uniform-tariff steady state. By contrast, domestic value added converges from below to its long-run level. This is because labor income, the main component of value added, is lower than in the long run, as firms rely more heavily on the temporarily cheaper imported materials as factor inputs.

The analogy between harmonization and a temporary reduction in the tariff rate in an economy without staggering has its limits. In the staggering economy, tariff dispersion introduces a cross-sectional misallocation of import and labor inputs, which is welfare decreasing. This source of misallocation is, by construction, absent in an economy with a uniform tariff.

7 Conclusion

We document that U.S. import tariff policy exhibits substantial staggering: in a typical quarter, some goods are duty free, while among dutiable goods some tariffs increase, some decrease, and others remain unchanged. Motivated by these facts, we develop a model of staggered tariff setting and embed it in a dynamic open-economy framework.

Figure 6: Macroeconomic Effects of Tariff Harmonization



Notes. The figure displays deviations from the uniform-tariff (no-dispersion) steady state. The initial degree of tariff dispersion is calibrated to match the cross-sectional tariff dispersion observed in the United States in 2025:Q2. The cross-sectional mean tariff is kept constant throughout the transition at the level observed in 2025:Q2.

Tariff staggering materially affects the propagation of tariff shocks. It generates hump-shaped macroeconomic responses even when the reset tariff follows an AR(1) process. It also causes the Razin–Svensson neutrality result to break down: because a permanent change in the reset tariff is incorporated only gradually into the mean tariff, it creates a built-in anticipation effect on the trade balance.

Finally, we show that reductions in tariff dispersion have real effects even up to first order, making the framework suitable for studying tariff harmonization. We find that dynamics set in motion by eliminating tariff dispersion are akin to those following a transitory tariff cut in an economy without staggering. This is because tariff dispersion induces importers to shift purchases toward goods subject to below-mean tariffs, lowering the effective tariff relative to the mean. Thus, along the transition to a uniform tariff, imports, exports, and domestic absorption converge from above to their long-run no-dispersion levels.

Taken together, these results underscore the importance of accounting for the cross-sectional distribution of tariffs when evaluating the macroeconomic consequences of tariff policy.

Appendix

A Data Sources and Construction

The data consist of monthly observations on U.S. imports for consumption and calculated import duties obtained from the U.S. International Trade Commission (USITC) and accessed on June 20, 2026. In U.S. trade statistics, “imports for consumption” refers to merchandise that has cleared Customs for entry into the U.S. market; it does not imply that the imported goods are used for final consumption. Import values are measured at customs value.

The data are organized at the six-digit Harmonized Tariff Schedule (HTS) product level and cover the period 1990:M1–2026:M3. We aggregate the monthly observations to quarterly frequency by summing imports and duties within each product and quarter. Thus, letting m_{it} and d_{it} denote quarterly imports and duties for product i , the product-level tariff rate is

$$\tau_{it} = \frac{d_{it}}{m_{it}}.$$

We use concordances from United Nations Statistics to track product codes across revisions of the Harmonized System classification and impose a balanced-panel requirement. The resulting panel contains 4,022 product lines in every quarter from 1990:Q1 through 2026:Q1.

All products are assigned fixed weights based on their import shares in 2006:

$$\omega_i = \frac{m_{i,2006}}{\sum_j m_{j,2006}},$$

where $m_{i,2006}$ denotes total imports of product i during 2006. These weights are used throughout the empirical analysis. In particular, the fixed-weight mean tariff, the mean tariff conditional on being dutiable, and the dutiable share are constructed according to (1), (2), and (3), respectively. The two mean-tariff series displayed in Figure 1 are seasonally adjusted.

Because tariff rates are calculated from observed duties and imports, small changes may reflect measurement error. We therefore classify a quarter-to-quarter tariff movement as a change only if

$$|\tau_{it} - \tau_{i,t-1}| \geq 0.001,$$

that is, if the change is at least 0.1 percentage points in absolute value. Among products that are dutiable in quarter t , tariff increases, tariff cuts, and unchanged tariffs are defined, respectively, by $\tau_{it} - \tau_{i,t-1} \geq 0.001$, $\tau_{it} - \tau_{i,t-1} \leq -0.001$, and $|\tau_{it} - \tau_{i,t-1}| < 0.001$. The shares displayed in Figure 3 are calculated using the fixed weights ω_i , renormalized over products that are dutiable in quarter t .

B Testing the AR orders of τ_t and $\tilde{\tau}_t$

This appendix provides statistical tests of the autoregressive orders of the cross-sectional mean tariff, τ_t , and of the reset tariff, $\tilde{\tau}_t$. It also tests the hypothesis that the estimated coefficients of the autoregressive process for τ_t are equal to their theoretical counterparts evaluated at their calibrated values. Finally, the appendix also provides estimates of the autoregressive coefficient and the standard deviation of the innovation of the reset tariff $\tilde{\tau}_t$, which are inputs in the calibration of the model.

B.1 Testing the AR Order of $\tilde{\tau}_t$

Using the 144 quarterly observations and a common effective sample, we obtain

Model Selection for $\tilde{\tau}_t$: Information Criteria			
Model	Estimated equation	AIC	BIC
AR(0)	$\tilde{\tau}_t = 3.043 + \sigma_{\tilde{\tau}}\epsilon_t$	712.49	715.44
AR(1)	$\tilde{\tau}_t = 1.165 + 0.6196\tilde{\tau}_{t-1} + \sigma_{\tilde{\tau}}\epsilon_t$	646.06	651.97
AR(2)	$\tilde{\tau}_t = 1.165 + 0.6196\tilde{\tau}_{t-1} - 0.0006\tilde{\tau}_{t-2} + \sigma_{\tilde{\tau}}\epsilon_t$	648.06	656.93

The nested tests are

Model Selection for $\tilde{\tau}_t$: Nested Tests		
Null hypothesis	F -statistic	p -value
AR(0) against AR(1)	86.67	$< 10^{-15}$
AR(1) against AR(2)	0.00004	0.995

Thus, both information criteria and the nested tests select AR(1). The Ljung–Box p -values at horizons 4, 8, and 12 are 0.42, 0.86, and 0.98, indicating no residual serial correlation. The preferred process is then

$$\tilde{\tau}_t - \tilde{\tau} = 0.6196 (\tilde{\tau}_{t-1} - \tilde{\tau}) + 2.32\epsilon_t^{\tilde{\tau}}.$$

with $\tilde{\tau}_t$ being expressed in percentage points. Thus, we calibrate $\rho_{\tilde{\tau}} = 0.62$ and $\sigma_{\tilde{\tau}} = 2.33$.

B.2 Testing the AR Order of τ_t

To compare the specifications on a common basis, we estimate AR processes of orders 0 through 3 using the sample for which three lags are available. The results are

Model Selection for τ_t^d : Information Criteria			
Model	Estimated equation	AIC	BIC
AR(0)	$\tau_t^d = 2.882 + \varepsilon_t$	535.50	538.45
AR(1)	$\tau_t^d = -0.003 + 1.020\tau_{t-1}^d + \varepsilon_t$	273.67	279.57
AR(2)	$\tau_t^d = 0.346 + 1.395\tau_{t-1}^d - 0.511\tau_{t-2}^d + \varepsilon_t$	253.35	262.19
AR(3)	$\tau_t^d = 0.430 + 1.379\tau_{t-1}^d - 0.436\tau_{t-2}^d - 0.091\tau_{t-3}^d + \varepsilon_t$	254.80	266.59

The nested tests yield

Model Selection for τ_t^d : Nested Tests		
Null hypothesis	F -statistic	p -value
AR(0) against AR(1)	763.93	$< 10^{-57}$
AR(1) against AR(2)	23.67	3.07×10^{-6}
AR(2) against AR(3)	0.53	0.466

Both information criteria select the AR(2) specification. The nested tests reject AR(0) in favor of AR(1) and AR(1) in favor of AR(2), but do not reject AR(2) in favor of AR(3).

The Ljung–Box p -values, adjusted for the number of estimated autoregressive coefficients, at horizons 4, 8, and 12 are 0.192, 0.749, and 0.966 suggesting that the AR(2) specification removes the residual serial correlation.

The preferred process is therefore

$$\tau_t^d = 0.346 + 1.395\tau_{t-1}^d - 0.511\tau_{t-2}^d + \varepsilon_t.$$

B.3 Testing the Parameter Restrictions Implied by the Theoretical Model

Consider a regression of τ_t^d onto τ_{t-1}^d and τ_{t-2}^d and a constant. Let ϕ_1 and ϕ_2 denote the coefficients on τ_{t-1}^d and τ_{t-2}^d , respectively, in this unrestricted AR(2) specification. The

theoretical model implies

$$\phi_1 = \theta + \rho_{\bar{\tau}}, \quad \phi_2 = -\theta \rho_{\bar{\tau}}.$$

Our calibration sets $\theta = 0.75$ and $\rho_{\bar{\tau}} = 0.62$, implying

$$\phi_1 = 1.37, \quad \phi_2 = -0.465.$$

We first test

$$H_0 : \phi_1 = 1.37.$$

The OLS estimate of ϕ_1 is 1.395 and its estimated standard error is 0.0844. The corresponding t -statistic and p -value are 0.30 and 0.766. Thus, the null hypothesis that the estimated coefficient equals its model-implied counterpart cannot be rejected at conventional significance levels.

We next test

$$H_0 : \phi_2 = -0.465.$$

The OLS estimate of ϕ_2 is -0.511 and its standard error is 0.1049. The corresponding t -statistic and p -value are -0.43 and 0.665. This restriction also cannot be rejected at conventional significance levels.

Finally, a joint test of

$$H_0 : \begin{cases} \phi_1 = 1.37, \\ \phi_2 = -0.465 \end{cases}$$

yields $F(2,138)=0.12$, with a p -value of 0.883. Thus, the two parameter restrictions implied by the theoretical model cannot be rejected either individually or jointly.

C Aggregation and Equilibrium

C.1 Derivation of Equilibrium Condition (29)

For convenience, we begin by reproducing equilibrium condition (29),

$$p_t^z = A e^{-a_t^m} (w_t^m)^\alpha \left[(1 + \tau_t) D_t(\zeta)^{\frac{1}{\zeta}} \right]^{1-\alpha}, \quad (29)$$

where, for any $k \in \mathbb{R}$,

$$D_t(k) \equiv \frac{\mathcal{I}_t(k)}{(1 + \tau_t)^k}, \quad (30)$$

and

$$\zeta \equiv \frac{(1-\eta)(1-\alpha)(1+\eta_h)}{(1+\eta_h-\alpha(1-\eta))} < 1.$$

Combine (8), (10), (11), and (16) to obtain

$$(w_{it}^m)^{1+\eta_h-\alpha(1-\eta)} \propto (1+\tau_{it})^{(1-\alpha)(1-\eta)},$$

where proportionality here means up to a factor independent of i . Define $\gamma \equiv 1+\eta_h-\alpha(1-\eta)$ and $\varphi \equiv \frac{(1-\alpha)(1-\eta)}{\gamma}$. It then follows from the above expression and from the definition of w_t^m , equation (17), that relative wages are

$$\frac{w_{it}^m}{w_t^m} = \frac{(1+\tau_{it})^\varphi}{[\mathcal{T}_t(\zeta)]^{1/(1+\eta_h)}}.$$

Using this expression and the law of one price, (28), to eliminate, respectively, w_{it}^m and p_{it}^m from equation (10), the price of differentiated import good i , p_{it}^z , can be written as

$$p_{it}^z = Ae^{-a_t^m} (w_t^m)^\alpha [\mathcal{T}_t(\zeta)]^{-\frac{\alpha}{1+\eta_h}} (1+\tau_{it})^{\zeta/(1-\eta)}. \quad (\text{C.1})$$

Using (C.1) to eliminate p_{it}^z from (12), yields

$$\begin{aligned} p_t^z &= Ae^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{-\frac{\alpha}{1+\eta_h}} \left[\int_0^1 (1+\tau_{it})^\zeta di \right]^{\frac{1}{1-\eta}} \\ &= Ae^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{-\frac{\alpha}{1+\eta_h}} \mathcal{T}_t(\zeta)^{\frac{1}{1-\eta}} \\ &= Ae^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{-\frac{\alpha}{1+\eta_h} + \frac{1}{1-\eta}} \\ &= Ae^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{\frac{(1-\alpha)}{\zeta}} \\ &= Ae^{-a_t^m} (w_t^m)^\alpha [\mathcal{T}_t(\zeta)^{\frac{1}{\zeta}}]^{1-\alpha} \\ &= Ae^{-a_t^m} (w_t^m)^\alpha (1+\tau_t)^{1-\alpha} \left(\frac{\mathcal{T}_t(\zeta)^{\frac{1}{\zeta}}}{1+\tau_t} \right)^{1-\alpha} \\ &= Ae^{-a_t^m} (w_t^m)^\alpha \left[(1+\tau_t) D_t(\zeta)^{\frac{1}{\zeta}} \right]^{1-\alpha}, \end{aligned}$$

where the second equality uses the definition of $\mathcal{T}_t(\cdot)$ and the third equality uses $\zeta = \varphi(1+\eta_h)$. The last equality is (29), which is what we had wanted to show.

C.2 Proof that $D_t(\zeta)^{1/\zeta} < 1$

Recall the assumptions $\eta_h > 0$ and $\alpha \in (0, 1)$. Recall also the definitions $\gamma \equiv 1 + \eta_h - \alpha(1 - \eta)$, $\varphi \equiv \frac{(1-\alpha)(1-\eta)}{\gamma}$, and $\zeta \equiv \varphi(1 + \eta_h)$.

Assume first that $\eta > 1$. It follows that $\gamma > 0$, $\varphi < 0$, and $\zeta < 0$. With $\zeta < 0$, Jensen's inequality implies that

$$\int_0^1 (1 + \tau_{it})^\zeta di > \left[\int_0^1 (1 + \tau_{it}) di \right]^\zeta.$$

Recall that $1 + \tau_t \equiv \int_0^1 (1 + \tau_{it}) di$ and that $\mathcal{T}_t(\zeta) \equiv \int_0^1 (1 + \tau_{it})^\zeta di$. So we can write

$$\mathcal{T}_t(\zeta) > (1 + \tau_t)^\zeta,$$

which implies that

$$D_t(\zeta) \equiv \frac{\mathcal{T}_t(\zeta)}{(1 + \tau_t)^\zeta} > 1.$$

Elevating the left- and right-hand sides to the power $1/\zeta < 0$, it follows that $D_t(\zeta)^{1/\zeta} < 1$, which is what we wanted to prove.

Now assume that $0 < \eta < 1$. In this case $\varphi, \zeta > 0$. With $\zeta > 0$, Jensen's inequality implies that

$$\int_0^1 (1 + \tau_{it})^\zeta di < \left[\int_0^1 (1 + \tau_{it}) di \right]^\zeta,$$

which in turn implies that

$$\mathcal{T}_t(\zeta) < (1 + \tau_t)^\zeta,$$

or

$$D_t(\zeta) = \frac{\mathcal{T}_t(\zeta)}{(1 + \tau_t)^\zeta} < 1.$$

Elevating the left- and right-hand sides to the power $1/\zeta > 0$, it follows that $D_t(\zeta)^{1/\zeta} < 1$, which is what we wanted to prove.

C.3 Derivation of Equilibrium Condition (33)

This appendix derives equilibrium condition (33), which we repeat here for convenience

$$(1 + \tau_t)m_t = (1 - \alpha)p_t^z z_t \frac{D_t(\zeta - 1)}{D_t(\zeta)}. \quad (33)$$

Let $m_t \equiv \int_0^1 m_{it} di$. Solve (9) for m_{it} and use the law of one price, equation (28), to eliminate p_{it}^m , to obtain

$$(1 + \tau_{it})m_{it} = (1 - \alpha)p_{it}^z z_{it}.$$

Use (11) to eliminate z_{it} from this expression. This yields

$$(1 + \tau_{it})m_{it} = (1 - \alpha)(p_{it}^z)^{1-\eta}(p_t^z)^\eta z_t.$$

Then use (C.1) to replace p_{it}^z and rearrange terms to get

$$m_{it} = (1 - \alpha)(p_t^z)^\eta z_t \left(A e^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{-\frac{\alpha}{1+\eta_h}} \right)^{1-\eta} (1 + \tau_{it})^{\zeta-1}.$$

Use this expression in the definition of m_t

$$\begin{aligned} m_t &= \int_0^1 m_{it} di \\ &= (1 - \alpha)(p_t^z)^\eta z_t \left(A e^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{-\frac{\alpha}{1+\eta_h}} \right)^{1-\eta} \int_0^1 (1 + \tau_{it})^{\zeta-1} di \\ &= (1 - \alpha)(p_t^z)^\eta z_t \left(A e^{-a_t^m} (w_t^m)^\alpha \mathcal{T}_t(\zeta)^{-\frac{\alpha}{1+\eta_h}} \right)^{1-\eta} \mathcal{T}_t(\zeta - 1). \end{aligned}$$

Use (29) to eliminate $A e^{-a_t^m} (w_t^m)^\alpha$ from the last expression and multiply both sides by $1 + \tau_t$ to obtain equation (33).

C.4 Proof that $D_t(\zeta - 1)/D_t(\zeta) > 1$

Let $k = \zeta < 1$. Using the definition of $D_t(k)$ given in (30), one can write

$$\frac{D_t(k-1)}{D_t(k)} = \frac{(1 + \tau_t)\mathcal{T}_t(k-1)}{\mathcal{T}_t(k)}.$$

Let $X_i \equiv 1 + \tau_{it}$ and $\bar{X} \equiv \int_0^1 X_i di$. Because $\tau_{it} \geq 0$, $X_i, \bar{X} \geq 1$. Recall from above that $k < 1$ and therefore $k - 1 < 0$. Note that if $X_i \geq \bar{X}$, then $X_i^{k-1} \leq \bar{X}^{k-1}$. And if $X_i \leq \bar{X}$, then $X_i^{k-1} \geq \bar{X}^{k-1}$. Thus we have

$$\begin{aligned} 0 &\geq (X_i - \bar{X})(X_i^{k-1} - \bar{X}^{k-1}) \\ &= X_i^k - X_i \bar{X}^{k-1} - \bar{X} X_i^{k-1} + \bar{X}^k. \end{aligned}$$

Integrating over varieties i , we obtain

$$\begin{aligned}
0 &\geq \int_0^1 X_i^k di - \bar{X} \int_0^1 X_i^{k-1} di \\
\bar{X} \int_0^1 X_i^{k-1} di &\geq \int_0^1 X_i^k di \\
(1 + \tau_t) \mathcal{T}_t(k-1) &\geq \mathcal{T}_t(k) \\
\frac{(1 + \tau_t) \mathcal{T}_t(k-1)}{\mathcal{T}_t(k)} &\geq 1,
\end{aligned}$$

which is what we wished to show.

D Calibration of η

Let ε_m denote the tariff elasticity of imported-material demand, m_{it} . Formally, it is defined as

$$\varepsilon_m \equiv -\frac{\partial \ln m_{it}}{\partial \ln(1 + \tau_{it})},$$

where the partial derivative refers to holding all aggregate variables constant. To derive an expression for ε_m in terms of structural parameters only, note that equation (C.1) implies that

$$\frac{\partial \ln p_{it}^z}{\partial \ln(1 + \tau_{it})} = \chi, \tag{D.1}$$

where

$$\chi \equiv \frac{(1 - \alpha)(1 + \eta_h)}{1 + \eta_h + \alpha(\eta - 1)}. \tag{D.2}$$

From (9) and (11) we have that

$$m_{it} \propto (p_{it}^z)^{1-\eta} (1 + \tau_{it})^{-1}, \tag{D.3}$$

where $\propto$ means up to aggregate variables and constant factors. From (D.1) and (D.3) it readily follows that the tariff elasticity is given by

$$\varepsilon_m = 1 + \chi(\eta - 1).$$

Using (D.2) to express χ in terms of structural parameters yields

$$\varepsilon_m = 1 + \frac{(1 - \alpha)(1 + \eta_h)(\eta - 1)}{1 + \eta_h + \alpha(\eta - 1)} = 1 - \zeta, \tag{D.4}$$

which is equation (38) in the body of the paper. The second equality follows from equation (31). Note that when $\alpha = 0$, so that imported materials do not require domestic labor, $\varepsilon_m = \eta$.

References

- Alessandria, George, and Oscar Avila, “Trade Integration, Industry Reallocation, and Welfare in Colombia,” *IMF Economic Review* 71, 2023, 649–687.
- Amiti, Mary, Matthieu Gomez, Sang Hoon Kong, and David E. Weinstein, “Trade Protection, Stock-Market Returns, and Welfare,” working paper, Columbia University, December 19, 2024.
- Anderson, James E., and J. Peter Neary, “Measuring the Restrictiveness of Trade Policy,” *The World Bank Economic Review* 8, 1994, 151–169.
- Auclert, Adrien, Matthew Rognlie, and Ludwig Straub, “The Macroeconomics of Tariff Shocks,” NBER Working Paper 33726, April 2025.
- Auray, Stéphane, Michael B. Devereux, and Aurélien Eyquem, “Self-Enforcing Trade Policy and Exchange Rate Adjustment,” *Journal of International Economics* 134, January 2022, 103552.
- Auray, Stéphane, Michael B. Devereux, and Aurélien Eyquem, “Trade Wars, Nominal Rigidities, and Monetary Policy,” *Review of Economic Studies*, 2024, <https://doi.org/10.1093/restud/rdae075>.
- Barattieri, Alessandro, Matteo Cacciatore, and Fabio Ghironi, “Protectionism and the Business Cycle,” *Journal of International Economics* 129, 2021, 103417.
- Bergin, Paul R., and Giancarlo Corsetti, “The Macroeconomic Stabilization of Tariff Shocks: What Is the Optimal Monetary Response?,” *Journal of International Economics* 143, 2023, 103758.
- Bianchi, Javier, and Louphou Coulibaly, “The Optimal Monetary Policy Response to Tariffs,” NBER Working Paper 33560, March 2025.
- Boer, Lukas, and Malte Rieth, “The Macroeconomic Consequences of Import Tariffs and Trade Policy Uncertainty,” IMF Working Paper 24-13, January 2024.
- Calvo, Guillermo A., “Staggered Prices in a Utility-Maximizing Framework,” *Journal of Monetary Economics* 12, 1983, 383–398.
- Calvo, Guillermo A., “On the Costs of Temporary Policy,” *Journal of Development Economics* 27, 1987, 245–261.
- Costinot, Arnaud, and Iv’an Werning, “How Tariffs Affect Trade Deficits,” NBER Working Paper 33709, June 2025.
- Cuba-Borda, Pablo, Albert Queralto, Ricardo Reyes-Heroles, and Mikaël Scaramucci, “Trade Costs and Inflation Dynamics,” IFDP 1411, Board of Governors of the Federal Reserve System, July 2025.
- den Besten, Tamar, Regis Barnichon, Diego Känzig, and Aayush Singh, “The Macroeco-

- conomic Effects of Tariffs: Insights from 180 Years of U.S. Trade Policy,” working paper, Northwestern University, April 2026.
- Erceg, Christopher, Andrea Prestipino, and Andrea Raffo, “Trade Policies and Fiscal Devaluations,” *American Economic Journal: Macroeconomics* 15, 2023, 104–140.
- Fajgelbaum, Pablo D., Pinelopi K. Goldberg, Patrick J. Kennedy, and Amit K. Khandelwal, “The Return to Protectionism,” *Quarterly Journal of Economics* 135, 2020, 1–55.
- Feenstra, Robert C., “Estimating the Effects of Trade Policy,” in Gene M. Grossman and Kenneth Rogoff, eds., *Handbook of International Economics*, Volume 3, 1995, Amsterdam: Elsevier, 1553–1595.
- Ferrante, Francesco, Andrea Prestipino, Andrea Raffo, and Michael E. Waugh, “Tariffs, Investment, and the Missing Trade Collapse,” NBER Working Paper 35630, August 2026.
- Goldberg, Linda S., and José Manuel Campa, “The Sensitivity of the CPI to Exchange Rates: Distribution Margins, Imported Inputs, and Trade Exposure,” *Review of Economics and Statistics* 92, 2010, 392–407.
- Irwin, Douglas A., “Trade Restrictiveness and Deadweight Losses from U.S. Tariffs,” *American Economic Journal: Economic Policy* 2, August 2010, 111–133.
- Itskhoki, Oleg, and Dmitry Mukhin, “The Optimal Macro Tariff,” manuscript, Harvard University, April 2025.
- Kee, Hiau Looi, Alessandro Nicita, and Marcelo Olarreaga, “Estimating Trade Restrictiveness Indices,” *The Economic Journal* 119, 2009, 172–199.
- Lamadon, Thibaut, Magne Mogstad, and Bradley Setzler, “Imperfect Competition, Compensating Differentials, and Rent Sharing in the U.S. Labor Market,” *American Economic Review* 112, 2022, 169–212.
- Razin, Assaf, and Lars E.O. Svensson, “Trade Taxes and the Current Account,” *Economics Letters* 13, 1983, 55–57.
- Schmitt-Grohé, Stephanie, and Martín Uribe, “Closing Small Open Economy Models,” *Journal of International Economics* 61, 2003, 163–185.
- Schmitt-Grohé, Stephanie, and Martín Uribe, “The Effects of Transitory, Permanent, and Anticipated U.S. Import Tariff Shocks,” NBER working paper 33997, July 2025.
- Schmitt-Grohé, Stephanie, and Martín Uribe, “Tariff-Dispersion Shocks: The Mean Is the Variance,” NBER working paper 35661, August 2026.
- Monacelli, Tommaso, “Tariffs and Monetary Policy,” mimeo, Bocconi University, 2025.
- United Nations Statistics Division, *Classifications on Economic Statistics: Harmonized System Correspondence Tables*, accessed September 13, 2026, <https://unstats.un.org/unsd/classifications/Econ>.

- U.S. International Trade Commission, USITC DataWeb: U.S. Trade and Tariff Data, accessed June 20, 2026, <https://dataweb.usitc.gov/>.
- Werning, Iván, Guido Lorenzoni, and Veronica Guerrieri, “Tariffs as Cost-Push Shocks: Implications for Optimal Monetary Policy,” working paper, University of Chicago, May 2025.
- Woodford, Michael, *Interest and Prices, Foundations of a Theory of Monetary Policy*, Princeton, NJ: Princeton University Press, 2003.
- Yun, Tack, “Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles,” *Journal of Monetary Economics* 37, 1996, 345–370.
- Yun, Tack, “Optimal Monetary Policy with Relative Price Distortions,” *American Economic Review* 95, 2005, 89–109.