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When tariffs bite: The short-run vs long-run welfare effects of trade wars

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CENTRE FOR INCLUSIVE TRADE POLICY

When tariffs bite: The short-run vs long-run welfare effects of trade wars

Pinar Gunes

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Abstract

This paper estimates short-run and long-run sector-specific trade elasticities using a panel of 170 countries and 22 manufacturing sectors over 1995-2022, and incorporates them in a multi-country, multi-sector framework calibrated for 77 countries. Counterfactual experiments evaluate how the welfare effects of tariff shocks vary with the nature of the shock, the time horizon, and the presence or absence of retaliation. The distinction between short-run and long-run elasticities affects the relative magnitude, rather than uniformly the direction, of the welfare response: under unilateral tariffs, trading partners' losses diminish over time as they redirect trade toward alternative markets, whereas under multilateral escalation net losses grow larger in the long run because the terms-of-trade and tariff revenue gains that partly cushion the impact effect erode faster than real-wage losses recover, leaving no untaxed suppliers to redirect toward.

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Non-Technical Summary

Tariffs have returned to the centre of international economic policy. This paper examines the effects of tariffs differ between the short and long run. It estimates how responsive trade is to changes in trade costs across 22 manufacturing sectors, using data covering 170 countries between 1995 and 2022. These estimates are then incorporated into a model of the global economy covering 77 countries. The model is used to examine how different types of tariff increases affect countries in the short run and after economies have had time to adjust.

The results show that there is no single relationship between the length of time after a tariff increase and its economic effects. Instead, the outcome depends importantly on how widely tariffs are imposed and whether firms and consumers have access to alternative trading partners.

When one country imposes tariffs while its trading partners do not retaliate, adjustment can reduce some of the losses experienced by the countries facing the tariffs. Over time, firms can shift their purchases towards suppliers in countries that are not subject to the new tariffs. This ability to redirect trade provides an alternative source of supply and reduces the impact of the original tariff. In the paper's example of a unilateral 25-percentage-point increase in US tariffs, the welfare losses experienced by trading partners become smaller over time. The welfare gain for the US also falls as the economy adjusts, from 1.56% in the short run to 1.15% in the long run.

The picture changes when tariff increases become more widespread. If trading partners retaliate, the country imposing the initial tariffs can lose the benefits it might otherwise obtain from its improved position in international markets. In the paper's US example, the initial welfare gain turns into a welfare loss when trading partners retaliate: the US welfare effect falls from a gain of 1.56% under unilateral action to a loss of 2.21% in the short run and 2.39% in the long run.

The distinction between short- and long-run effects is particularly important in a broader trade war, where many countries raise tariffs against one another. In this situation, there are fewer alternative markets to which firms can redirect trade. As a result, the adjustment that can cushion the effects of unilateral tariffs is much less effective. In the paper's multilateral tariff-escalation scenario, average welfare losses increase as economies adjust, from 2.61% in the short run to 2.96% in the long run when intra-EU trade is exempt.

These findings have important implications for how policymakers assess the effects of tariffs. The economic impact observed shortly after a tariff is introduced may not provide a reliable indication of its eventual effect. Firms need time to change suppliers, reorganise production and establish alternative trading relationships. Whether this adjustment reduces or increases the eventual cost depends on whether alternative markets remain available.

The results therefore highlight the importance of considering the structure of a tariff shock, rather than treating all tariff increases as equivalent. A tariff imposed by one country may have different consequences from a situation in which several countries respond with their own tariffs. For policymakers assessing the potential effects of trade restrictions, both the immediate disruption and the longer-term reorganisation of trade need to be taken into account.

When Tariffs Bite: The Short-Run vs Long-Run Welfare Effects of Trade Wars

Pinar Gunes*

September 17, 2026

Preliminary working paper. Comments are welcome.

Abstract

This paper estimates short-run and long-run sector-specific trade elasticities using a panel of 170 countries and 22 manufacturing sectors over 1995-2022, and incorporates them in a multi-country, multi-sector framework calibrated for 77 countries. Counterfactual experiments evaluate how the welfare effects of tariff shocks vary with the nature of the shock, the time horizon, and the presence or absence of retaliation. The distinction between short-run and long-run elasticities affects the relative magnitude, rather than uniformly the direction, of the welfare response: under unilateral tariffs, trading partners' losses diminish over time as they redirect trade toward alternative markets, whereas under multilateral escalation net losses grow larger in the long run because the terms-of-trade and tariff-revenue gains that partly cushion the impact effect erode faster than real-wage losses recover, leaving no untaxed suppliers to redirect toward.

Keywords: Trade policy, dynamic trade elasticity, gravity models, trade war

JEL codes: F13, F14, C23.

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1 Introduction

It takes time for countries to adjust to economic shocks. Sudden increases in tariffs, for example, do not instantaneously translate into fully adjusted trade patterns. In the short run, firms face adjustment frictions: production technologies are fixed, labor tends to be immobile, supply chains are slow to reorganize, and entry and exit decisions are costly. Trade elasticities may therefore differ substantially between the short run and the long run, once the economy has had time to adapt. Although much of the quantitative trade literature has traditionally abstracted from this distinction by applying a single trade elasticity across all horizons Arkolakis et al. (2012); Dekle et al. (2007); Caliendo and Parro (2015); Costinot and Rodríguez-Clare (2014), including models based on Ricardian, monopolistic-competition, and heterogeneous-firm frameworks Eaton and Kortum (2002); Krugman (1980); Melitz (2003), a growing literature has begun to model and estimate gradual trade adjustment explicitly Ruhl (2008); Fontagné et al. (2018); Yilmazkuday (2019); Olivero and Yotov (2012); Anderson and Yotov (2020, 2025); Boehm et al. (2023); Chen et al. (2026). Because adjustment can amplify or dampen the initial effects of a trade shock, treating trade policy as static and evaluating only its immediate consequences may be misleading.

Building on this recent literature, I develop a practical approach to estimating short-run and long-run trade elasticities within a dynamic gravity framework and embed them in a quantitative general equilibrium model to evaluate the welfare effects of tariff shocks. I model bilateral trade costs as persistent rather than as objects that reset fully in every period: current bilateral trade costs depend partly on their past values and partly on current tariffs and other bilateral determinants. This structure captures the persistence of established supplier relationships, production networks, distribution capacity, and market-specific knowledge. Following a tariff change, only part of the eventual trade response occurs immediately; the remainder emerges gradually as firms reconsider existing relationships and reorganize their sourcing and sales.

The quantitative framework builds on the Ricardian model of Eaton and Kortum (2002), which I extend to a multi-country, multi-sector setting with dynamically evolving trade costs. Labor is the only factor of production, markets are perfectly competitive, and countries import final goods from the lowest-cost supplier subject to iceberg trade costs. Within each sector, productivity across producers follows a Fréchet distribution, and the dispersion of productivity—the key parameter governing the trade elasticity—is allowed to vary across sectors. This cross-sectoral heterogeneity is central to capturing how tariff changes affect sectors differently across time horizons. Throughout the paper, the long run refers to the completed adjustment of trade patterns and sourcing relationships, rather than to capital accumulation.

The model is solved in relative changes using the "exact-hat algebra" approach of Dekle et al. (2007), as extended to a multi-sector setting by Caliendo and Parro (2015). The counterfactual system requires data on bilateral trade flows, production, and tariffs, together with the estimated sector-specific elasticities, and reduces to one equation per country regardless of the number of sectors. Short-run counterfactuals use the elasticities governing the immediate response to a tariff shock, whereas long-run counterfactuals use the elasticities implied by the completed adjustment process. Both are calculated from the same baseline trade shares, tariff revenues, market-clearing conditions, and general-equilibrium structure. Their comparison therefore isolates the quantitative importance of the adjustment horizon. I estimate the parameters using sector-level manufacturing trade data for 170 countries over 1995–2022 and calibrate the model for 77 countries and 22 sectors using the latest available data from 2022. On a trade-weighted basis, the calibrated sample covers approximately 97% of manufacturing imports among the countries in the estimation sample.

The estimated elasticities exhibit substantial heterogeneity across sectors and time horizons. Short-run elasticities range from 0.23 to 4.34, while their long-run counterparts range from 0.40 to 6.70 — systematically larger in magnitude, consistent with the presence of adjustment frictions documented throughout the literature. I use the calibrated model to evaluate the welfare effects of several tariff scenarios: a unilateral 25-percentage-point increase by the United States, retaliation in which all trading partners respond with equivalent increases on US imports, and a multilateral escalation in which all countries raise tariffs by 25 percentage points with intra-EU trade exempt.

The welfare effects vary considerably with the nature of the shock and the time horizon. Under the unilateral US tariff increase, the United States is the only country that gains meaningfully, recording a welfare improvement of 1.56% in the short run — driven entirely by terms-of-trade improvement rather than efficiency improvements. The countries that lose the most — Canada (−3.59%), Mexico (−3.18%), and Costa Rica (−3.01%) — are those most deeply integrated with the US market. In the long run, trading partners' losses decline as they redirect trade toward alternative markets, while the US gain shrinks to 1.15% as its terms-of-trade advantage erodes. Under retaliation, however, the US gain is entirely eliminated: welfare falls to −2.21% in the short run and −2.39% in the long run, as US exports face higher tariffs in every destination market. For trading partners, the picture is milder than under unilateral action, and mean welfare rises from −0.41% to −0.16% and the number of countries recording welfare gains increases from five to thirty-four, as partners collect tariff revenue on US imports and partially shield their producers from US competition. Even the most US-dependent economies lose less than before — Canada's loss narrows to −1.87% and Mexico's to −2.46% — while Cambodia is the exception, deepening to −2.52% as its own retaliatory tariff compounds rather than offsets its losses.

Under the multilateral tariff escalation, losses are substantially larger and the long-run effect exceeds the short-run one, the opposite ordering to the unilateral case. The average welfare loss is 2.61% in the short run and 2.96% in the long run, with the most open economies suffering the most — Hong Kong (−10.29%), Laos (−9.59%), and Tunisia (−8.76%). Four EU members record positive short-run gains, led by Luxembourg. Critically, every country is worse off in the long run than in the short run. The decomposition shows why: with few untaxed suppliers available, higher long-run responsiveness erodes the terms-of-trade and tariff-revenue gains that partly offset the impact real-wage losses faster than those real-wage losses themselves recover, so net welfare losses deepen as economies adjust fully to the distorted equilibrium.

The paper makes three contributions to the literature.

First, and most directly, it contributes to the empirical structural gravity literature by developing a sector-specific method for jointly estimating short-run and long-run trade elasticities from annual data. Existing approaches estimate trade elasticities using cross-country price variation Eaton and Kortum (2002), tariff variation Caliendo and Parro (2015), simulated method of moments Simonovska and Waugh (2014), import-demand estimation (Feenstra, 1994), home-bias measures Head and Ries (2001), gravity-based methods surveyed by Anderson and Van Wincoop (2004) and Yotov et al. (2016), and country-specific methods developed by Freeman et al. (2025). These approaches exploit the multiplicative structure of the gravity equation, which arises in a broad class of trade models Krugman (1980); Eaton and Kortum (2002); Anderson and Van Wincoop (2003); Melitz (2003); Chaney (2008), but generally do not distinguish elasticities across adjustment horizons. A long-standing macro-trade literature nevertheless shows that short-run responses to relative-price shocks are systematically smaller than long-run reallocations (Ruhl, 2008; Alessandria et al., 2021). More recent work has incorporated this insight into structural gravity. Olivero and Yotov (2012)

show that estimates based on consecutive-year panels can conflate the immediate response with continuing adjustment to earlier shocks and recommend using interval data. Anderson and Yotov (2020) formalize this insight in a structural short-run gravity model and estimate short-run trade elasticities that are roughly one-quarter of their long-run counterparts, while Anderson and Yotov (2025) extend the framework by allowing adjustment costs to vary across time intervals. My approach instead uses persistence to identify the adjustment process. A sector-specific autoregressive dynamic panel-gravity specification jointly estimates the immediate response to a trade-cost shock and the rate at which its effect accumulates, thereby recovering both the short-run impact elasticity and the long-run steady-state elasticity from annual data. Unlike standard interval-based gravity estimation, the method does not require bilaterally symmetric trade costs (Head and Mayer, 2014). The quantitative framework also relates to extensions of the Eaton–Kortum model incorporating nonhomothetic preferences (Fieler, 2011), sectoral productivity differences (Costinot et al., 2012), the sources of comparative advantage (Chor, 2010), applications to historical and development settings (Shikher, 2012; Donaldson, 2018), and general conditions for equilibrium existence and uniqueness (Allen et al., 2020). Relative to this literature, the paper introduces variation in trade elasticities across adjustment horizons, a dimension not usually incorporated into standard quantitative tariff counterfactuals.

Second, the paper complements structural models and empirical evidence on dynamic trade adjustment. At the micro level, Arkolakis et al. (2011) develop a trade model with staggered adjustment à la Calvo (1983), in which only a fraction of firms reoptimize their sourcing in each period, thereby generating sluggish aggregate trade dynamics. Chen et al. (2026) extend this logic to a full dynamic general-equilibrium setting, characterizing optimal sourcing decisions under search and relationship-formation costs and deriving the dynamic equilibrium using hat algebra. The empirical evidence points in the same direction. Trade elasticities vary systematically with the frequency at which they are estimated (Ruhl, 2008; Fontagné et al., 2018, 2022; Yilmazkuday, 2019); supply-chain relationships exhibit substantial persistence (Boehm et al., 2023); and, even within the same product, firms with different managerial capabilities adjust at different speeds (Bas et al., 2025). Dynamic frictions also matter for welfare: Anderson et al. (2020) estimate that gradual adjustment generates a dynamic path multiplier of approximately 1.8 for the gains from trade liberalization. In contrast to fully structural dynamic models, I do not impose a particular microeconomic technology governing when firms reconsider suppliers or solve a fully forward-looking transition path. Instead, I estimate a parsimonious law of motion for bilateral trade costs and use its short-run and long-run implications as sufficient statistics for counterfactual analysis. The objective is not to replace models that explicitly describe firms' dynamic decisions, but to provide an empirically tractable framework, justified by and consistent with their microfoundations, that can be incorporated into standard sectoral quantitative trade models.

Third, the paper contributes to the quantitative trade-policy literature evaluating the general-equilibrium welfare effects of tariff shocks. The counterfactual analysis builds on the "exact-hat algebra" approach developed by Dekle et al. (2007) and extended to multi-sector settings by Caliendo and Parro (2015). It also connects to the quantitative trade-war literature pioneered by Ossa (2014), who characterizes the Nash equilibrium of global tariff wars driven by terms-of-trade motives, and to subsequent work by Fajgelbaum et al. (2020), who estimate the effects of the 2018 US tariff increases, and de Souza et al. (2024), who evaluate trade sanctions against Russia. A common feature of these contributions is the use of a single, time-invariant trade elasticity, which does not distinguish immediate welfare effects from those that emerge after trade patterns have fully adjusted. I depart from this practice by allowing trade elasticities to differ across horizons and show that the adjustment horizon changes the relative magnitude of the welfare response: long-run

adjustment facilitates trade diversion that attenuates trading partners' losses following unilateral protection, but under multilateral escalation it erodes the terms-of-trade and revenue gains that cushion the impact effect, deepening net losses. A separate but complementary long-run channel is capital adjustment. The models in Baqaee and Malmberg (2025a) and Baqaee and Malmberg (2025b) include capital and therefore differ from the Ricardian environment considered here. Baqaee and Malmberg (2025a) show that tariffs can reallocate resources away from capital formation, causing long-run consumption losses to exceed their static welfare effects, while Baqaee and Malmberg (2025b) find that capital adjustment is the dominant long-run amplification mechanism in trade wars. Because my model abstracts from capital accumulation, the mechanism documented here instead operates through the gradual reorganization of sourcing and trade patterns. Introducing capital adjustment could alter—and potentially amplify—the effects reported here, although the direction and magnitude of the interaction may depend on the tariff shock.

The remainder of the paper is organized as follows. Section 2 describes the quantitative model. Section 3 describes the data. Section 4 presents the estimation methodology for trade elasticities. Section 5 describes the counterfactual analysis. Section 6 presents the welfare impacts of tariff shocks, and Section 7 concludes.

2 The quantitative model

In this section, I sketch out a multi-country multi-sector general equilibrium version of trade as in Caliendo and Parro (2015). The model mainly builds on Eaton and Kortum (2002)'s model of Ricardian trade with a continuum of goods $\omega \in [0,1]$. There are N countries and S sectors. There are only manufacturing sectors and all markets are perfectly competitive. Labor is the only factor of production and it is fully mobile across sectors and immobile across countries.

2.1 Households

Each country i is endowed with L_i representative households who maximize their utility by consuming goods from sector s C_i^s. The preferences of households are given by

$$u(C_i) = \prod_{s=1}^{S} C_i^{s\alpha_i^s} \quad \text{where} \quad \sum_{s=1}^{S} \alpha_i^s = 1. \tag{1}$$

Because labor is the only source of income and is supplied inelastically, consumers maximize utility subject to total income, Y_i.

As is standard in the literature, individual varieties are combined before consumption using a sector-specific constant-elasticity-of-substitution (CES) aggregator

$$Q_i^s = \left[\int r_i^s(\omega^s)^{1-\frac{1}{\sigma^s}} d\omega^s \right]^{\sigma^s/(\sigma^s-1)}, \tag{2}$$

where $\sigma^s \geq 0$ is the elasticity of substitution across goods within sector s and $r_i^s(\omega^s)$ is the demand for good ω^s. This maximization is subject to a budget constraint that aggregates buyers in country i to X_i, country i's total spending, where $X_i = \sum_1^S X_i^s$ and $X_i^s = \int_0^1 r_i^s(\omega) p_i^s(\omega)$.

The solution to the problem of the consumer gives the following demand for good ω^s in country i

$$r_i^s(\omega^s) = \left(\frac{p_i^s(\omega^s)}{P_i^s}\right)^{-\sigma^s} Q_i^s. \tag{3}$$

CES preferences yield a Dixit-Stiglitz price index

$$P_i^s = \Big[\int p_i^s(\omega^s)^{1-\sigma^s} d\omega^s\Big]^{1/(1-\sigma^s)}, \tag{4}$$

where $p_i^s(\omega^s)$ denotes the lowest price of good ω^s across all locations i.

2.2 Goods

A continuum of goods $\omega^s \in [0,1]$ is produced in each sector s. Productivity of producers of goods differs across sectors and countries. The efficiency of producing good ω^s in country i is denoted by $z_i^s(\omega^s)$. The distribution of productivities among goods are independent across countries and sectors. The production technology of a good ω^s is given by

$$q_i^s(\omega^s) = z_i^s(\omega^s) l_i^s(\omega^s), \tag{5}$$

where $l_i^s(\omega^s)$ is the amount of labor employed within the production process. I assume that there is perfect competition and production with constant returns to scale. So, firms price at unit cost

$$p_i^s(\omega^s) = c_i / z_i^s(\omega^s), \tag{6}$$

where c_i denotes the unit cost which is simply given by

$$c_i = w_i, \tag{7}$$

where w_i is the country-specific wage. Because labor is fully mobile across sectors, wages do not vary across sectors.

2.3 International trade costs and prices

I assume two types of trade costs: iceberg trade costs and ad valorem tariffs. Following Samuelson (1954), delivering one unit of a tradable sector-s good from origin country j to destination country i requires producing $d_{ij}^s \geq 1$ units in country j, with $d_{ii}^s = 1$. Goods imported by country i from country j are subject to the ad valorem tariff τ_{ij}^s. Combining these trade costs gives

$$\kappa_{ij}^s = \widetilde{\tau}_{ij}^s d_{ij}^s, \qquad \widetilde{\tau}_{ij}^s = 1 + \tau_{ij}^s. \tag{8}$$

To rule out arbitrage, I impose the triangle inequality

$$\kappa_{ih}^s \kappa_{hj}^s \geq \kappa_{ij}^s \qquad \text{for all } i, j, h,$$

where the indirect route runs from origin country j through country h to destination country i.

A unit of good ω^s produced in country j and delivered to country i is available at the unit price $c_j \kappa_{ij}^s / z_j^s(\omega^s)$. Because every country purchases each good from the lowest-cost supplier, the price of good ω^s in country i is

$$p_i^s(\omega^s) = \min_j \left\{ \frac{c_j \kappa_{ij}^s}{z_j^s(\omega^s)} \right\}. \tag{9}$$

As already mentioned, I assume that the efficiency of producing a good ω^s in any country i varies by country and sector and follows a Fréchet distribution with a location parameter, $T_i^s \geq 0$, that varies by country and sector, and shape parameter, θ^s, that varies by sector. These distributions are independent across countries and sectors. In the context of this model, a higher T_i^s implies a higher average productivity in a given country-sector pair, and a lower θ^s means a higher dispersion of productivity across goods. Translating these parameters into trade terminology, T_i^s can be interpreted in two ways. First, it can be interpreted as an indicator of comparative advantage across industries. For example, if $T_i^s / T_j^s > T_i^m / T_j^m$, then country i has comparative advantage in industry s. Second, it can also be interpreted as the absolute advantage of a country for a given sector. For instance, if $T_i^s > T_j^s$ then country i has an absolute advantage over country j in sector s. On the other hand, parameter θ^s identifies the comparative advantage across goods within a specific industry. A lower value of θ^s indicates more dispersion of productivities among producers, meaning a higher comparative advantage within the industry.

In the context of this paper, two factors determine the cost of production in country i in comparison to country j in any sector s: (i) the relative effective wages $\left(\frac{\kappa_{ij}^s w_i}{w_j}\right)$; (ii) relative technology parameters.[1] As θ^s increases $\left(\frac{T_i^s}{T_j^s}\right)^{-1/\theta^s}$ converges to 1 and effective wages overtake technology in determining costs. That is why lower-income countries tend to specialize in sectors where θ^s is high, because their cost advantage comes from low wages while higher-income countries tend to specialize in sectors with a low θ^s as their cost advantage comes from efficient production.

Following the properties of the Fréchet distribution, the sector-specific price index can be expressed as

$$P_i^s = \Upsilon^s \left[\sum_{h=1}^{N} T_h^s \left(c_h \kappa_{ih}^s \right)^{-\theta^s} \right]^{-1/\theta^s}, \tag{10}$$

for all sectors s and countries i where $\Upsilon^s = \left[\Gamma\left(\frac{\theta^s + 1 - \sigma^s}{\theta^s} \right) \right]^{1/(1-\sigma^s)}$ is a constant and Γ represents the Gamma function. [2]

[1] If we take the expectation of the cost of delivering one unit of good ω^s from country i to country j over ω^s we obtain: $\frac{E(p_{ij}^s(\omega^s))}{E(p_{jj}^s(\omega^s))} = \left(\frac{T_i^s}{T_j^s}\right)^{-1/\theta^s} \frac{\kappa_{ji}^s w_i}{w_j}$ (see Fieler (2011)).

[2] While this framework allows demand being inelastic, $\sigma^s \leq 1$, the restriction $\sigma^s < \theta^s + 1$ must hold to guarantee having a well defined price index (see Dekle et al. (2007)).

I assume that consumers buy the goods at prices P_i^s. Assuming Cobb-Douglas preferences (see Equation (1)), the consumption price index in country i becomes

$$P_i = \prod_{s=1}^{S} (P_i^s/\alpha_i^s)^{\alpha_i^s}. \tag{11}$$

2.4 Expenditure shares

Total expenditure on sector-s goods in destination country i is $X_i^s = P_i^s Q_i^s$. Let X_{ij}^s denote expenditure in destination country i on sector-s goods from origin country j. The corresponding expenditure share is $\pi_{ij}^s = X_{ij}^s/X_i^s$. Using the properties of the Fréchet distribution, this share is

$$\pi_{ij}^s = \frac{T_j^s \left[c_j \kappa_{ij}^s\right]^{-\theta^s}}{\sum_{h=1}^{N} T_h^s \left[c_h \kappa_{ih}^s\right]^{-\theta^s}}. \tag{12}$$

Thus, the bilateral expenditure share π_{ij}^s takes the form of a multi-sector gravity equation. Tariffs affect this share directly through κ_{ij}^s. A higher θ^s implies less dispersion in production efficiency within sector s and therefore a larger response of expenditure shares to changes in relative prices and trade barriers; see Eaton and Kortum (2002).

2.5 Total expenditure and trade balance

Total expenditure on sector-s goods in country i is

$$X_i^s = \alpha_i^s Y_i, \tag{13}$$

where total income is

$$Y_i = w_i L_i + R_i + D_i. \tag{14}$$

Thus, income is the sum of labor income, tariff revenue R_i, and the exogenous trade deficit D_i. Tariff revenue is

$$R_i = \sum_{s=1}^{S} \sum_{j=1}^{N} \tau_{ij}^s M_{ij}^s, \qquad M_{ij}^s = X_i^s \frac{\pi_{ij}^s}{1+\tau_{ij}^s},$$

where M_{ij}^s denotes country i's imports of sector-s goods from country j, excluding tariff payments. Let E_{ij}^s denote country i's exports to country j:

$$E_{ij}^s = X_j^s \frac{\pi_{ji}^s}{1+\tau_{ji}^s}.$$

National trade deficits satisfy $D_i = \sum_{s=1}^{S} D_i^s$, where

$$D_i^s = \sum_{j=1}^{N} M_{ij}^s - \sum_{j=1}^{N} E_{ij}^s.$$

Using these definitions, the aggregate trade-balance condition is

$$\sum_{s=1}^{S}\sum_{j=1}^{N} X_i^s \frac{\pi_{ij}^s}{1+\tau_{ij}^s} - D_i = \sum_{s=1}^{S}\sum_{j=1}^{N} X_j^s \frac{\pi_{ji}^s}{1+\tau_{ji}^s}. \tag{15}$$

3 Data

The model is parsimonious and requires only a limited set of parameters and variables for estimation and computation of counterfactuals. As in Caliendo and Parro (2015), the analysis relies on tariff, bilateral trade, and production data: (i) to estimate trade elasticities, θ^s; and (ii) to conduct counterfactual exercises. This section describes the data sources and the construction of the key variables.

Bilateral trade flows Bilateral trade flows are obtained from the International Trade and Production Database for Estimation (ITPD-E). Values are reported in thousands of U.S. dollars at current prices and include cost, insurance, and freight (CIF). The original ITPD-E data are reported at the 4-digit product level and are converted to ISIC Rev. 3 using the concordance table provided in the database. The data are then aggregated to the 2-digit sectoral level, yielding 22 manufacturing sectors corresponding to ISIC Rev. 3 divisions 15–36. Combining these data with the tariff data described below, I construct a panel covering 22 sectors and 170 countries for the estimation of trade elasticities. The full list of countries used to estimate the production dispersion parameters is provided in the Appendix. Table 1 reports summary statistics for the variables used in estimating the dispersion parameters.

Tariffs Bilateral tariff data at the sectoral level for the years from 1995 to 2022 are obtained from the United Nations Statistical Division Trade Analysis and Information System (UNCTAD–TRAINS). The tariff measures are tariff lines and are reported in two ways: simple and weighted-average effective applied rates at the 2-digit ISIC Rev. 3 industry level. Effective applied rates refer to the actual tariff applied, taking into account whether there is any trade agreement between countries. I use simple average rates in trade elasticity estimations and the counterfactual exercises.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.	Min.	Max.	*N*
Tariff	1.6	7.9	0.0	350	776,869
Imports	476.1	7,052.6	0.0	927,465.90	776,869
Log imports	1.7	3.5	-13.8	13.7	744,585

Notes: The sample covers 170 countries, 22 ISIC Rev. 3 sectors, and the years 1995–2022. Imports and tariffs vary by reporter, partner, sector, and year ($ijst$).

Counterfactual sample The counterfactual analysis is conducted for a sample of 77 countries and 22 manufacturing sectors using the latest available data from 2022. The 77 countries — which include all

OECD members, all EU members, the ASEAN economies, and the major G20 economies — account for approximately 97 percent of sample members' total manufacturing imports on a trade-weighted basis, rendering a rest-of-world aggregate unnecessary.

Domestic trade Domestic trade is not directly observed in trade databases for the majority of countries. Although the ITPD-E database includes domestic trade flows for some countries, coverage is incomplete for a substantial portion of the sample. I therefore construct domestic trade using gross output and export data from the OECD Trade in Value Added (TiVA) 2025 database, which provides comprehensive coverage for all 77 countries in the counterfactual sample.

Domestic trade for country i in sector s is computed as the difference between gross output and gross exports, where gross exports include exports to all destinations worldwide, not only to the 77 countries in the sample. This ensures that trade with non-sample partners is correctly subtracted from gross output rather than being erroneously attributed to domestic production.

The TiVA database reports data at the ISIC Rev. 4 sector level, whereas the bilateral trade data and the estimated trade elasticities use ISIC Rev. 3. I map between the two classifications using the United Nations correspondence table between ISIC Rev. 3 and ISIC Rev. 4. Where TiVA sectors correspond one-to-one with ISIC Rev. 3 divisions, domestic trade is used directly. Where TiVA sectors are more aggregated than the corresponding ISIC Rev. 3 divisions, I distribute domestic trade across subsectors using each country's export composition from the ITPD-E bilateral trade data as a proxy. The full details of the concordance and the disaggregation procedure are provided in the Appendix.

4 Estimating Dynamic Trade Elasticities

The counterfactual model requires sector-specific trade elasticities. Following Caliendo and Parro (2015), no additional behavioral parameters are needed once these elasticities have been obtained. To distinguish adjustment horizons, I estimate the short-run elasticity, θ^s_{SR}, together with the persistence parameter, φ^s, and use them to construct the corresponding long-run elasticity, θ^s_{LR}.

Within the Eaton–Kortum framework, θ^s is inversely related to the dispersion of the productivity distribution and governs the sensitivity of trade flows to changes in trade costs. When θ^s is large, productivity differences across countries are relatively small, so modest tariff changes can induce substantial shifts in sourcing. When θ^s is small, trade reflects larger productivity differences that are more difficult for tariffs to overcome, resulting in a more limited reallocation of trade.

I estimate these elasticities within a dynamic gravity framework. Following Egger and Nigai (2015), let X_{ijt} denote bilateral expenditure in destination country i on goods from origin country j at time t. It is expressed as the product of an exporter-time factor, A_{jt}; an importer-time factor, B_{it}; a bilateral component, Γ_{ijt}; and a multiplicative error, U_{ijt}:

$$X_{ijt} = A_{jt} B_{it} \Gamma_{ijt} U_{ijt}. \tag{16}$$

Allowing each component to vary by sector and taking logarithms gives

$$x_{ijt}^s = a_{jt}^s + b_{it}^s + \gamma_{ijt}^s + u_{ijt}^s, \tag{17}$$

where i is the importer, j is the exporter, and lowercase letters denote logarithms of their uppercase counterparts. The exporter-time and importer-time fixed effects absorb country-specific determinants, including the multilateral-resistance terms. The remaining bilateral component, $\gamma_{ijt}^s = \log \Gamma_{ijt}^s$, is decreasing in bilateral trade frictions; equivalently, a higher value indicates greater bilateral trade freeness conditional on the country-time effects. The estimated residual from Equation (17) provides the empirical counterpart of γ_{ijt}^s; hats are suppressed below for notational simplicity.

Standard quantitative and structural gravity applications typically model bilateral trade costs as functions of contemporaneous observables, such as distance, tariffs, and trade agreements (Eaton and Kortum, 2002; Caliendo and Parro, 2015; Novy, 2013), as surveyed by Yotov et al. (2016) and Yotov (2024). This treatment does not distinguish the immediate response to a policy change from the response after sourcing relationships have fully adjusted. A growing theoretical and empirical literature, however, shows that trade adjustment is gradual.

On the theoretical side, Arkolakis et al. (2011) develop a perfectly competitive trade model with staggered sourcing adjustment à la Calvo (1983). In each period, only a fraction of firms can re-optimize, while the remainder retain their existing suppliers. Chen et al. (2026) extend this logic to a dynamic general-equilibrium setting in which search and relationship-formation costs generate persistence in bilateral sourcing. These models imply that short-run elasticities capture the response of firms able or willing to adjust immediately, whereas long-run elasticities incorporate the cumulative response as sourcing relationships are reorganized.

The empirical evidence is consistent with this mechanism. Olivero and Yotov (2012) show that consecutive-year gravity estimates can conflate impact responses with continuing adjustment to earlier shocks and recommend using interval data. Anderson and Yotov (2020) develop a structural short-run gravity model with fixed bilateral capacities and obtain short-run trade elasticities approximately one-quarter of their long-run counterparts. Anderson and Yotov (2025) estimate elasticities ranging from 0.4 in the short run to 4.8 in the long run, with full adjustment taking approximately 15 years. The international elasticity puzzle—the finding that elasticities estimated from high-frequency variation are much smaller than those obtained from long-run variation—provides related evidence (Ruhl, 2008; Fontagné et al., 2018). Yilmazkuday (2019) connects this discrepancy to the different objects captured by short-run macroeconomic and longer-run substitution elasticities. At a more disaggregated level, Fontagné et al. (2022) document frequency-dependent product-level elasticities, while Bas et al. (2025) show that adjustment also varies with firms' managerial capabilities. A related dynamic general-equilibrium literature demonstrates that transition paths matter for welfare: Anderson et al. (2020), for example, combine structural gravity with capital accumulation and estimate that transitional dynamics magnify the static gains from liberalization by a factor of approximately 1.8.

Motivated by this evidence, I model the bilateral trade component as an autoregressive process and estimate the following specification separately for each sector:

$$\gamma_{ijt}^s = \varphi^s \gamma_{ij,t-1}^s - \theta_{SR}^s \log\left(\tilde{\tau}_{ijt}^s\right) + \mu_{ij}^s + v_{ijt}^s, \tag{18}$$

Here, $\tilde{\tau}^s_{ijt} = 1 + \tau^s_{ijt}$ is the tariff imposed by destination country i on sector-s goods imported from origin country j, μ^s_{ij} denotes importer–exporter fixed effects, and v^s_{ijt} is an error term. The negative sign reflects the definition of γ^s_{ijt} as trade freeness: an increase in tariffs reduces the bilateral trade component. Accordingly, $\theta^s_{SR} > 0$ is the magnitude of the short-run, or impact, trade elasticity.

The parameter φ^s governs the persistence of bilateral trade relationships. A higher value implies that inherited sourcing patterns exert a stronger influence on current trade and that adjustment is slower. Under a staggered-sourcing interpretation, φ^s captures the reduced-form persistence generated by firms that maintain existing suppliers. Under a partial-adjustment interpretation, $1 - \varphi^s$ is the rate at which the bilateral trade component moves toward the level implied by current tariffs and other fundamentals. These interpretations motivate the autoregressive specification without requiring φ^s to equal a particular structural re-optimization probability.

In the long run, the bilateral component has fully adjusted and no longer changes between periods. The magnitude of its steady-state response to a tariff change is therefore

$$\theta^s_{LR} = \frac{\theta^s_{SR}}{1 - \varphi^s}. \tag{19}$$

Unlike interval-based approaches, which infer adjustment by comparing trade flows observed at different intervals (Olivero and Yotov, 2012; Anderson and Yotov, 2020), this specification estimates both θ^s and φ^s from annual data. It also does not require bilaterally symmetric trade costs, an assumption commonly used in interval-based gravity estimation (Head and Mayer, 2014).

Table 2 reports the estimated short-run elasticities, persistence parameters, and implied long-run elasticities. The short-run estimates range from 0.23 for tobacco products to 4.34 for other transport equipment. Under the Eaton–Kortum interpretation, sectors at the lower end of this range exhibit greater productivity dispersion and less substitutability across foreign suppliers, whereas sectors at the upper end exhibit smaller productivity differences and greater substitutability.

Table 2: Short-Run and Long-Run Trade Elasticities

Sector	θ^s_{SR}	θ^s_{LR}	φ^s	$\theta^s_{LR} - \theta^s_{SR}$
Food products and beverages	0.92	1.55	0.41	0.63
Tobacco products	0.23	0.40	0.42	0.17
Textiles	2.36	3.64	0.35	1.28
Wearing apparel; fur	0.98	1.58	0.38	0.60
Leather products	1.92	3.05	0.37	1.13
Wood products	3.22	4.94	0.35	1.72
Paper products	3.29	5.20	0.37	1.91
Printing and publishing	2.69	3.84	0.30	1.15
Coke and refined products	3.46	4.89	0.29	1.43
Chemicals	3.09	4.93	0.37	1.84
Rubber and plastics	1.80	2.71	0.34	0.91
Non-metallic mineral products	2.50	3.85	0.35	1.35
Basic metals	4.28	6.70	0.36	2.42
Fabricated metal products	3.13	4.27	0.27	1.14
Machinery n.e.c.	3.56	4.58	0.22	1.02
Office and computing equipment	2.78	3.80	0.27	1.02
Electrical machinery	2.73	3.84	0.29	1.11
Radio, TV, and communication	2.88	4.29	0.33	1.41
Medical and optical instruments	3.54	4.86	0.27	1.32
Motor vehicles	0.54	0.82	0.35	0.28
Other transport equipment	4.34	5.48	0.21	1.14
Furniture; manufacturing n.e.c.	1.51	2.14	0.29	0.63

Notes: θ^s_{SR} is the short-run trade elasticity estimated in Equation (18). The long-run trade elasticity is $\theta^s_{LR} = \theta^s_{SR}/(1-\varphi^s)$, as shown in Equation (19). The persistence parameter φ^s governs the speed of adjustment. The final column reports the difference between the long-run and short-run elasticities. The 22 sectors correspond to ISIC Rev. 3 divisions 15–36.

The point estimates of φ^s are positive in every sector, so the implied long-run elasticities exceed their short-run counterparts. This pattern is consistent with gradual adjustment, but it is not an independent test of adjustment frictions: once $\varphi^s > 0$, the ranking follows mechanically from Equation (19). The persistence estimates themselves provide the more direct measure of adjustment speed. They range from 0.21 for other transport equipment to 0.42 for tobacco products, implying faster adjustment in the former and slower adjustment in the latter.

The absolute gap $\theta^s_{LR} - \theta^s_{SR}$ depends jointly on the impact elasticity and persistence and should therefore not be interpreted as a direct ranking of adjustment frictions. Basic metals has the largest gap (2.42), followed by paper products (1.91) and chemicals (1.84), partly because these sectors already have relatively large impact elasticities. Tobacco products (0.17), motor vehicles (0.28), and wearing apparel (0.60) have the smallest gaps, but their persistence estimates are not necessarily the lowest. In particular, tobacco combines the highest estimated persistence with the smallest impact elasticity. This illustrates why φ^s, rather than the absolute elasticity gap, is the appropriate statistic for comparing adjustment speeds across sectors.

The central empirical finding is that short-run and long-run trade elasticities differ systematically. This

distinction motivates evaluating tariff shocks separately across the two adjustment horizons, but it does not establish an unconditional ranking of their welfare effects. As the counterfactual exercises in the next section show, whether the long-run welfare effect is larger or smaller than its short-run counterpart depends on the nature of the tariff shock.

5 Measuring Welfare Effects of Trade Costs

This section describes the counterfactual methodology used to quantify the welfare effects of tariff changes. The base year is 2022, the latest year for which the required data are available. The sample comprises $N = 77$ countries and $S = 22$ manufacturing sectors, chosen to maximize coverage while maintaining reliable information on tariffs, production, and trade flows. Appendix A.1 provides a detailed account of the data used in the analysis.

I follow the approach of Dekle et al. (2007), extended to a multi-country, multi-sector environment by Caliendo and Parro (2015). Rather than solving the model in levels under each policy scenario, I characterize equilibrium in terms of proportional changes in endogenous variables — an approach commonly known as "hat algebra." This strategy identifies the counterfactual effects of tariff changes without requiring the recovery of technology parameters T_i^s or iceberg trade costs d_{ij}^s, both of which are difficult to pin down from the data.

Definition 1. *Let $(\mathbf{w}, P)$ be an equilibrium under tariff structure τ and $(\mathbf{w}', P')$ an equilibrium under tariff structure τ'. Define $(\hat{w}, \hat{P})$ as the equilibrium under τ' relative to τ, where a hat denotes the proportional change of a variable: $\hat{x} = x'/x$.*

Using Equations (7), (10), and (12), the equilibrium conditions can be expressed in changes. The change in unit costs is simply

$$\hat{c}_i = \hat{w}_i. \tag{20}$$

Changes in the sectoral price indices follow as

$$\hat{P}_i^s = \left[\sum_{j=1}^{N} \pi_{ij}^s \left(\hat{\kappa}_{ij}^s \hat{c}_j \right)^{-\theta^s} \right]^{-1/\theta^s}, \tag{21}$$

and changes in bilateral expenditure shares are given by[3]

$$\hat{\pi}_{ij}^s = \left[\frac{\hat{c}_j \hat{\kappa}_{ij}^s}{\hat{P}_i^s} \right]^{-\theta^s}. \tag{22}$$

The change in real wages can then be written as

$$\log \frac{\hat{w}_i}{\hat{P}_i} = -\sum_{s=1}^{S} \frac{\alpha_i^s}{\theta^s} \log \hat{\pi}_{ii}^s, \tag{23}$$

[3]In this Ricardian framework, the elasticity of trade with respect to trade costs is governed by the productivity-dispersion parameter θ^s, not by the elasticity of substitution as in Armington models.

which relates to changes in domestic expenditure shares: a country whose consumers shift spending toward domestically produced goods — that is, one whose $\hat{\pi}^s_{ii}$ rises — experiences a decline in real wages, as the shift reflects a contraction in access to cheaper foreign varieties.

Counterfactual total expenditure is

$$X_i^{s'} = \alpha_i^s Y_i^{'}, \tag{24}$$

where counterfactual income comprises labor income, tariff revenue, and the trade deficit:

$$Y_i^{'} = \hat{w}_i w_i L_i + \sum_{s=1}^{S}\sum_{j=1}^{N} \tau_{ij}^{s'} \frac{\pi_{ij}^{s'}}{1+\tau_{ij}^{s'}} X_i^{s'} + D_i. \tag{25}$$

The counterfactual trade-balance condition requires

$$\sum_{s=1}^{S}\sum_{j=1}^{N} \frac{\pi_{ij}^{s'}}{1+\tau_{ij}^{s'}} X_i^{s'} - D_i = \sum_{s=1}^{S}\sum_{j=1}^{N} \frac{\pi_{ji}^{s'}}{1+\tau_{ji}^{s'}} X_j^{s'}. \tag{26}$$

Because iceberg costs are held fixed, $\hat{\kappa}^s_{ij} = (1+\tau^{s'}_{ij})/(1+\tau^s_{ij})$ captures the change in total bilateral trade costs generated by the tariff change.

Finally, the welfare decomposition is obtained by totally differentiating $\text{Welfare}_i = Y_i/P_i$ and using the equilibrium conditions of the model:

$$\begin{aligned} d\log \text{Welfare}_i = \frac{1}{Y_i}\sum_{s=1}^{S}\sum_{j=1}^{N} \underbrace{\left(E^s_{ij}\, d\log c_i - M^s_{ij}\, d\log c_j\right)}_{\text{Terms of trade}} \\ + \frac{1}{Y_i}\sum_{s=1}^{S}\sum_{j=1}^{N} \underbrace{\tau^s_{ij} M^s_{ij}\left(d\log M^s_{ij} - d\log c_j\right)}_{\text{Volume of trade}}. \end{aligned} \tag{27}$$

The first term captures changes in the terms of trade — the relative price of a country's exports to its imports — while the second captures changes in the volume of trade, reflecting how tariff-induced quantity adjustments interact with existing tariff wedges. The decomposition makes clear that welfare can improve even when real wages fall, provided that tariff revenue gains are sufficiently large.

The system is solved by finding the $N \times 1$ vector of wage changes $\hat{w}$ that satisfies the trade balance condition (26), with US wages serving as the numéraire. All other equilibrium objects — prices, trade shares, expenditures, and welfare — follow directly from the wage solution.

6 Welfare Effects of Tariff Increases

I quantify the welfare effects of tariff changes through three counterfactual experiments, all motivated by the resurgence of protectionist trade policy in recent years. In the first, the United States imposes a unilateral 25-percentage-point increase in ad valorem tariffs on all imports, with no retaliatory response from trading partners. In the second, the US imposes the same tariff increase, but all trading partners retaliate with

equivalent 25-percentage-point increases on imports from the US only. In the third, all countries raise tariffs by 25 percentage points across all non-EU bilateral pairs and sectors simultaneously. The first experiment isolates the direct effects of US action in the absence of strategic responses; the second reveals how retaliation transforms these effects; the third captures the systemic consequences of full-blown multilateral trade conflict.

Before presenting the results, two methodological points deserve attention. First, the model matches the base year, 2022, exactly. Since observed trade deficits are exogenous to the model, counterfactual changes to trade policy do not adjust them. Following Caliendo and Parro (2015), I address this by eliminating all aggregate deficits: I first calibrate the model with observed deficits and then solve for a zero-deficit equilibrium, $D_i^{'} = 0$ for every country i, which serves as the base year for counterfactual analysis.

Second, all experiments are evaluated under short-run and long-run trade elasticities. The short-run elasticity captures the immediate response to tariff changes, when existing sourcing relationships and production structures constrain the speed of adjustment. The long-run elasticity reflects the equilibrium that is obtained once trade patterns fully adjust and converge to their new steady state. The short-run results therefore represent the immediate effect of the tariff shock, while the long-run results characterize the economy's eventual resting point.

6.1 Experiment 1: US Unilateral Tariff Increase

The first experiment considers a unilateral 25-percentage-point tariff increase imposed by the United States on all trading partners. The counterfactual change in tariffs is defined as

$$\widehat{\tau}^s_{\text{US},j} = \frac{1 + \tau^s_{\text{US},j,2022} + 0.25}{1 + \tau^s_{\text{US},j,2022}} \qquad \text{for all } j \in \mathcal{N} \setminus \{\text{US}\} \text{ and } s \in \mathcal{S}. \tag{28}$$

This scenario serves as a natural benchmark. By assuming no retaliation, it cleanly identifies how much of the tariff burden is absorbed by foreign exporters versus passed on to US consumers, and it quantifies the direct trade destruction between the US and its partners. It also represents the best-case outcome for the United States — an upper bound on the potential gains from unilateral protection — against which more realistic scenarios involving retaliation can be compared.

Table 3 reports the results, decomposing welfare into its terms of trade (ToT) and volume of trade (VoT) components. In this model without intermediate inputs, the VoT effect corresponds exactly to the change in real wages, so the decomposition separates welfare into a pure efficiency component (VoT) and a redistribution component operating through relative price movements and tariff revenue (ToT). The pattern is stark: the United States is the only country that gains meaningfully in welfare terms, recording an increase of +1.56% in the short run. Nearly every country loses; the few exceptions — Cyprus (0.32%), Laos (0.13%), Côte d'Ivoire (0.07%), and Malta (0.06%) — record only negligible gains. The average welfare decline is 0.41%, with the heaviest losses falling on countries most deeply integrated with the US market — Canada (−3.59%), Mexico (−3.18%), Costa Rica (−3.01%), and Ireland (−1.60%).

Yet the nature of the US gain is revealing. Nearly every country in the sample, including the United States (−2.76%), suffers a decline in real wages. The US records positive welfare only because tariff revenue, redistributed to households as a lump sum, more than offsets the real wage loss. Its ToT improvement of 4.32% — driven by tariff revenue and cheaper import prices as foreign exporters absorb part of the tariff burden — more than compensates for this efficiency loss. The gain is therefore not an efficiency improvement

but a pure revenue transfer extracted from trading partners. No country produces more efficiently as a result of the tariff. This confirms that the tariff is globally efficiency-reducing: the positive US welfare outcome is entirely a terms-of-trade transfer from trading partners, not a net creation of value.

The asymmetry in the decomposition is striking. The terms of trade effects are near zero for every country except the United States. Among trading partners, the ToT effects are uniformly small — typically below 0.15% in absolute value — reflecting the fact that the US captures essentially all of the terms-of-trade gains generated by the tariff. The volume-of-trade effects are negative or approximately zero for nearly every country, with Cyprus, Laos, Côte d'Ivoire, and Malta as small positive exceptions.

In the long run, the overall picture remains qualitatively unchanged — the US is still the sole meaningful winner — but the magnitudes shift in an instructive direction. Losses decline for most trading partners, while the sample-wide average welfare loss falls from 0.41% to 0.39%, Canada improves from −3.59% to −3.36%, and Mexico from −3.18% to −3.04%. The US gain, meanwhile, shrinks from 1.56% to 1.15%. The decomposition reveals the source of this attenuation: the US ToT improvement falls from 4.32% to 3.84%, while its VoT loss remains virtually unchanged (from −2.76% to −2.69%). The mechanism is straightforward. Under a unilateral shock, the US is the only market that has become more expensive; the rest of the world remains open. As trade elasticities rise in the long run, affected countries redirect exports toward alternative destinations and substitute away from US imports more effectively. The same higher elasticity that enables this reallocation also erodes US market power: foreign exporters are less willing to absorb the tariff burden when they have better outside options, and the terms-of-trade advantage that generated the US welfare gain is correspondingly diminished.

Table 3: Welfare Effects from Unilateral US Tariff Increase (%)

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Argentina	-0.17	-0.02	-0.14	-0.16	-0.03	-0.13
Australia	-0.46	0.01	-0.47	-0.42	0.01	-0.43
Austria	-0.32	-0.02	-0.30	-0.31	-0.03	-0.28
Bangladesh	-0.17	-0.03	-0.14	-0.17	-0.04	-0.13
Belarus	0.00	0.00	0.00	0.01	0.00	0.01
Belgium	-0.47	-0.04	-0.43	-0.45	-0.06	-0.39
Brazil	-0.33	-0.04	-0.29	-0.32	-0.05	-0.27
Brunei	-0.30	0.00	-0.30	-0.27	0.00	-0.27
Bulgaria	-0.03	-0.01	-0.03	-0.03	-0.01	-0.02
Cambodia	-1.16	-0.04	-1.12	-1.16	-0.06	-1.10
Cameroon	-0.11	-0.01	-0.10	-0.10	-0.01	-0.09
Canada	-3.59	0.00	-3.59	-3.36	0.00	-3.36
Chile	-1.29	-0.08	-1.21	-1.24	-0.10	-1.13
China	-0.10	-0.01	-0.09	-0.10	-0.02	-0.08
Colombia	-0.74	-0.03	-0.71	-0.68	-0.04	-0.64
Costa Rica	-3.01	0.01	-3.02	-2.85	0.02	-2.86
Côte d'Ivoire	0.07	0.01	0.06	0.09	0.02	0.07
Croatia	-0.10	0.00	-0.09	-0.09	-0.01	-0.09

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Table 3: Welfare Effects from Unilateral US Tariff Increase (%) *(continued)*

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Cyprus	0.32	-0.01	0.32	0.27	-0.01	0.28
Czech Republic	-0.14	-0.01	-0.13	-0.13	-0.02	-0.12
Denmark	-0.36	-0.01	-0.35	-0.35	-0.02	-0.34
Egypt	-0.12	0.00	-0.12	-0.11	0.00	-0.11
Estonia	-0.33	-0.01	-0.32	-0.33	-0.01	-0.31
Finland	-0.23	-0.02	-0.22	-0.22	-0.02	-0.20
France	-0.24	-0.02	-0.21	-0.23	-0.03	-0.20
Germany	-0.33	-0.02	-0.30	-0.32	-0.03	-0.28
Greece	-0.13	-0.01	-0.13	-0.13	-0.01	-0.11
Hong Kong	-0.31	0.00	-0.31	-0.27	0.00	-0.27
Hungary	-0.19	-0.01	-0.18	-0.18	-0.01	-0.17
Iceland	-0.41	0.00	-0.41	-0.38	0.00	-0.38
India	-0.24	-0.05	-0.19	-0.24	-0.06	-0.18
Indonesia	-0.15	-0.02	-0.13	-0.14	-0.02	-0.12
Ireland	-1.60	-0.08	-1.53	-1.55	-0.11	-1.44
Israel	-0.64	-0.02	-0.63	-0.62	-0.02	-0.59
Italy	-0.19	-0.01	-0.17	-0.18	-0.02	-0.16
Japan	-0.25	-0.01	-0.24	-0.24	-0.01	-0.23
Jordan	-0.61	-0.04	-0.57	-0.57	-0.06	-0.52
Kazakhstan	-0.22	-0.01	-0.21	-0.21	-0.02	-0.19
Laos	0.13	0.00	0.13	0.14	0.00	0.14
Latvia	-0.07	-0.01	-0.06	-0.06	-0.01	-0.05
Lithuania	-0.31	-0.01	-0.30	-0.30	-0.02	-0.28
Luxembourg	-0.14	-0.02	-0.13	-0.14	-0.02	-0.12
Malaysia	-0.62	-0.02	-0.60	-0.60	-0.03	-0.57
Malta	0.06	-0.02	0.08	0.05	-0.02	0.08
Mexico	-3.18	-0.13	-3.05	-3.04	-0.18	-2.85
Morocco	-0.36	0.00	-0.36	-0.33	0.00	-0.33
Myanmar	-0.06	0.00	-0.06	-0.06	0.00	-0.06
Netherlands	-0.49	-0.03	-0.45	-0.47	-0.05	-0.42
New Zealand	-0.47	-0.02	-0.45	-0.44	-0.02	-0.42
Nigeria	-0.12	-0.01	-0.12	-0.11	-0.01	-0.10
Norway	-0.29	0.00	-0.28	-0.26	0.00	-0.26
Pakistan	-0.17	-0.02	-0.15	-0.17	-0.03	-0.14
Peru	-0.74	0.00	-0.74	-0.69	0.00	-0.69
Philippines	-0.39	-0.02	-0.37	-0.38	-0.03	-0.34
Poland	-0.17	-0.01	-0.15	-0.16	-0.02	-0.14
Portugal	-0.17	-0.01	-0.16	-0.16	-0.01	-0.15
Romania	-0.06	0.00	-0.06	-0.07	0.00	-0.06
Russia	-0.03	0.00	-0.03	-0.02	0.00	-0.02
Saudi Arabia	-0.27	-0.01	-0.26	-0.25	-0.01	-0.23

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Table 3: Welfare Effects from Unilateral US Tariff Increase (%) *(continued)*

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Senegal	-0.10	0.00	-0.09	-0.06	0.00	-0.06
Singapore	-0.88	0.00	-0.88	-0.82	0.00	-0.82
Slovakia	-0.13	-0.01	-0.12	-0.12	-0.01	-0.11
Slovenia	-0.26	-0.02	-0.24	-0.25	-0.02	-0.23
South Africa	-0.49	-0.02	-0.46	-0.46	-0.03	-0.43
South Korea	-0.38	-0.04	-0.34	-0.36	-0.05	-0.31
Spain	-0.23	-0.02	-0.21	-0.21	-0.03	-0.19
Sweden	-0.26	-0.02	-0.25	-0.25	-0.02	-0.23
Switzerland	-0.68	0.00	-0.68	-0.63	0.00	-0.63
Taiwan	-0.57	0.00	-0.57	-0.53	0.00	-0.53
Thailand	-0.55	-0.04	-0.51	-0.55	-0.06	-0.49
Tunisia	-0.14	0.00	-0.14	-0.14	0.00	-0.14
Türkiye	-0.31	-0.03	-0.28	-0.30	-0.05	-0.25
Ukraine	-0.20	-0.01	-0.20	-0.19	-0.01	-0.19
United Arab Emirates	-0.43	0.00	-0.43	-0.39	0.00	-0.39
United Kingdom	-0.58	-0.01	-0.57	-0.54	-0.01	-0.53
United States	1.56	4.32	-2.76	1.15	3.84	-2.69
Vietnam	-0.50	-0.03	-0.47	-0.50	-0.05	-0.46
Mean	-0.41	0.04	-0.45	-0.39	0.03	-0.42

Notes: Welfare is decomposed as $\widehat{Welfare}_j = \widehat{ToT}_j + \widehat{VoT}_j$. The broad ToT component includes changes in external relative prices and tariff revenue. VoT captures changes in the volume of trade and, because the model excludes intermediate inputs, equals the real-wage change. Balanced trade ($D = 0$) is imposed using the two-step procedure. Short-run results use θ^s_{SR}; long-run results use θ^s_{LR}. The US imposes a 25-percentage-point tariff increase on all imports, with no retaliation by trading partners. The sample contains 77 countries and 22 sectors. Values are percentages.

6.2 Experiment 2: Retaliation

The second experiment maintains the US tariff increase of 25 percentage points but assumes that all 76 trading partners retaliate by imposing equivalent 25-percentage-point increases on imports from the US only. Tariffs between non-US countries are unchanged. This scenario isolates the effect of retaliation directed specifically at the United States, without the additional complications of a global trade war.

Table 4 reports the results. The contrast with Experiment 1 is dramatic. The US welfare gain is entirely eliminated: welfare falls to -2.21% in the short run and -2.39% in the long run. The decomposition reveals why. The US still captures a positive ToT effect (3.30% in the short run), but this is now far smaller than under the unilateral shock (4.32%), because retaliating partners are taxing US exports and thereby eroding the US terms-of-trade advantage. Meanwhile, the VoT loss deepens from -2.76% to -5.52%, as US exports now face higher tariffs in every destination market, compounding the efficiency costs of the US's own tariff.

The welfare effects are strikingly different from the unilateral case. Mean welfare improves from -0.41% to -0.16%, and the number of countries recording positive welfare rises from 5 to 34. Partners benefit from

two channels: they collect tariff revenue on US imports (positive ToT), and the retaliatory tariffs partially insulate their domestic producers from US competition. The largest gains accrue to countries with little direct exposure to the US market — Cyprus (0.66%), Peru (0.50%), Côte d'Ivoire (0.42%), and the United Arab Emirates (0.38%) — while most of the highly US-dependent economies still suffer substantially, though less than under the unilateral scenario: Canada improves from −3.59% to −1.87% and Mexico from −3.18% to −2.46%. Cambodia is the notable exception, deepening from −1.16% to −2.52%, as its own retaliatory tariff on US imports compounds rather than offsets its losses.

In the long run, the US loss deepens from −2.21% to −2.39%. Unlike the unilateral case, where the US gain merely eroded over time, here the loss grows. The decomposition shows that the US ToT improvement falls from 3.30% to 2.61% as partners redirect away from US products, while the VoT loss improves modestly from −5.52% to −5.00%. The net effect is a deeper loss: the revenue channel weakens faster than the efficiency channel improves.

Table 4: Welfare Effects from Retaliation against the US (%)

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Argentina	0.08	0.24	-0.16	0.03	0.18	-0.15
Australia	0.13	0.82	-0.68	0.05	0.69	-0.64
Austria	-0.15	0.33	-0.48	-0.19	0.25	-0.44
Bangladesh	-0.24	0.05	-0.29	-0.26	0.00	-0.26
Belarus	0.02	0.01	0.01	0.02	0.01	0.01
Belgium	0.04	0.64	-0.61	-0.08	0.47	-0.55
Brazil	-0.01	0.39	-0.40	-0.07	0.30	-0.37
Brunei	0.10	0.49	-0.39	0.02	0.41	-0.39
Bulgaria	0.07	0.10	-0.03	0.04	0.08	-0.03
Cambodia	-2.52	0.02	-2.55	-2.33	-0.02	-2.31
Cameroon	-0.02	0.11	-0.12	-0.02	0.09	-0.11
Canada	-1.87	4.09	-5.96	-1.87	3.53	-5.40
Chile	0.18	1.89	-1.70	-0.04	1.59	-1.63
China	-0.02	0.11	-0.13	-0.04	0.08	-0.13
Colombia	-0.20	0.84	-1.05	-0.26	0.66	-0.92
Costa Rica	-0.58	4.34	-4.93	-0.83	3.80	-4.63
Côte d'Ivoire	0.42	0.27	0.15	0.36	0.23	0.13
Croatia	-0.10	0.06	-0.16	-0.10	0.05	-0.14
Cyprus	0.66	0.09	0.57	0.55	0.07	0.47
Czech Republic	0.10	0.25	-0.15	0.05	0.20	-0.14
Denmark	-0.40	0.21	-0.62	-0.39	0.16	-0.55
Egypt	0.06	0.23	-0.17	0.02	0.18	-0.16
Estonia	-0.30	0.26	-0.56	-0.31	0.21	-0.52
Finland	-0.06	0.27	-0.32	-0.09	0.21	-0.29
France	0.04	0.35	-0.31	-0.02	0.27	-0.29
Germany	0.00	0.44	-0.44	-0.07	0.34	-0.41
Greece	-0.06	0.13	-0.19	-0.07	0.10	-0.17

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Table 4: Welfare Effects from Retaliation against the US (%) *(continued)*

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Hong Kong	0.21	0.70	-0.48	0.14	0.57	-0.43
Hungary	-0.04	0.24	-0.28	-0.07	0.19	-0.26
Iceland	0.11	0.69	-0.58	0.02	0.59	-0.57
India	-0.20	0.11	-0.31	-0.23	0.05	-0.28
Indonesia	-0.07	0.14	-0.21	-0.09	0.10	-0.19
Ireland	-1.28	1.30	-2.57	-1.32	1.00	-2.32
Israel	-0.45	0.62	-1.07	-0.47	0.50	-0.97
Italy	-0.12	0.17	-0.29	-0.14	0.12	-0.26
Japan	0.10	0.45	-0.35	0.02	0.35	-0.33
Jordan	-0.76	0.30	-1.06	-0.68	0.23	-0.91
Kazakhstan	0.08	0.36	-0.28	0.03	0.30	-0.26
Laos	0.31	0.05	0.26	0.30	0.04	0.26
Latvia	0.03	0.11	-0.08	0.01	0.08	-0.07
Lithuania	-0.32	0.17	-0.49	-0.31	0.13	-0.44
Luxembourg	0.09	0.25	-0.16	0.03	0.19	-0.16
Malaysia	-0.17	0.76	-0.93	-0.28	0.61	-0.88
Malta	0.36	0.15	0.20	0.26	0.11	0.14
Mexico	-2.46	2.75	-5.21	-2.55	2.18	-4.73
Morocco	0.09	0.60	-0.51	0.00	0.49	-0.49
Myanmar	-0.04	0.05	-0.09	-0.06	0.04	-0.10
Netherlands	0.17	0.80	-0.63	0.03	0.62	-0.59
New Zealand	-0.11	0.59	-0.70	-0.16	0.49	-0.65
Nigeria	-0.03	0.13	-0.16	-0.03	0.11	-0.14
Norway	0.08	0.49	-0.41	0.02	0.39	-0.38
Pakistan	-0.19	0.10	-0.28	-0.21	0.05	-0.26
Peru	0.50	1.52	-1.02	0.29	1.27	-0.98
Philippines	-0.13	0.44	-0.56	-0.18	0.35	-0.53
Poland	0.07	0.25	-0.19	0.02	0.20	-0.18
Portugal	-0.19	0.09	-0.28	-0.18	0.07	-0.25
Romania	-0.01	0.08	-0.09	-0.03	0.06	-0.09
Russia	-0.01	0.03	-0.04	-0.01	0.02	-0.03
Saudi Arabia	0.04	0.39	-0.35	0.00	0.33	-0.33
Senegal	0.04	0.25	-0.20	0.06	0.21	-0.15
Singapore	0.01	1.41	-1.39	-0.12	1.17	-1.30
Slovakia	-0.08	0.12	-0.20	-0.09	0.10	-0.19
Slovenia	-0.13	0.24	-0.37	-0.15	0.18	-0.33
South Africa	-0.06	0.62	-0.68	-0.12	0.50	-0.63
South Korea	0.02	0.49	-0.47	-0.07	0.38	-0.45
Spain	0.02	0.30	-0.28	-0.03	0.22	-0.26
Sweden	-0.15	0.25	-0.40	-0.17	0.19	-0.36
Switzerland	-0.10	0.96	-1.06	-0.23	0.73	-0.96

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Table 4: Welfare Effects from Retaliation against the US (%) *(continued)*

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Taiwan	0.01	0.87	-0.87	-0.10	0.72	-0.82
Thailand	-0.47	0.38	-0.85	-0.51	0.28	-0.79
Tunisia	0.09	0.29	-0.20	0.03	0.24	-0.20
Türkiye	-0.16	0.25	-0.41	-0.21	0.17	-0.38
Ukraine	-0.01	0.26	-0.27	-0.04	0.22	-0.27
United Arab Emirates	0.38	0.97	-0.58	0.26	0.82	-0.56
United Kingdom	0.02	0.87	-0.85	-0.08	0.69	-0.78
United States	-2.21	3.30	-5.52	-2.39	2.61	-5.00
Vietnam	-0.70	0.20	-0.90	-0.69	0.13	-0.82
Mean	-0.16	0.57	-0.73	-0.21	0.46	-0.67

Notes: Welfare is decomposed as $\widehat{Welfare}_j = \widehat{ToT}_j + \widehat{VoT}_j$. The broad ToT component includes changes in external relative prices and tariff revenue. VoT captures changes in the volume of trade and, because the model excludes intermediate inputs, equals the real-wage change. Balanced trade ($D = 0$) is imposed using the two-step procedure. Short-run results use θ^s_{SR}; long-run results use θ^s_{LR}. The US imposes a 25-percentage-point tariff increase on all imports and all 76 trading partners retaliate with an equivalent 25-percentage-point increase on US imports only; tariffs between non-US countries are unchanged. The sample contains 77 countries and 22 sectors. Values are percentages.

6.3 Experiment 3: Multilateral Tariff Escalation

The third experiment assumes that all countries raise tariffs by 25 percentage points across all non-EU bilateral pairs:

$$\widehat{\tau}^s_{ij} = \begin{cases} \dfrac{1 + \tau^s_{ij,2022} + 0.25}{1 + \tau^s_{ij,2022}}, & i \neq j, \quad (i,j) \notin \mathcal{EU} \times \mathcal{EU}, \\ 1, & i = j \quad \text{or} \quad (i,j) \in \mathcal{EU} \times \mathcal{EU}, \end{cases} \qquad s \in \mathcal{S}, \tag{29}$$

Here, $\mathcal{EU}$ denotes the set of EU member states. Domestic trade and intra-EU trade are therefore exempt from the tariff increase.

This scenario captures the systemic consequences of a world in which trade conflict extends beyond bilateral disputes to encompass the entire global trading system. It provides a measure of the costs of full-blown multilateral protectionism.

Table 5 reports the results. The losses are substantially larger than in either of the preceding experiments. Mean welfare falls by 2.61% in the short run, more than six times the average loss under the unilateral US tariff. The most open economies outside the EU are devastated: Hong Kong (−10.29%), Laos (−9.59%), and Tunisia (−8.76%) suffer losses exceeding 8%. The decomposition reveals a fundamentally different structure from the unilateral case. The terms of trade effects are now positive for the majority of countries, as each tariff-imposing nation collects revenue on its imports. The largest ToT improvements accrue to the most

open economies — Hong Kong (19.43%), Laos (16.93%), Tunisia (14.45%), and Singapore (14.38%) — but these same countries also suffer the most severe VoT losses, as high openness simultaneously exposes them to severe trade destruction. For most countries, the real wage losses dominate, producing negative welfare overall.

The United States records a welfare loss of −1.31% in the short run, a stark reversal from the 1.56% gain obtained under the unilateral scenario. The decomposition shows that the US still collects substantial tariff revenue (ToT of 3.56%), but the VoT loss (−4.87%) overwhelms it. The only countries that record positive welfare are EU members shielded by the intra-EU tariff exemption: Luxembourg (0.16%), Hungary (0.15%), the Czech Republic (0.06%), and Poland (0.06%). With intra-EU tariffs unchanged, these countries can redirect trade internally while collecting revenue on external imports.

The long-run results sharpen these findings dramatically. Mean welfare declines from −2.61% to −2.96%, and every country without exception is worse off in the long run than in the short run. The number of countries with positive welfare collapses from 4 to 0 — no country retains a welfare gain once adjustment is complete. The United States moves from −1.31% to −1.62%. The decomposition clarifies why the loss deepens, and the mechanism mirrors that of the retaliation experiment rather than the unilateral one. For the US, the ToT component contracts from 3.56% to 2.89%, while the VoT component improves modestly from −4.87% to −4.51%; the same pattern holds on average, with mean ToT falling from 5.21% to 4.38% and mean VoT improving from −7.82% to −7.34%. The net welfare loss grows because the positive tariff-revenue and terms-of-trade component shrinks faster than the negative real-wage component recovers. Intuitively, higher long-run elasticities erode each country's ability to sustain the terms-of-trade and revenue gains that partly offset the real-wage losses on impact: with tariffs elevated across all non-EU pairs simultaneously, there are no untaxed foreign suppliers toward which to redirect—except within the EU network—so the revenue base on which the ToT gain rests contracts as trade volumes adjust downward. The result is that the revenue channel weakens more than the efficiency channel improves, and net losses widen once adjustment is complete.

Comparing the three experiments yields a clear conclusion. Under a unilateral tariff increase, the United States can capture welfare gains that persist across both time horizons, albeit diminishing in magnitude as trading partners adjust. Retaliation eliminates and reverses this gain, but requires coordinated action by a large number of partners. A multilateral tariff escalation generates losses that are widespread, large, and growing over time: the short-run estimates that form the basis of most applied trade policy analysis systematically understate the welfare costs that materialize once adjustment is complete.

Table 5: Welfare Effects from Multilateral Tariff Escalation (%)

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Argentina	-0.84	1.52	-2.36	-1.20	1.01	-2.20
Australia	-3.55	6.68	-10.23	-4.10	5.58	-9.68
Austria	-1.00	2.35	-3.34	-1.19	1.87	-3.06
Bangladesh	-0.97	2.97	-3.94	-1.35	2.34	-3.69
Belarus	-1.77	3.74	-5.51	-2.07	3.11	-5.18
Belgium	-0.45	3.01	-3.46	-0.82	2.38	-3.20

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Table 5: Welfare Effects from Multilateral Tariff Escalation (%) *(continued)*

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Brazil	-1.18	1.52	-2.70	-1.49	0.97	-2.46
Brunei	-2.83	6.00	-8.83	-3.32	5.48	-8.80
Bulgaria	-0.16	2.74	-2.91	-0.53	2.13	-2.66
Cambodia	-5.45	11.88	-17.33	-5.87	10.51	-16.38
Cameroon	-4.31	3.86	-8.17	-4.82	2.80	-7.62
Canada	-4.57	8.06	-12.62	-4.98	6.86	-11.84
Chile	-6.05	6.37	-12.42	-6.83	4.88	-11.71
China	-0.31	1.13	-1.44	-0.48	0.85	-1.33
Colombia	-2.25	3.07	-5.32	-2.60	2.25	-4.85
Costa Rica	-5.11	10.20	-15.31	-5.40	8.92	-14.33
Côte d'Ivoire	-1.60	3.11	-4.70	-2.08	2.38	-4.45
Croatia	-0.03	0.85	-0.88	-0.15	0.64	-0.80
Cyprus	-1.99	3.83	-5.82	-2.20	3.12	-5.32
Czech Republic	0.06	3.72	-3.66	-0.28	3.13	-3.41
Denmark	-1.78	2.16	-3.94	-1.91	1.74	-3.65
Egypt	-1.35	3.68	-5.03	-1.63	2.94	-4.57
Estonia	-1.96	3.76	-5.72	-2.26	2.98	-5.24
Finland	-1.11	1.85	-2.96	-1.27	1.43	-2.70
France	-1.26	2.21	-3.47	-1.43	1.78	-3.21
Germany	-1.05	2.93	-3.98	-1.30	2.39	-3.69
Greece	-1.07	2.52	-3.60	-1.30	1.93	-3.23
Hong Kong	-10.29	19.43	-29.72	-10.43	18.40	-28.83
Hungary	0.15	2.28	-2.13	-0.05	1.83	-1.88
Iceland	-7.35	11.13	-18.48	-8.03	9.77	-17.80
India	-1.11	1.39	-2.50	-1.47	0.82	-2.29
Indonesia	-1.04	3.19	-4.23	-1.38	2.58	-3.96
Ireland	-1.68	5.99	-7.67	-2.12	4.98	-7.10
Israel	-2.48	5.75	-8.23	-2.92	4.76	-7.69
Italy	-0.74	1.55	-2.29	-0.89	1.17	-2.07
Japan	-0.85	3.09	-3.94	-1.07	2.55	-3.62
Jordan	-3.99	6.01	-10.00	-4.81	4.52	-9.33
Kazakhstan	-6.72	9.46	-16.18	-7.21	8.34	-15.55
Laos	-9.59	16.93	-26.52	-10.06	15.71	-25.77
Latvia	-1.98	2.14	-4.12	-2.02	1.71	-3.73
Lithuania	-1.73	1.54	-3.27	-1.79	1.16	-2.96
Luxembourg	0.16	1.44	-1.28	-0.02	1.16	-1.19
Malaysia	-3.44	7.67	-11.11	-4.01	6.37	-10.39
Malta	-2.50	4.69	-7.20	-2.73	4.04	-6.77
Mexico	-2.86	5.96	-8.81	-3.17	4.95	-8.11
Morocco	-3.98	9.16	-13.14	-4.26	8.15	-12.42
Myanmar	-0.96	5.19	-6.15	-1.38	4.29	-5.67

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Table 5: Welfare Effects from Multilateral Tariff Escalation (%) *(continued)*

	Short run			Long run		
Country	Welfare	ToT	VoT	Welfare	ToT	VoT
Netherlands	-0.26	4.57	-4.83	-0.68	3.76	-4.45
New Zealand	-3.11	6.89	-10.01	-3.66	5.92	-9.57
Nigeria	-2.15	2.54	-4.69	-2.39	2.25	-4.63
Norway	-4.81	7.69	-12.50	-5.24	6.40	-11.64
Pakistan	-0.96	2.40	-3.35	-1.32	1.73	-3.06
Peru	-3.12	5.50	-8.61	-3.54	4.46	-8.00
Philippines	-2.63	6.65	-9.28	-3.00	5.74	-8.74
Poland	0.06	2.78	-2.72	-0.30	2.27	-2.57
Portugal	-0.56	1.23	-1.80	-0.65	0.93	-1.58
Romania	-0.09	1.55	-1.64	-0.26	1.21	-1.47
Russia	-1.18	2.29	-3.47	-1.37	1.83	-3.20
Saudi Arabia	-3.38	4.93	-8.31	-3.95	3.95	-7.90
Senegal	-5.14	7.17	-12.31	-5.80	5.89	-11.69
Singapore	-7.03	14.38	-21.41	-7.29	12.54	-19.83
Slovakia	-0.32	3.39	-3.71	-0.60	2.86	-3.46
Slovenia	-1.69	5.70	-7.38	-2.15	4.77	-6.93
South Africa	-4.22	5.91	-10.13	-4.82	4.62	-9.44
South Korea	-1.69	3.25	-4.94	-2.13	2.40	-4.53
Spain	-0.57	2.55	-3.11	-0.87	2.05	-2.92
Sweden	-1.37	1.97	-3.34	-1.51	1.57	-3.07
Switzerland	-4.63	8.84	-13.46	-5.08	7.62	-12.71
Taiwan	-2.38	6.74	-9.12	-2.78	5.59	-8.37
Thailand	-2.83	6.98	-9.81	-3.19	5.90	-9.09
Tunisia	-8.76	14.45	-23.21	-8.81	13.23	-22.04
Türkiye	-2.62	5.52	-8.15	-2.92	4.39	-7.32
Ukraine	-3.75	5.70	-9.45	-4.21	4.56	-8.77
United Arab Emirates	-7.36	12.45	-19.81	-7.63	11.03	-18.66
United Kingdom	-4.38	7.68	-12.06	-4.74	6.33	-11.07
United States	-1.31	3.56	-4.87	-1.62	2.89	-4.51
Vietnam	-2.11	5.90	-8.02	-2.47	4.82	-7.29
Mean	-2.61	5.21	-7.82	-2.96	4.38	-7.34

Notes: Welfare is decomposed as $\widehat{Welfare}_j = \widehat{ToT}_j + \widehat{VoT}_j$. The broad ToT component includes changes in external relative prices and tariff revenue. VoT captures changes in the volume of trade and, because the model excludes intermediate inputs, equals the real-wage change. Balanced trade ($D = 0$) is imposed using the two-step procedure. Short-run results use θ^s_{SR}; long-run results use θ^s_{LR}. All countries raise tariffs by 25 percentage points on every bilateral pair except pairs in which both countries are EU members, whose tariffs are unchanged; 5,150 of 5,852 directed pairs are shocked in each sector. The 27 EU members are treated as a customs union. The sample contains 77 countries and 22 sectors. Values are percentages.

7 Conclusion

This paper quantifies the welfare effects of tariff increases in a multi-country, multi-sector Eaton–Kortum model, building on the "exact hat algebra" approach of Dekle et al. (2007) as implemented by Caliendo and Parro (2015). The framework is parsimonious — it requires only data on bilateral trade flows, production, and tariffs, together with estimated trade elasticities — yet rich enough to capture the channels through which tariffs propagate across countries and sectors. A key contribution is the estimation of sector-specific trade elasticities that distinguish between short-run and long-run responses, allowing the analysis to trace how the welfare consequences of tariff shocks evolve as economies adjust.

Three counterfactual experiments illustrate the importance of the scope of the tariff action, the presence of retaliation, and the time horizon over which effects are evaluated. Under a unilateral US tariff increase, the United States is the sole meaningful beneficiary, recording a welfare gain of 1.56% in the short run. Almost all trading partners lose, with the heaviest effects falling on the most US-exposed economies: Canada (-3.59%), Mexico (-3.18%) and Costa Rica (-3.01%). Yet, the US gain is entirely revenue-driven — real wages fall in nearly every country, including the United States — and it shrinks to 1.15% in the long run as trading partners redirect trade toward alternative markets and the US terms-of-trade advantage erodes.

Under retaliation against the US, in which all trading partners impose equivalent tariff increases on US imports, the US gain is entirely eliminated: welfare falls to -2.21% in the short run and -2.39% in the long run.

Under a multilateral escalation in which all countries raise tariffs simultaneously, the losses are far larger and the long-run effect exceeds the short-run one — the reverse ordering to the unilateral case. Mean welfare declines by 2.61% on impact and by 2.96% in the long run. The most open economies outside the EU are devastated: Hong Kong (-10.29%), Laos (-9.59%), and Tunisia (-8.76%). The only countries that record positive welfare are EU members shielded by the intra-EU tariff exemption, and even these gains disappear entirely once adjustment is complete. The mechanism that cushioned trading partners under the unilateral shock — reallocation toward untaxed markets — is unavailable when tariffs rise everywhere—except within the EU—simultaneously. As a result, higher long-run elasticities erode the terms-of-trade gains that partly offset the short-run real-wage losses faster than those real-wage losses recover, so net losses widen rather than narrow as adjustment completes. Every country without exception is worse off in the long run than in the short run.

The contrast across the three experiments yields a clear message. Welfare gains from unilateral tariffs are available to a large, relatively closed economy like the United States, but a multilateral escalation generates losses that are widespread, large, and growing over time. The distinction between short-run and long-run elasticities affects the relative magnitude, rather than uniformly the direction, of the welfare response. In these experiments, long-run adjustment attenuates trading partners' losses under unilateral protection but increases net losses under multilateral escalation. Ignoring this distinction risks misleading policymakers about the true long-run consequences of trade policy.

The analysis abstracts from several margins that may affect the magnitudes reported here, including intermediate inputs, services trade, richer preference heterogeneity, and dynamic investment responses. Incorporating these features would enrich the analysis, but the core finding — that the distinction between short-run and long-run trade elasticities is quantitatively important for welfare evaluation, and that the direction of long-run amplification depends critically on the structure of the tariff shock — is likely to survive in richer

environments.

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A Appendix

A.1 Data: Mapping TiVA to ISIC Rev. 3 for domestic trade

A sector concordance is required because the TiVA database uses ISIC Rev. 4 classifications while the ITPD-E bilateral trade data and the estimated trade elasticities use ISIC Rev. 3 divisions (15–36). Table A.2 reports the full concordance. Three types of mapping arise.

Eleven TiVA sectors correspond one-to-one with ITPD-E divisions and are used directly: wood products, coke and refined petroleum, rubber and plastics, non-metallic mineral products, basic metals, fabricated metal products, electrical machinery, machinery not elsewhere classified, motor vehicles, other transport equipment, and furniture and manufacturing n.e.c. One sector requires aggregation. ISIC Rev. 3 division 24 (manufacture of chemicals and chemical products) includes pharmaceuticals, which ISIC Rev. 4 reports separately as two sectors - chemicals and pharmaceuticals. I sum TiVA domestic trade for these two sectors to match the single ITPD-E division.

Four TiVA sectors are more aggregated than the corresponding ITPD-E divisions and require disaggregation. TiVA reports food, beverages, and tobacco as a single sector (C10T12), but this corresponds to two ITPD-E divisions (food and beverages; tobacco products). Similarly, TiVA combines textiles, apparel, and leather into one sector (C13T15), covering three ITPD-E divisions (textiles; wearing apparel; leather and footwear). Paper and printing is reported as a combined sector (C17_18), covering two divisions (paper products; publishing and printing). Computer, electronic, and optical products is a single TiVA sector (C26), covering three divisions (office and computing machinery; radio, television, and communication equipment; medical and optical instruments).

For these sectors, I distribute TiVA domestic trade across subsectors using each country's export composition from the ITPD-E bilateral trade data. Specifically, for country i and TiVA aggregate sector A comprising ITPD-E subsectors $\{s_1, s_2, \ldots\}$, the domestic trade allocated to subsector s_k is:

$$X_{ii}^{s_k} = \frac{\text{EXP}_i^{s_k}}{\sum_{\ell:\, s_\ell \in A} \text{EXP}_i^{s_\ell}} \times X_{ii}^{A} \tag{30}$$

where $\text{EXP}_i^{s_k} = \sum_{j \neq i} X_{ji}^{s_k}$ is country i's total exports in subsector s_k, computed from the ITPD-E bilateral trade data for 2022. Because $X_{ji}^{s_k}$ denotes expenditure in destination country j on goods from origin country i, this expression follows the destination–origin convention used throughout the paper. This approach assumes that a country's domestic production composition across subsectors mirrors its export composition, a reasonable approximation given that both reflect the same underlying pattern of comparative advantage.

The resulting domestic trade matrix covers 77 countries and 22 manufacturing sectors. This matrix is combined with bilateral trade flows from the ITPD-E to construct the full expenditure matrix, where the diagonal elements represent domestic trade and the off-diagonal elements represent bilateral imports.

Table A.1: Industry Classification

Number	Industry	ISIC Rev. 3
1	Food products and beverages	15
2	Tobacco products	16
3	Textiles	17
4	Wearing apparel; dressing and dyeing of fur	18
5	Leather, leather products, and footwear	19
6	Wood and products of wood and cork	20
7	Paper and paper products	21
8	Printing and publishing	22
9	Coke, refined petroleum products, and nuclear fuel	23
10	Chemicals and chemical products	24
11	Rubber and plastic products	25
12	Other non-metallic mineral products	26
13	Basic metals	27
14	Fabricated metal products, except machinery and equipment	28
15	Machinery and equipment, n.e.c.	29
16	Office, accounting, and computing machinery	30
17	Electrical machinery and apparatus, n.e.c.	31
18	Radio, television, and communication equipment	32
19	Medical, precision, and optical instruments	33
20	Motor vehicles, trailers, and semi-trailers	34
21	Other transport equipment	35
22	Furniture; manufacturing n.e.c.	36

Table A.2: Sector Concordance: TiVA (ISIC Rev. 4) to ITPD-E (ISIC Rev. 3)

ITPD-E (ISIC Rev. 3)	Description		TiVA (ISIC Rev. 4)	Mapping
15	Food and beverages	←	C10T12	Disaggregation
16	Tobacco products	←	C10T12	Disaggregation
17	Textiles	←	C13T15	Disaggregation
18	Wearing apparel	←	C13T15	Disaggregation
19	Leather and footwear	←	C13T15	Disaggregation
20	Wood products	←	C16	Direct
21	Paper products	←	C17_18	Disaggregation
22	Publishing and printing	←	C17_18	Disaggregation
23	Coke and petroleum	←	C19	Direct
24	Chemicals and pharmaceuticals	←	C20 + C21	Aggregation
25	Rubber and plastics	←	C22	Direct
26	Non-metallic minerals	←	C23	Direct
27	Basic metals	←	C24	Direct
28	Fabricated metals	←	C25	Direct
29	Machinery n.e.c.	←	C28	Direct
30	Office and computing	←	C26	Disaggregation
31	Electrical machinery	←	C27	Direct
32	Radio, TV, and communication	←	C26	Disaggregation
33	Medical and optical	←	C26	Disaggregation
34	Motor vehicles	←	C29	Direct
35	Other transport equipment	←	C30	Direct
36	Furniture; manufacturing n.e.c.	←	C31T33	Direct

Notes: Direct indicates a one-to-one match between TiVA and ITPD-E sectors. Aggregation indicates that TiVA sectors are summed to match one ITPD-E division. Disaggregation indicates that a TiVA aggregate is divided across ITPD-E divisions using export shares from the ITPD-E bilateral trade data.

List of countries used in the trade elasticity estimations The list below enumerates all reporting territories appearing in the raw ITPD-E data. The estimation panel retains the 170 countries with sufficient bilateral trade and tariff coverage over 1995–2022; territories without usable observations (for example, uninhabited or non-reporting entities) drop out of the estimation sample.

Afghanistan, Albania, Algeria, American Samoa, Andorra, Angola, Anguilla, Antarctica, Antigua and Barbuda, Argentina, Armenia, Aruba, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belgium-Luxembourg, Belize, Benin, Bermuda, Bhutan, Bolivia, Bonaire, Sint Eustatius and Saba, Bosnia and Herzegovina, Botswana, Bouvet Island, Brazil, British Indian Ocean Territory, British Virgin Islands, Brunei, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Canada, Cayman Islands, Central African Republic, Chad, Chile, China, Christmas Island, Cocos (Keeling) Islands, Colombia, Comoros, Cook Islands, Costa Rica, Côte d'Ivoire, Croatia, Cuba, Curacao, Cyprus, Czech Republic, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, Equatorial Guinea, Eritrea, Eswatini, Estonia, Ethiopia, Falkland Islands, Faroe Islands, Federated States of Micronesia, Fiji, Finland, France, French Guiana, French Polynesia, French Southern Territories, Free Zones, Gabon, Gambia, Georgia, Germany, Ghana, Gibraltar, Greece, Greenland, Grenada,

Guadeloupe, Guam, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Heard Island and McDonald Islands, Honduras, Hong Kong, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Korea, Kuwait, Kyrgyzstan, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Macao, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Martinique, Mauritania, Mauritius, Mayotte, Mexico, Moldova, Monaco, Mongolia, Montenegro, Montserrat, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Niue, Norfolk Island, North Korea, North Macedonia, Northern Mariana Islands, Norway, Oman, Pakistan, Palau, Palestine, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Pitcairn, Poland, Portugal, Qatar, Republic of the Congo, Reunion, Romania, Russia, Rwanda, Saint Barthelemy, Saint Helena, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Serbia and Montenegro, Seychelles, Sierra Leone, Singapore, Sint Maarten, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Georgia and the South Sandwich Islands, South Sudan, Spain, Sri Lanka, Sudan, Suriname, Sweden, Switzerland, Syria, Taiwan, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tokelau, Tonga, Trinidad and Tobago, Tunisia, Türkiye, Turks and Caicos Islands, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, United States Minor Outlying Islands, Uruguay, Uzbekistan, Vanuatu, Vatican City, Venezuela, Vietnam, Wallis and Futuna, Western Sahara, Yemen, Zambia, and Zimbabwe.

List of countries used in the counterfactual experiments Argentina, Australia, Austria, Bangladesh, Belarus, Belgium, Brazil, Brunei, Bulgaria, Cambodia, Cameroon, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Côte d'Ivoire, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Korea, Laos, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Myanmar, Netherlands, New Zealand, Nigeria, Norway, Pakistan, Peru, Philippines, Poland, Portugal, Romania, Russia, Saudi Arabia, Senegal, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Türkiye, Ukraine, United Arab Emirates, United Kingdom, United States, and Vietnam.

Table A.3: Estimation Results: Sector-Specific Trade Elasticities and Persistence Parameters

Sector	θ^s_{SR}	φ^s
Food products and beverages	0.916^{***}	0.409^{***}
	(0.076)	(0.005)
Tobacco products	0.234	0.417^{***}
	(0.143)	(0.011)
Textiles	2.357^{***}	0.353^{***}
	(0.115)	(0.005)
Wearing apparel; fur	0.984^{***}	0.375^{***}
	(0.105)	(0.005)
Leather products	1.918^{***}	0.371^{***}
	(0.139)	(0.005)
Wood products	3.217^{***}	0.349^{***}
	(0.178)	(0.006)
Paper products	3.293^{***}	0.366^{***}
	(0.186)	(0.006)
Printing and publishing	2.693^{***}	0.300^{***}
	(0.184)	(0.006)
Coke and refined products	3.464^{***}	0.292^{***}
	(0.416)	(0.008)
Chemicals	3.092^{***}	0.372^{***}
	(0.199)	(0.005)
Rubber and plastics	1.796^{***}	0.337^{***}
	(0.129)	(0.005)
Non-metallic mineral products	2.499^{***}	0.352^{***}
	(0.150)	(0.006)
Basic metals	4.282^{***}	0.360^{***}
	(0.237)	(0.006)
Fabricated metal products	3.134^{***}	0.267^{***}
	(0.156)	(0.005)
Machinery n.e.c.	3.565^{***}	0.221^{***}
	(0.159)	(0.005)
Office and computing equipment	2.780^{***}	0.268^{***}
	(0.240)	(0.007)
Electrical machinery	2.725^{***}	0.291^{***}
	(0.154)	(0.005)
Radio, TV, and communication	2.883^{***}	0.328^{***}
	(0.176)	(0.005)
Medical and optical instruments	3.539^{***}	0.272^{***}
	(0.186)	(0.006)
Motor vehicles	0.536^{***}	0.346^{***}
	(0.135)	(0.006)
Other transport equipment	4.337^{***}	0.209^{***}
	(0.254)	(0.006)
Furniture; manufacturing n.e.c.	1.512^{***}	0.292^{***}
	(0.125)	(0.005)

Notes: Each row reports sector-specific estimates from Equation (18). The parameter θ^s_{SR} is the short-run trade elasticity (productivity-dispersion parameter), and φ^s governs the speed of adjustment. The long-run elasticity is $\theta^s_{LR} = \theta^s_{SR}/(1-\varphi^s)$. Standard errors appear in parentheses. *** denotes significance at the 1% level. The 22 sectors correspond to ISIC Rev. 3 divisions 15–36. The estimation sample covers 170 countries from 1995 through 2022.