The 2025 Trade War: Dynamic Impacts Across U.S. States and the Global Economy*

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We use detailed tariff data and a dynamic trade and reallocation model with downward nominal wage rigidities to quantitatively assess the economic consequences of the recent increase in U.S. import tariffs and the responses of its trading partners. Higher tariffs trigger an expansion in U.S. manufacturing and agricultural employment, but this comes at the expense of a decline in service employment, with overall employment declining as lower real wages reduce labor-force participation. For the United States as a whole, real income falls around 0.1% by 2028, the last year we assume the high tariffs are in effect. Importantly, our analysis disaggregates the U.S. into its 50 states, while incorporating cross-state redistribution of the tariff-generated fiscal revenue, allowing us to analyze which states gain or lose more from the shock. Some of the most populous states, like California, New York, and Texas, suffer real income declines of up to 1.4%. On the flip side, 34 states gain, in some cases as much as 1.9%. Turning to cross-country results, some close U.S. trading partners—like Canada, Mexico, and Ireland—suffer the largest real income losses.

JEL codes: F10, F11, F13, F16, F40, F42.

Keywords: Tariff Changes, U.S. Tariffs, Liberation Day, Canada, Mexico, China.

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1 Introduction

The U.S. government has recently implemented a series of substantial tariff hikes, including additional duties of 25% on automobiles and auto parts, 50% on copper, aluminum, and steel, and new tariffs on goods from Canada, Mexico, China, and Brazil. Tariff rates on other countries have also increased sharply, ranging from 10 to 50 percent. As a result, the average applied tariff has risen above 25%—a level not seen since the 1930s.[1] This substantial increase in tariffs could have significant economic implications.

This paper uses a dynamic quantitative trade model to study the consequences of these tariff increases, focusing on total and sector-level employment, wages, and real income across U.S. states and other countries. Our baseline exercise assumes that the tariffs revert to their 2024 levels after fours years and that other countries react as they have done in the data, i.e. mostly without retaliating. However, we also analyze how the effects of the shock depend on its persistence or on the extent of retaliation by other countries. We place special emphasis on how the shock impacts U.S. outcomes, but turn to cross-country results towards the end of the paper.

We start by constructing a novel dataset covering both U.S. import tariffs and the tariffs faced by U.S. exporters at a daily and tariff-line level from January 2018 through August 2025. We build on the dataset of Teti (2024), which reports Most Favored Nation (MFN) and preferential tariff rates at the six-digit Harmonized System (HS) level for all country pairs in 2019, and extend it for the United States and its trading partners through 2025 using the same methodology. We supplement these data with the additional tariffs imposed by the United States during the first Trump administration, taking U.S. and Chinese import tariffs from Bown (2021) and collecting other retaliatory measures directly from countries' official legal gazettes. To construct tariff changes in 2025, we hand-code

[1] We acknowledge that current U.S. trade policy operates in a rapidly shifting and uncertain environment. Crucially, our framework is not limited to the specific tariffs analyzed here and serves as a flexible tool to evaluate the economic impacts of any set of tariffs across sectors, U.S. states, and other countries.

the major policy changes of the second Trump administration—including Section 301, Section 232, IEEPA, the "fentanyl" tariffs, and the reciprocal tariff rates.

We refer to our new dataset as the *Global Tariff Database: U.S. Trade War Extension* (henceforth GTD–U.S. Trade War).[2] Once aggregated up, the dataset indicates that the average U.S. import tariff rose from 1.5% in January 2018 to 4.8% in early 2025 and reached 25.4% by mid-August, while the average tariff faced by U.S. exports increased only slightly, from 2.6% in January 2018 to 4.6% by August 2025.

Our dataset differs from other recent tariff-tracking efforts in three key ways. First, we cover the full set of U.S. bilateral trade relationships rather than only selected ones. Second, we incorporate: (i) exemptions for exports qualifying under trade agreements, such as the USMCA, using preference utilization rates, and (ii) content-based tariff rules, under which the tariff rate applies only to specific components of an import. Third, following the methodology developed in Teti (2024), we assign to each bilateral relationship the correct baseline tariff: MFN, preferential, or the one applicable for countries not covered by normal trade relations (Column 2), ensuring that new tariff measures are layered on the correct existing tariff rates and avoiding common pitfalls in some previous studies.

Besides tariff data, our quantitative analysis also requires sector-level input-output flows as well as trade flows between all pairs of U.S. states and other countries included in our sample. We leverage multiple data sources, a set of proportionality assumptions to make all datasets internally consistent, and implications from a gravity model to construct sector-level trade flows among all region pairs in our sample. This dataset encompasses 110 regions (50 U.S. states, 59 additional countries, and an aggregated rest of the world region) and 15 sectors (home production, 12 manufacturing sectors, services, and agriculture) for our base year of 2024. The inclusion of services and agriculture—sectors rarely modeled thoroughly in previous theoretical papers—enables us to offer a more comprehensive cross-sector understanding of the implications of the recent tariff changes.

[2] The Global Tariff Database: U.S. Trade War Extension is available at Feodora A. Teti's website (`https://feodorateti.github.io/`) and will be updated regularly.

Our quantitative analysis makes use of the dynamic model developed by Rodriguez-Clare, Ulate, and Vasquez (2025, henceforth RUV) and employed by Ulate, Vasquez, and Zarate (2025, henceforth UVZ), but extends it in key ways to incorporate tariffs. Specifically, we develop a novel procedure that allows for a flexible pattern of tariff revenue redistribution across U.S. states, so that tariff revenues collected on a given state's imports do not necessarily equal the tariff revenues that state ultimately receives. This is particularly relevant given the redistributive fiscal role of the U.S. federal government.

As in RUV and UVZ, the model features multiple sectors linked by an input-output structure, trade that satisfies the gravity equation, short-run involuntary unemployment due to downward nominal wage rigidity (henceforth DNWR), and a home-production sector. Trade takes place between regions (either U.S. states or other countries), and workers can move across sectors in a region, subject to mobility costs. As in Caliendo et al. (2019), workers draw idiosyncratic shocks to the utility of working in each sector in each period. Based on these shocks, the costs of switching sectors, and expected real income in future periods, workers choose which sector to participate in.

As in Schmitt-Grohe and Uribe (2016), we capture DNWR by assuming that the nominal wage in any period must be no less than a factor δ times the nominal wage in the previous period.[3] Given the presence of DNWR, the model requires a nominal anchor that prevents nominal wages from increasing enough as to make the DNWR never bind.[4] We assume that world nominal GDP in dollars grows at an exogenous constant rate of γ. This assumption captures central banks' unwillingness to allow inflation or unemployment to become too high while keeping the model tractable. While this nominal anchor may not capture the subtleties of real-world monetary policy, it allows us to incorporate a complex trade structure with multiple sectors and regions, intermediate inputs, and

[3]See Section 2 of RUV for a discussion of the evidence in favor of DNWR and the advantages of using such a feature in trade models. As in RUV, we only apply the DNWR constraint in the manufacturing sectors, treating the service and agricultural sectors as if they operated under wage flexibility. Results in the case where DNWR applies to all sectors are available upon request.

[4]Our baseline analysis assumes flexible exchange rates between the U.S. dollar and other currencies.

forward-looking mobility into our framework while still being able to solve the model.[5]

We quantify the impact of the shock using the "dynamic exact-hat algebra" approach introduced by Caliendo et al. (2019). This technique guarantees that our model matches sector-level production, trade, and reallocation patterns in the base year. We then introduce an unexpected increase in tariffs that reverts after a certain number of years. Besides the parameters implicitly calibrated by the exact hat algebra methodology using data from the base year (2024), we require an explicit calibration of four parameters. These are the DNWR parameter, δ, the growth rate of world nominal GDP in dollars, γ, the inverse elasticity of mobility across sectors, ν, and the trade elasticity, $\sigma - 1$. We set δ to one, so nominal wages cannot fall, and γ to 3%, in line with the inflation observed in recent years. Finally, we take σ from the trade literature, and obtain ν from RUV.

Our analysis implies that U.S. employment falls by approximately 0.25% relative to the pre-shock baseline. During the high-tariff period, engaging in the home-production sector (which provides a constant utility flow) becomes more appealing, resulting in lower labor force participation. The impact of the tariff shock on the labor market varies by sector. There are temporary employment increases in manufacturing and agriculture, while the service sector experiences temporary employment reductions. Once the shock dissipates, manufacturing wages face downward pressure as the economy adjusts to the lower tariffs, generating involuntary unemployment in the presence of DNWR.

For the U.S. as a whole, we find a decrease in the real wage of around 0.7% in 2028, the last year the elevated tariffs are active in our baseline specification. The decline in the real wage is partially offset by an increase in tariff revenue rebates, resulting in a much smaller decline in real income for agents in the labor force. Specifically, the cumulative percentage decline in U.S. real income between 2024 and 2028 is around 0.1%.

The effect of the tariff shock varies significantly by state. States that lose the most, such as California, Michigan, and Texas, allocate a higher share of their expenditure to fi-

[5] Utilizing other types of nominal anchors prevents us from using the efficient Alvarez-and-Lucas type algorithm developed by RUV to deal with the DNWR, increasing computation time substantially.

nal and intermediate goods from the countries most adversely affected by the new tariffs.

We study how different assumptions affect our results, considering alternative values for the trade elasticity, the persistence of the shock, or the extent of retaliation by other countries. The main lesson is that the trade elasticity has a pronounced impact on the results. If the trade elasticity is low enough, overall labor force participation can increase when tariffs are high, and the United States can even experience a real income gain. When the trade elasticity is low, the United States has stronger market power relative to its smaller trading partners, allowing it to benefit from imposing tariffs. However, perhaps surprisingly, manufacturing employment experiences a less pronounced boost.

Turning to cross-country results, the effects of the shock vary internationally and depend on trade openness and the new tariffs imposed on a given country. U.S. close trading partners—like Canada, Mexico, and Ireland—suffer the largest real income losses. By contrast, some countries subject to the smallest "reciprocal" tariff increase of 10%, such as Great Britain, experience gains due to reduced competition in their export markets.

We emphasize that our model is designed to analyze the direct consequences of a tariff shock in a general equilibrium trade model, taking into account tariff redistribution across U.S. states. It does not incorporate the broader ramifications that may arise from heightened uncertainty or shifts in geopolitical dynamics. As discussed further in the Conclusion, the model also does not incorporate endogenous trade deficits, capital accumulation, or non-unitary elasticity of substitution across production inputs. Nevertheless, the framework provides valuable insights into the economic consequences of the shock as it propagates across regions and industries through global value chains.

Our paper contributes to the growing literature on the economic consequences of recent trade tensions between the U.S. and China. Fajgelbaum et al. (2020) examine the effects of the 2018 trade war on the U.S., finding that higher tariffs led to real income losses of approximately 0.04% of U.S. GDP. Consistent with this, Amiti et al. (2019) analyze the incidence of tariffs on U.S. import prices and find that they did not decline, implying that the tariffs were largely passed on to U.S. consumers and producers.

Flaaen and Pierce (2019) study the employment effects on the U.S. manufacturing sector, finding that industries more exposed to tariff increases experienced relative declines in employment and output. Additional work by Peake and Santacreu (2020) reinforces these results, showing that U.S. states more exposed to international trade experienced weaker employment and output growth. Our contribution to this literature relies on extending the model from RUV to incorporate import tariffs and their fiscal revenue, allowing us to study the dynamic general equilibrium effects of the recent tariff increases.

Our research also relates to the literature on trade wars and optimal tariffs. Ossa (2014) and Lashkaripour (2021) examine optimal tariffs under trade conflict and emphasize the potential gains from cooperation. Itskhoki and Mukhin (2025) study optimal tariffs with trade imbalances and show that they are not necessarily related to a country's trade deficit; they also estimate that a U.S. unilateral optimal tariff could raise welfare by 0.6%, whereas a trade war could reduce welfare by 2.7%.

Recent studies have examined the implications of rising tariffs and trade uncertainty. For instance, Caliendo et al. (2025) develop a model with aggregate uncertainty that endogenizes trade imbalances and find that higher U.S. tariffs reduce trade deficits but raise domestic prices and lower real consumption. Ignatenko et al. (2025) analyze the impact of the tariff hikes on U.S. trade deficits and welfare, showing that while tariffs may help reduce the deficit, retaliatory measures by trade partners can reduce U.S. welfare by up to 0.1%. Our contribution is to study the 2025 tariff increases within a framework that incorporates dynamic effects, wage rigidities, and distributional effects across U.S. states.

The remainder of the paper is organized as follows. Section 2 outlines the construction of the tariff dataset. Section 3 provides an overview of the model and Section 4 describes our calibration. Section 5 presents the results of our baseline analysis for U.S. states. Section 6 investigates the sensitivity of our results to changes in key assumptions. Section 7 focuses on how the results vary across countries and Section 8 concludes.

2 U.S. Trade Policy 2018–2025: Timeline and Data

The Trump administration's return to office in January 2025 marked the third—and harshest—phase in the recent escalation of U.S. trade policy. Tariffs had first risen sharply under the first Trump administration and were then largely maintained during the Biden administration. By mid-August 2025, just eight months into Trump's second term, average applied tariffs had jumped from 4.8% in January 2025 to 25.4% (see panel A of Figure 1).[6] This marks the steepest escalation in U.S. import protection since the Smoot–Hawley Tariff Act of the 1930s.

Under the first Trump administration, tariff increases were concentrated on imports from China: the average U.S. tariff on Chinese goods, weighted by 2017 import values, rose from 2.9% to 16.1%.[7] The rest of the world was largely spared, apart from the global Section 232 duties under the Trade Expansion Act of 1962 (25% on steel and 10% on aluminum) and the safeguard measures on washing machines and solar panels.[8]

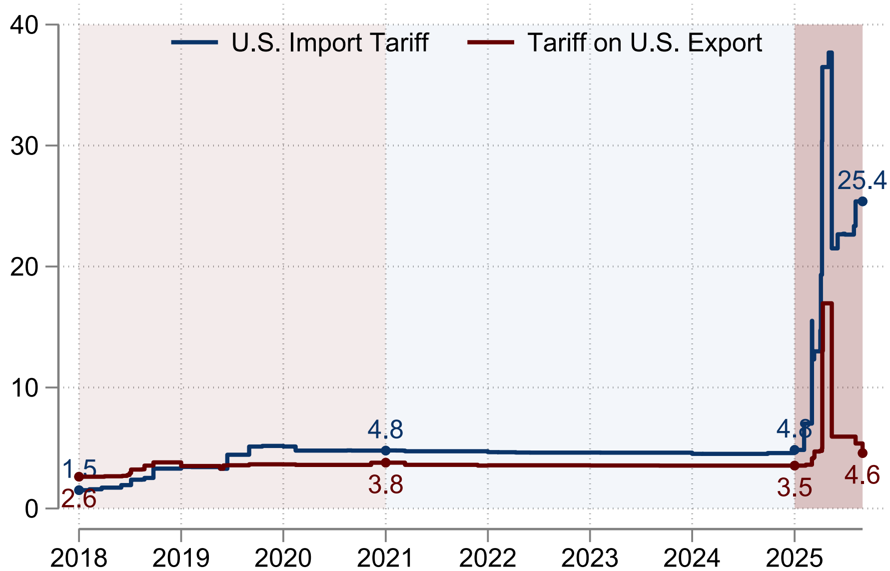
When President Biden took office in 2021, he left the China tariffs intact and, in September 2024, extended them by adding new duties on electric vehicles and other strategic products. Meanwhile, he struck quota-based deals that effectively removed the steel and aluminum duties for the European Union, Japan, and the United Kingdom. By late 2024, China stood apart, facing far higher tariffs than the rest of the world.

In 2025, U.S. tariff policy shifted from focusing on China alone to targeting all U.S. trading partners, including long-standing partners with trade agreements such as Canada and Mexico that had previously faced near-zero duties. The first new measures were announced under the International Emergency Economic Powers Act (IEEPA) in February

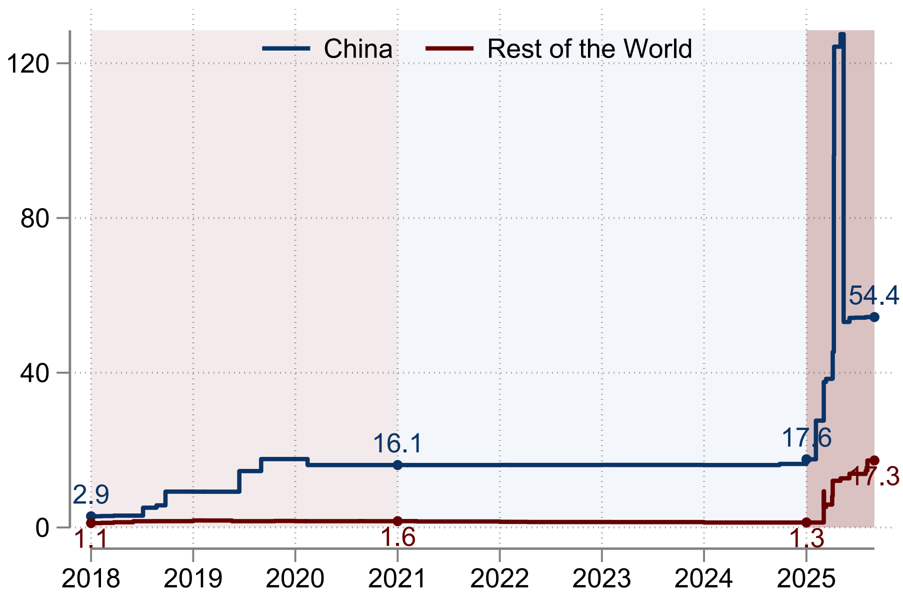
[6]Exporter–product tariffs are weighted by 2017 trade values from CEPII's BACI database.

[7]These Section 301 tariffs were introduced in four waves (two in 2018, two in 2019). Products in the first three waves faced a 25% tariff, while those in the final wave initially faced 15% but this was later reduced to 7.5% (see Figure 1).

[8]The Section 232 duties were lifted during the first Trump administration for Canada and Mexico following the conclusion of the USMCA and for South Korea under a quota arrangement. Argentina, Australia, and Brazil were exempt from the outset, while all other countries remained subject to the tariffs. The safeguard tariffs were progressively reduced on an annual basis.



(a) Tariffs on U.S. imports and exports



(b) Tariffs on U.S. imports by trading partner (China vs. RoW)

Figure 1: This figure shows the trade-weighted average daily tariffs (in p.p.) that the United States has imposed and faced between January 1st, 2018 and August 15th, 2025. MFN and preferential tariff rates are from Teti (2024). U.S. tariff rates imposed during the first Trump Administration are from Bown (2021). All other tariff rates were hand-coded based on U.S. Federal Register notices and national legal texts. Trade weights are constructed from CEPII's BACI bilateral trade flows for the year 2017 (Gaulier and Zignago, 2010). Further details on data sources and construction are provided in Appendix A. Light-red shading denotes the first Trump administration, light blue the Biden administration, and dark red the second Trump administration.

2025 and covered imports from China, Mexico, and Canada. While the additional 10% tariff on all Chinese imports took effect immediately, and was raised to 20% in March, the 25% tariffs on Mexico and Canada were temporarily paused and became effective in March. For Canada, the tariffs were increased to 35% on August 1st. We refer to the Mexico and Canada duties, framed by the administration as a response to fentanyl trafficking, as "fentanyl tariffs". In August, the administration extended the IEEPA tariffs to Brazil at a rate of 40%, exempting only imports under the Agreement on Civil Aviation and a small set of sensitive products.

For Mexico and Canada, only non-USMCA-compliant imports were subject to the fentanyl tariffs. We proxy the affected import share using preference utilization rates (PURs) at the exporter-product-level, interpreting $1 - PUR_{i,k}$ as the share of imports not claiming USMCA preferences for exporter country i, product k. This yields an implied effective tariff of $t_{i,k} = (1 - PUR_{i,k}) \times 25\%$.[9] For Brazil, we apply the same method as for Mexico and Canada to estimate the exempt share using PURs and calculate the implied tariff accounting for the exemptions under the Agreement on Civil Aviation.

Section 232 became one of the administration's main vehicles for increasing tariffs across products and trading partners. In March 2025, it imposed a uniform 25% tariff on all steel and aluminum imports, eliminating previous country exemptions and raising the aluminum rate from 10% to 25%. In April, a new 25% tariff was added on automobiles, followed by a 25% tariff on car parts in May. In June, the steel and aluminum tariffs were doubled to 50%—with an exemption for the United Kingdom, which by then had become the first country to sign a trade "deal" with the United States—and on August 1st, a 50% tariff was imposed on copper products. For steel, aluminum, and copper derivatives, the 50% rate applied only to the metal content; we assume a 50% content share to compute effective ad valorem rates. The Section 232 tariffs apply broadly to all U.S. trading partners and in addition to any existing duties (i.e., Section 301 or IEEPA).

[9] We use import data from Schott (2008), which include the country subcode indicating the tariff program each shipment entered under. We aggregate these data over 2017–2018. See Appendix A for details.

Because of their tightly integrated automobile supply chains, Canada and Mexico were largely exempted from the new Section 232 tariffs on cars and car parts through special USMCA provisions. Car parts that qualify as USMCA-compliant are fully exempt, while USMCA-compliant cars are subject to Section 232 tariffs only on their non-U.S. content. We draw on existing estimates of U.S. content—38% for Mexico (Contreras, 2024) and 50% for Canada (Canadian Vehicle Manufacturers' Association, 2025)—and use 2017–2018 preference utilization rates to determine the share of USMCA-compliant imports.

Proclaiming "Liberation Day" on April 2nd, 2025, the administration continued to substantially alter U.S. tariff policy. It imposed a 10% across-the-board tariff on imports from all countries, layered on top of existing duties such as Section 301, safeguard tariffs, IEEPA, and normal trade relations rates (but not Section 232 tariffs). For 69 countries running large trade surpluses with the United States, this 10% duty was set to be replaced one week later by much higher "reciprocal" rates, reaching up to 50%. In practice, the swap occurred only for China; for all other listed countries, implementation was paused and ultimately replaced by bilateral "reciprocity deals" negotiated over the summer. For China, the reciprocal tariffs were initially set at 34% but were raised to 84% after Beijing announced retaliatory duties, and then to 125% following a second round of Chinese retaliation. A bilateral agreement on May 14th rolled these tariffs back to the 10% baseline rate now applied to all U.S. trading partners.[10]

The reciprocity "deals", which took effect on August 7th, reduced the U.S. import tariffs announced in April in exchange for partner commitments on improved market access and purchases of U.S. exports. While the new U.S. reciprocity tariffs have been in force since August 7th, the corresponding measures by partner countries are less clear, as official legal documents are difficult or impossible to obtain.[11] We include only measures

[10]The same exemptions applied to both the 10% baseline and the reciprocal tariffs: Annex 2 of Executive Order 14257 excluded pharmaceuticals, semiconductors, energy products, and critical minerals, and products already covered by Section 232 tariffs were excluded from the new duties (i.e., they continued facing only the Section 232 rate, with no additional reciprocal tariff applied). Canada and Mexico were not on the list and were exempt.

[11]Illustrating the lack of formal documentation, for example, information for Vietnam and South Korea

that could be unambiguously translated into product-level tariff changes; further details are provided in Appendix A.

While many countries imposed retaliatory tariffs during the first Trump administration—most notably China, which was both the main target and imposed the largest retaliatory tariffs—in 2025, only China retaliated substantially. Beyond China, the European Union briefly reactivated its steel and aluminum countermeasures until the reciprocity "deal" was signed, and Canada also introduced new measures. However, after Canada was hit with a 35% tariff in August (rather than 25%), it eliminated almost all of its retaliatory tariffs to signal goodwill. Overall, retaliation was limited: the trade-weighted average tariffs faced by U.S. exporters in foreign markets remained virtually unchanged, apart from a steep increase in China's tariffs from 6.2% in January 2018 to 15.3% in January 2025 and 26.9% by mid-August 2025 (see Appendix Figure A.4). We return to the issue of the lack of retaliation by other countries and its impacts on model-generated results in Section 6.

As an important contribution of this paper, we introduce a new dataset that records all of the trade policy changes described above at a daily frequency, both at the national tariff-line level and at the internationally-comparable HS6 level, spanning January 2018 through August 15th, 2025—capturing all tariff changes from the start of the Trump administration to the present. The dataset accounts for exemptions applicable under certain trade agreements and product-level carve-outs, and applies the complex stacking rules that determine the effective tariff rates when multiple measures overlap. It covers all U.S. tariffs and the corresponding responses of trading partners, reporting both policy changes and the implied ad valorem tariff levels. To establish the baseline of MFN and preferential tariffs, we update the raw data to the latest available year and apply the filling algorithm introduced by Teti (2024).

comes from statements on social media platforms such as Truth Social and X (formerly Twitter).

3 A Dynamic Spatial Trade Model with Tariffs

We use a dynamic multi-sector quantitative trade and reallocation model featuring nominal wage rigidities and input-output linkages akin to the one in RUV and UVZ to examine the recent tariff increases imposed by the U.S. Importantly, we extend the model to incorporate tariff changes and their associated fiscal revenue. In this section, we outline the main features of the model, deferring further mathematical details to Appendix C. The model incorporates a total of I regions ($I = 110$: the 50 U.S. states, 59 other countries, and an aggregate rest of the world region) and S sectors ($S = 15$: home production, 12 manufacturing sectors, services, and agriculture). Since allowing for cross-state migration does not significantly affect our results, we simplify the analysis by assuming away labor mobility across U.S. states.

Preferences and production Total consumption in a region is a Cobb-Douglas aggregate of consumption across all the market sectors with given time-invariant expenditure shares denoted by $\alpha_{j,s}$ (where j denotes the region and s the sector). As in a multi-sector Armington model, consumption within a market sector is a CES aggregate of the variety produced by each region, with an elasticity of substitution σ_s. We denote the region i, sector s, and time t triad as (i, s, t).

Production uses two factors: labor and intermediate inputs. Specifically, the technology for producing the (i, s, t) good takes the following Cobb-Douglas form:

$$Y_{i,s,t} = A_{i,s,t} L_{i,s,t}^{\phi_{i,s}} \prod_{k=1}^{S} M_{i,ks,t}^{\phi_{i,ks}},$$

where $A_{i,s,t}$ is total factor productivity in (i, s, t), $L_{i,s,t}$ is employment in (i, s, t), $M_{i,ks,t}$ is the quantity of intermediate inputs of sector k used in (i, s, t), $\phi_{i,s}$ is the time-invariant labor share in (i, s), and $\phi_{i,ks}$ is the share of inputs that sector s uses from sector k in region i. Production has constant returns to scale, i.e. $\phi_{i,s} + \sum_k \phi_{i,ks} = 1$. There are also iceberg trade costs $\tau_{ij,s,t} \geq 1$ for shipping the sector s good from region i to region j at time t.

Tariffs, trade shares, and revenues There are ad valorem tariffs $t_{ij,s,t}$ imposed by country j on imports that come from country i in sector s at time t. These tariffs will play a crucial role as they are the object being shocked in our main quantitative exercise. Furthermore, these tariffs will also generate revenue for the country that imposes them, which is an important aspect to keep track of. The presence of these tariffs and their associated fiscal revenue is the main difference between our model here and the one in RUV and UVZ.[12]

There is perfect competition in production. Letting $W_{i,s,t}$ denote the wage in dollars in (i,s,t) and $P_{i,k,t}$ denote the dollar price of the composite good of sector k, in region i, at time t, the dollar price in region j of the (i,s,t) good is then equal to its unit cost,

$$p_{ij,s,t} = \tau_{ij,s,t}(1 + t_{ij,s,t}) A_{i,s,t}^{-1} W_{i,s,t}^{\phi_{i,s}} \prod_{k=1}^{S} P_{i,k,t}^{\phi_{i,ks}},$$

with corresponding trade shares given by

$$\lambda_{ij,s,t} \equiv \frac{p_{ij,s,t}^{1-\sigma_s}}{\sum_{r=1}^{I} p_{rj,s,t}^{1-\sigma_s}}.$$

We assume that tariff revenue collected on imports by any U.S. state is transferred to the federal government, which subsequently redistributes it across states—potentially in a manner that is not proportional to the revenue each state initially contributed. To flexibly capture this feature, we assume that the total tariff revenue received (TRR) by region i at time t is

$$TRR_{i,t} = \sum_{j} \theta_{ji} TRC_{j,t}, \tag{1}$$

[12] Caliendo and Parro (2015) also incorporates tariff revenue when evaluating the effect of NAFTA. However, they treat the United States as a single region. Our framework allows for a more flexible redistribution schedule that incorporates internal allocation of tariff revenues across U.S. states.

where $TRC_{j,t}$ corresponds to the tariff revenue collected by region j at time t and θ_{ji} is the (time invariant) share of its tariff revenue that region j sends to region i. The only constraint on these shares is that they must sum to one for a given tariff-revenue-sender region when summing across all the tariff-revenue-receiving regions, i.e. $\sum_i \theta_{ji} = 1 \ \ \forall j$.

In our quantitative implementation, we assume that tariff revenue collected is redistributed within the United States according to the share of the population that a given state represents, but our framework can easily accommodate extensions where tariff revenue is disproportionately allocated to certain states (e.g., those that voted for a given political party in the last election) or sectors. Tariff revenues in countries other than the United States simply stay in that country (as we do not disaggregate other countries into smaller regions).

The total revenue collected by region j, $TRC_{j,t}$, is

$$TRC_{j,t} = \sum_s \sum_i \frac{t_{ij,s,t}}{1+t_{ij,s,t}} \lambda_{ij,s,t} EXP_{j,s,t} = \sum_s \psi_{j,s,t} EXP_{j,s,t}, \quad (2)$$

where $EXP_{j,s,t}$ is total expenditure of region j in sector s at time t, including purchases by final consumers and intermediate good purchases, and $\psi_{j,s,t}$ is the share of expenditure in (j,s,t) that is collected as tariff revenue, defined as $\psi_{j,s,t} \equiv \sum_i t_{ij,s,t}/(1+t_{ij,s,t})\lambda_{ij,s,t}$.

Let $R_{i,s,t}$ denote total revenues in sector s of region i. Noting that demand of industry k in region j of intermediates from sector s is $\phi_{j,sk} R_{j,k,t}$ and allowing for exogenous deficits (where $D_{j,t}$ is used to denote the transfers received by region j at time t, with $\sum_j D_{j,t} = 0$), we know that total expenditure by region j in sector s at time t is

$$EXP_{j,s,t} = \alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} + TRR_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t}. \quad (3)$$

Introducing equations (2) and (3) into (1) and rearranging, we get

$$TRR_{i,t} = \sum_j \theta_{ji} \sum_s \psi_{j,s,t} \left[\alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} + TRR_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right]. \quad (4)$$

Additionally, the market-clearing condition for sector s in region i can be written as

$$R_{i,s,t} = \sum_{j=1}^{I} \frac{\lambda_{ij,s,t}}{1+t_{ij,s,t}} \left(\alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} + TRR_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right). \quad (5)$$

Appendix C details how to combine equations (4) and (5) into a novel computationally-efficient matrix equation that can be used to solve for period-by-period sectorial revenues while allowing for flexible tariff revenue redistribution through the θ coefficients.

Downward nominal wage rigidity We denote the number of agents participating in (i, s, t) by $\ell_{i,s,t}$. In a typical trade model, employment in a sector-region has to equal labor supply in that same sector-region ($L_{i,s,t} = \ell_{i,s,t}$). By contrast, we follow Schmitt-Grohe and Uribe (2016), allowing for a downward nominal wage rigidity (DNWR) which indicates that the nominal wage in (i, s, t) has to be greater than δ times the nominal wage in $(i, s, t-1)$, $W_{i,s,t} \geq \delta W_{i,s,t-1}$.[13] As a consequence of this rigidity, employment does not have to equal labor supply, leading to the following weak inequality, $L_{i,s,t} \leq \ell_{i,s,t}$.

Unemployment only occurs if the wage is at its lower bound. Hence, the previous inequalities are augmented by a complementary slackness condition, indicating that at least one of them has to hold with equality,

$$(\ell_{i,s,t} - L_{i,s,t})(W_{i,s,t} - \delta W_{i,s,t-1}) = 0.$$

The previous condition says that employment and wages are determined by supply and demand when the wage is unconstrained. By contrast, when the wage is at its lower

[13]The DNWR applies in the local currency of region i, which needs to be converted into U.S. dollars using an exchange rate. This is described in more depth in Appendix C.

bound, the labor market does not clear, and there is rationing (i.e., unemployment) as labor supply exceeds labor demand.

Labor supply Agents in the model can either engage in home production (sector zero) or seek work in the labor market (sectors 1 through S). Participating in home production yields a time-invariant level of real consumption which does not depend on economic conditions. By contrast, a given market sector $s > 0$ offers an endogenous level of real consumption $c_{i,s,t}$.

Given the presence of downward nominal wage rigidity, agents must take into account the possibility of unemployment when selecting which sector to participate in. To simplify the analysis, we assume a representative agent in each region-sector.[14] Additionally, the income for agents is not only given by their wage income, but it also includes the tariff revenue received by the region where agents live. We assume that, across workers in a region, tariff revenue received is distributed among market sectors according to labor supply weights. With all these ingredients, the real per-capita consumption level $c_{i,s,t}$ resulting from participating in market sector s is

$$c_{i,s,t} = \frac{W_{i,s,t}L_{i,s,t} + \frac{\ell_{i,s,t}}{\sum_{k=1}^{S}\ell_{i,k,t}}TRR_{i,t}}{\ell_{i,s,t}P_{i,t}},$$

where $P_{i,t}$ is the aggregate price index in region i.

Agents choose their sector of employment while facing idiosyncratic amenity shocks and switching costs, and they take into account the expected future income across all sectors (i.e., the $c_{i,s,t}$'s) with perfect foresight. The idiosyncratic preference shocks follow a Gumbel distribution, making the participation decision tractable and allowing for closed-form expressions (see Appendix C for additional details). A key parameter in the model is the elasticity of switching across sectors within a region, given by $1/\nu$.

[14]This is equivalent to assuming that the income generated in a sector-region is equally shared between all agents in that sector-region. We refer the interested reader to RUV for details on how to implement a more general type of insurance than the one modeled here.

Nominal anchor Since the model incorporates nominal rigidities, it is necessary to introduce a "nominal anchor" to prevent nominal wages from increasing so rapidly each period as to make the DNWR constraint always non-binding. We adopt a nominal rule that captures the idea that central banks are unwilling to tolerate persistently high inflation or unemployment, while also being tractable enough for our quantification.[15] Specifically, we assume that world nominal GDP measured in U.S. dollars grows at a constant rate γ each year,

$$\sum_{i=1}^{I}\sum_{s=1}^{S} W_{i,s,t}L_{i,s,t} = (1+\gamma)\sum_{i=1}^{I}\sum_{s=1}^{S} W_{i,s,t-1}L_{i,s,t-1}.$$

While this assumption is useful for solving the model, it has limitations as it does not reflect the optimal monetary policy of any particular country. Thus, we abstract from discussing the implications of the tariff shock for aggregate inflation, since the model is not designed to study this aspect. Nevertheless, the model remains informative about the behavior of relative prices, which we discuss in the results section.

Dynamic hat algebra The main objective of the paper is to examine the effects of an unanticipated tariff shock. To achieve this in a computationally tractable way, we use "dynamic exact hat algebra" (Caliendo et al., 2019), which allows us to match production, trade, and reallocation patterns in the base year. We can then introduce a change in the level of tariffs, without knowing the initial levels of fundamentals (like technology and iceberg trade costs), and study the economy's adjustment to such a shock.

To study the effects of the tariff shock, we assume the base year is 2024. At that point, new tariffs have not been implemented yet, and the model matches real-world production, trade, and sectoral flow patterns perfectly. Then, the shock is introduced in 2025, and the agents in the model learn the full path of the shock. As the new tariffs are implemented, employment, prices, production, and trade respond accordingly.

[15] This nominal anchor allows us to solve our model using a fast algorithm in the spirit of Alvarez and Lucas (2007) developed in RUV to deal with the complementary slackness condition implied by the DNWR.

4 Data, Calibration, and Shocks

4.1 Data for the Quantitative Exercise

Our quantitative exercise requires trade and employment data from 50 U.S. states, 59 other countries, and a rest of the world region. We incorporate 14 market sectors—12 manufacturing subsectors, services, and agriculture—plus a home production sector. We collect data on initial tariffs for our baseline year and then introduce the change in tariffs between that year and August 15th, 2025 as our "tariff shock".[16] The remaining data-construction steps closely follow UVZ but use 2024 as the base year in the quantification. We summarize the data construction below, with additional details in Appendix B.

Initial tariffs We construct the baseline tariff levels as described in Section 2. To account for multiple changes in tariffs during 2019, we compute a weighted average based on the number of days each tariff was in force. We first calculate the weighted average (weighted by bilateral trade value) of the tariffs at the 4-digit HS level and map them to 3-digit NAICS codes, following Liao et al. (2021). Then, we assign each NAICS code to the 13 non-services market sectors described in Appendix B.1 and compute the weighted average (again, weighted by bilateral trade value) for the tariffs at the importer-sector level.

Labor, consumption, and input shares We use data from the BEA and the OECD's Inter Country Input-Output Database (ICIO) to compute value-added shares (equated to the labor share in the model) and input-output coefficients across regions. Consumption shares can be backed out from trade flows, labor shares, and input shares.

[16]While our baseline year is 2024, the tariff shock that we introduce in the model between 2024 and 2025 actually incorporates all the tariff changes between the United States and other countries that occurred between 2019 and 2025. We do this to capture the full extent of the recent trade war. As illustrated in Figure 1, most of the changes since 2019 and 2025 occurred in the last year, so introducing just the tariff changes between 2024 and 2025 would only have a small impact on our results.

Bilateral trade flows We build a matrix of bilateral trade flows between all sectors and regions following the four steps below. First, we take sector-level bilateral trade data among countries from ICIO. Second, we calculate the bilateral trade flows in manufacturing between U.S. states by combining ICIO and the Commodity Flow Survey (CFS). Because some CFS industry aggregates (summed across all states) may not match the amounts that the United States trades with itself according to ICIO, we multiply the CFS flows by a "proportionality" constant that adjusts the CFS values up or down so that the total of U.S. internal flows across all states equals the total U.S. internal trade from ICIO. This procedure retains the relative significance of each state in each industry as reflected in the CFS.

Third, we use the Import and Export Merchandise Trade Statistics from the U.S. Census to calculate sector-level trade flows in manufacturing and agriculture between each U.S. state and other countries. We also apply the corresponding proportionality constant to keep internal consistency with ICIO. Fourth, we construct trade flows in services and agriculture among all regions inferred from two gravity structures. To do so, we obtain U.S. state-level services production from the Regional Economic Accounts of the BEA and state-level services expenditure from the Personal Consumption Expenditures (PCE) database of the BEA. We combine these with ICIO data and data on bilateral distances to construct service trade flows across all regions, following a gravity approach. We apply a similar methodology for agriculture, integrating data from the Agriculture Census with ICIO and the National Marine Fisheries Service Census to obtain state-level production data for crops, livestock, and seafood. Further details can be found in Appendix B.2.

Labor supply and mobility Employment data by sector comes from the WIOD Socio-Economic Accounts (SEA) and ILO for countries, and the BLS for U.S. states. Labor force participation represents the share of individuals aged 25-65 who are employed or unemployed. The shares of workers moving across the different sectors within U.S. states are computed from the CPS, while frictionless mobility is assumed for other countries.

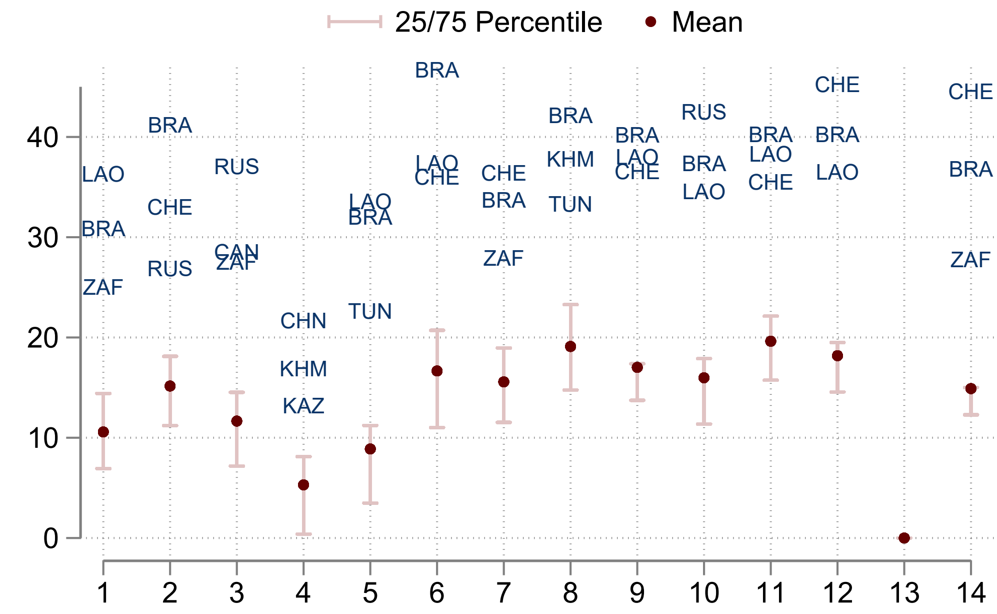
4.2 Tariff Shock and Parameter Calibration

Tariff shock To quantify the tariff changes implemented by the Trump administration, we use the tariff rates for August 15th implied by the GTD–U.S. Trade War, aggregate them to the sector level using 2017 trade weights (as for the initial tariffs), and calculate the resulting sector-level changes as the shocks in the model. We apply the same procedure to the tariffs faced by U.S. exporters in foreign markets. For trade relationships not involving the United States, we assume there is no change in tariffs.

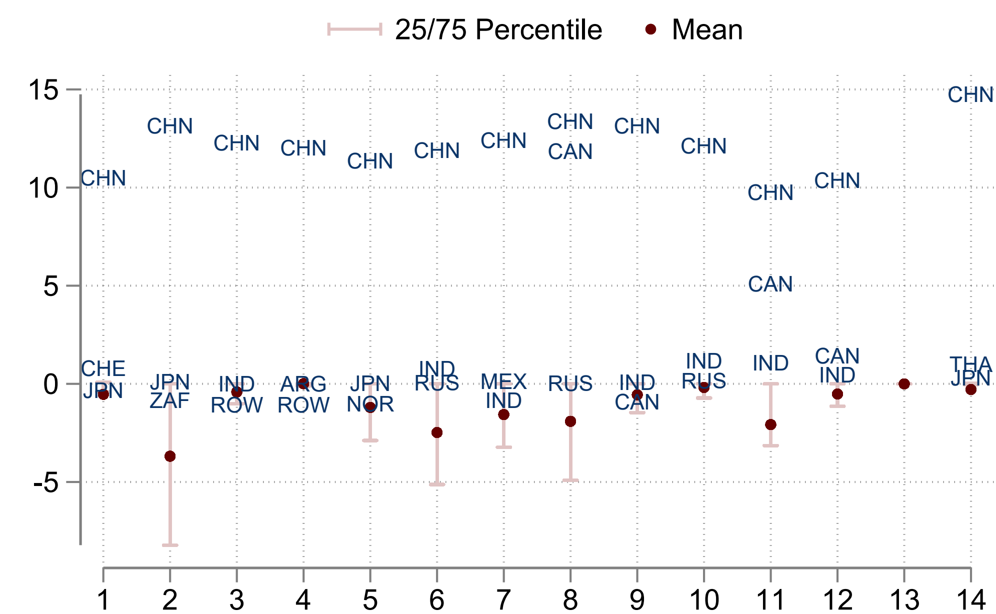
Figure 2a plots the resulting change in U.S. import and export tariffs across the sectors in our model, showing the average across all trading partners, the 25th and 75th percentiles, and the three most affected partners. Tariff increases vary substantially across sectors, with metals (sector 8), transportation equipment (sector 11), and furniture and miscellaneous manufacturing (sector 12) experiencing the largest increases of around 20 percentage points. The sharpest increases are observed for Brazil, Switzerland, Russia, China, and South Africa.[17] In contrast to the large U.S. tariff increases, very few countries retaliated in kind, and in some sectors the average tariff burden on U.S. exports even declined as partners reduced tariffs through new deals or in an effort to appease the U.S. As of August 15th, only Canada and, much more substantially, China imposed higher duties, with tariffs on U.S. exports to China rising by at least 10 percentage points across all sectors (see Figure 2b).

Parameter calibration Regarding the parameters used in the baseline specification, note that for a given δ (the DNWR parameter), if γ (the nominal growth rate of world GDP in U.S. dollars) is higher, then the DNWR is less likely to bind. Likewise, for a given γ, if δ is lower, then the DNWR is less likely to bind. Therefore, we require a normalization and set $\delta = 1$ (as in UVZ), indicating that nominal wages in dollars cannot fall, and putting the burden of the nominal adjustment on γ. We set $\gamma = 3\%$ due to the relatively high

[17] In 2022, the United States removed Russia from Column 1 Normal Trade Relations (NTR) status and made it subject to Column 2 tariffs as part of sanctions following the invasion of Ukraine.



(a) Change in tariffs on U.S. imports



(b) Change in tariffs on U.S. exports

Figure 2: This figure shows the average tariff change by sector for U.S. imports and exports, along with the 25th and 75th percentiles and the three exporters/importers facing the largest tariff changes. The sectors are: **(1)** Food & Tobacco; **(2)** Textiles & Apparel; **(3)** Wood & Paper; **(4)** Mining & Petroleum; **(5)** Chemicals; **(6)** Plastics & Rubber; **(7)** Nonmetallic Minerals; **(8)** Metals; **(9)** Machinery; **(10)** Electronics & Electrical; **(11)** Transport Equipment; **(12)** Furniture & Misc.; **(13)** Services; and **(14)** Agriculture.

nominal growth rate in the post-pandemic period. The implications of altering this γ go in the expected direction. The higher the γ, the less binding the DNWR is, and the less unemployment is generated in the model. For a high γ of 5% or higher, the model has essentially the same behavior as the model without DNWR.

We take the inverse elasticity of moving across sectors (ν) directly from RUV, setting $\nu = 0.55$. Finally, we assume that $\sigma_s = \sigma \; \forall s$, which implies that the trade elasticity ($\sigma_s - 1$ in absolute value) is the same in all sectors. In our baseline, we use $\sigma = 6$ (as is standard in the trade literature, see Costinot and Rodriguez-Clare, 2014), but we discuss robustness to alternative values of σ like the ones proposed by Boehm et al. (2023) in Section 6.

5 Baseline Results

We now investigate the effects of the tariff shock described in the previous section. The baseline exercise uses a model where there is no migration across U.S. states, world nominal GDP in dollars grows at 3% per year, the affected countries retaliate against the U.S. to the extent they did in the data (as discussed in Section 4.2), and the tariff shock lasts for four years (i.e., it is active from 2025 to 2028 inclusive). We discuss the effects on labor force participation and unemployment, real wages, relative prices (sectoral prices divided by the aggregate price index), real value added, and welfare. We consider the effects for the U.S. as a whole and at the level of broad sectors (manufacturing, services, and agriculture) and U.S. states.[18]

Figure 3 summarizes the results by presenting the effects on participation, real wages, relative prices, and the real value added across sectors. Specifically, the cumulative percentage change in labor force participation (i.e., labor supply) since 2024 is in the top left, the one for real wages is in the top right, the one for relative prices is in the bottom left, and the one for real value added (excluding tariff revenue) is in the bottom right.[19]

[18] The broad manufacturing sector is an aggregate of the 12 individual manufacturing sectors in our model, described in detail in Appendix B.1.

[19] All U.S. aggregate variables that need to be deflated by a U.S. aggregate price index, such as real wages,

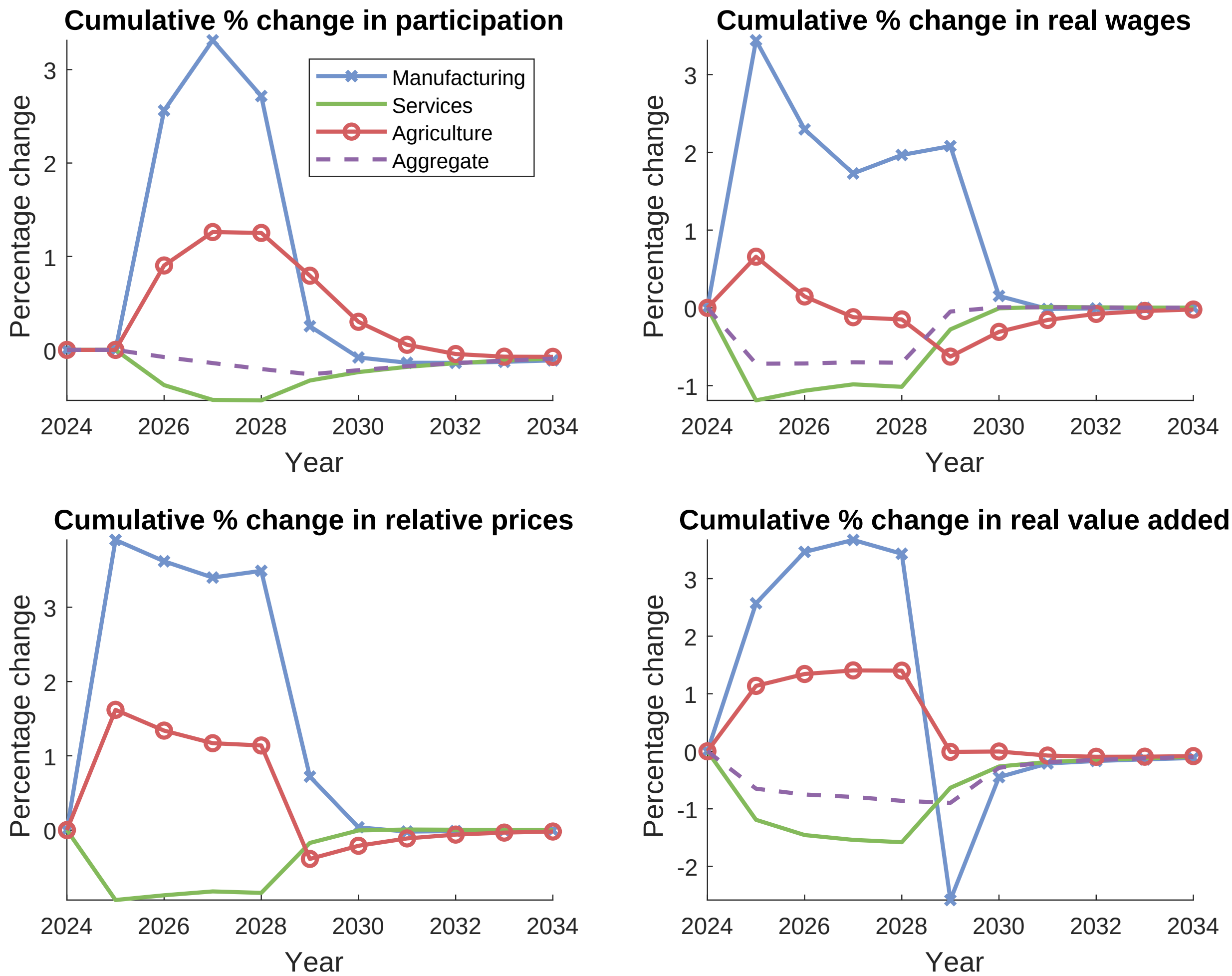


Figure 3: Paths of relevant variables for the U.S. on aggregate. The cumulative percentage change in participation (labor supply) since 2024 is in the top left, the cumulative percentage change in real wages is in the top right, the cumulative percentage change in relative prices is in the bottom left, and the cumulative percentage change in real value added is in the bottom right. Manufacturing is the crossed blue line, services is the solid green line, agriculture is the red line with circular markers, and the dashed purple line represents the aggregate across sectors.

The manufacturing sector is depicted by the crossed blue line, services by the solid green line, agriculture by the red line with circles, and the dashed purple line represents the aggregate across sectors.

Changes in participation broadly follow changes in real wages, with slight year-to-year differences arising from lagged and anticipatory effects. In turn, real wages,

relative prices, and real value added, are deflated with the weighted average of the regional price index, $P_{i,t}$, across the 50 U.S. states using population shares as weights.

relative prices, and real value added follow changes in demand triggered by the tariff shock. Higher U.S. import tariffs reallocate demand towards U.S. manufacturing (especially given the lack of meaningful retaliation by other countries), increasing its relative price and real wage. At the peak, real manufacturing value added increases by 3.7%, while participation increases by more than 3.3%.

By contrast, participation, the real wage, the relative price, and value added fall for services. This sector is not protected by the higher tariffs and experiences a decrease in value added of around 1.6% in 2028. The agricultural sector experiences effects that are located somewhere in between those in the manufacturing and service sectors, namely moderately higher participation, prices, and value added. By 2028, real value added in agriculture has increased by around 1.4%.

Aggregate U.S. labor force participation (shown by the dashed purple line on the top left panel of Figure 3) decreases by up to 0.25% during the years when the tariff shock is active. This aggregate fall in participation occurs because, while tariffs are high, participating in the home-production sector (which provides a constant real utility flow) temporarily becomes more attractive than participating in the market sectors. This shift occurs because high tariffs make the market sectors less productive through an increase in intermediate input costs, explaining the decline in the aggregate real wage, of around 0.7% by 2028, shown in the top right of Figure 3. This fall in the real wage is amplified by the decline in participation, leading to a fall in real value added of around 0.9% by 2028.

The presence of DNWR implies that labor supply and demand might not coincide in our model, leading to the possibility of unemployment. The left panel of Figure 4 displays the cumulative percentage change in employment since 2024 in the solid green line, the cumulative percentage change in participation since 2024 in the dashed purple line, and the level of unemployment (in percent) in the red line with circular markers.[20] A minuscule amount of unemployment of around 2 basis points is generated between 2025

[20] The dashed purple line corresponds to the dashed purple line in the top right panel of Figure 3.

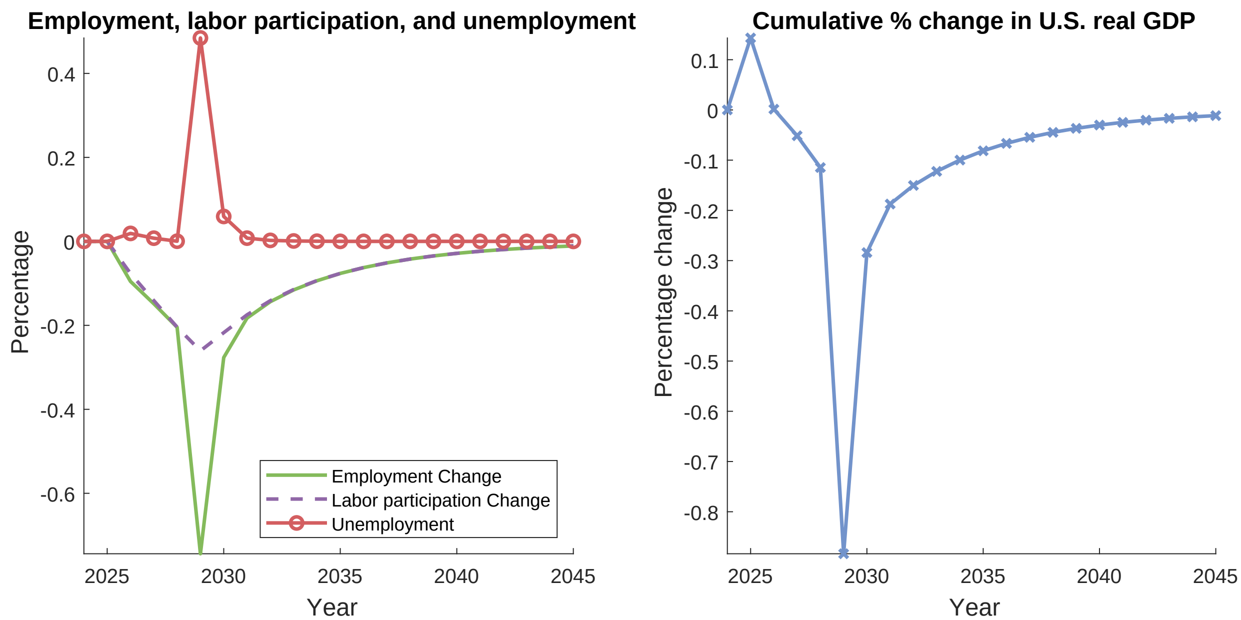


Figure 4: Paths of relevant variables for the U.S. on aggregate. The left panel displays the cumulative percentage change in employment since 2024 (solid green line), the cumulative percentage change in labor supply since 2024 (dashed purple line), and the level of unemployment in percent (red line with circular markers). The right panel displays the cumulative percentage change in real GDP (which coincides with real income) for the U.S. on aggregate since 2024. Notice that real GDP is inclusive of tariff revenues. The years in the x-axis go from 2024 until 2045.

and 2026. This happens in a few states whose manufacturing sector is more exposed to domestic tariffs on the input side relative to their exposure to the positive protectionist effect of the domestic tariffs on their output. By contrast, when the shock ends in 2029, the U.S. manufacturing sector experiences a negative demand shock, and the DNWR binds in many states, triggering a more significant increase in aggregate unemployment, which reaches 0.5% in 2029. The DNWR and the unemployment it generates play an important role in the quantitative results we obtain. Without DNWR, the U.S. would experience a real income (and welfare) gain from the tariff shock, given the lack of retaliation by other countries, an issue we return to in Section 6. The cumulative change in total U.S. employment, given by the green line in Figure 4, reaches a trough of -0.75% in 2029.

The right panel of Figure 4 presents the cumulative percentage change since 2024 in U.S. real GDP, which is inclusive of tariff revenues and coincides with real income for the

U.S. as a whole. The 0.9% decline in aggregate real value added by 2028 depicted in the bottom right panel of Figure 3 is partially offset by the increase in tariff revenue rebates, so real GDP only falls around 0.1% by 2028. The unemployment generated in 2029 further lowers real GDP, which declines by 0.9% in 2029 and then recovers gradually.[21]

A key advantage of our framework, where the U.S. is disaggregated into its 50 states, is that it allows us to assess how the shock impacts each of these sub-national units. Figure 5 presents a map depicting the cumulative change in real income between 2024 and 2028, in percent, across U.S. states.[22] Some states where real income falls the most are Texas, California, and Michigan, while some states where it falls the least (and in fact increases) are West Virginia, Wyoming, and Oklahoma. While U.S. real income falls only around 0.1% by 2028, this masks large cross-state heterogeneity in real income changes, which range between an increase of 1.9% and a decrease of 1.4%.

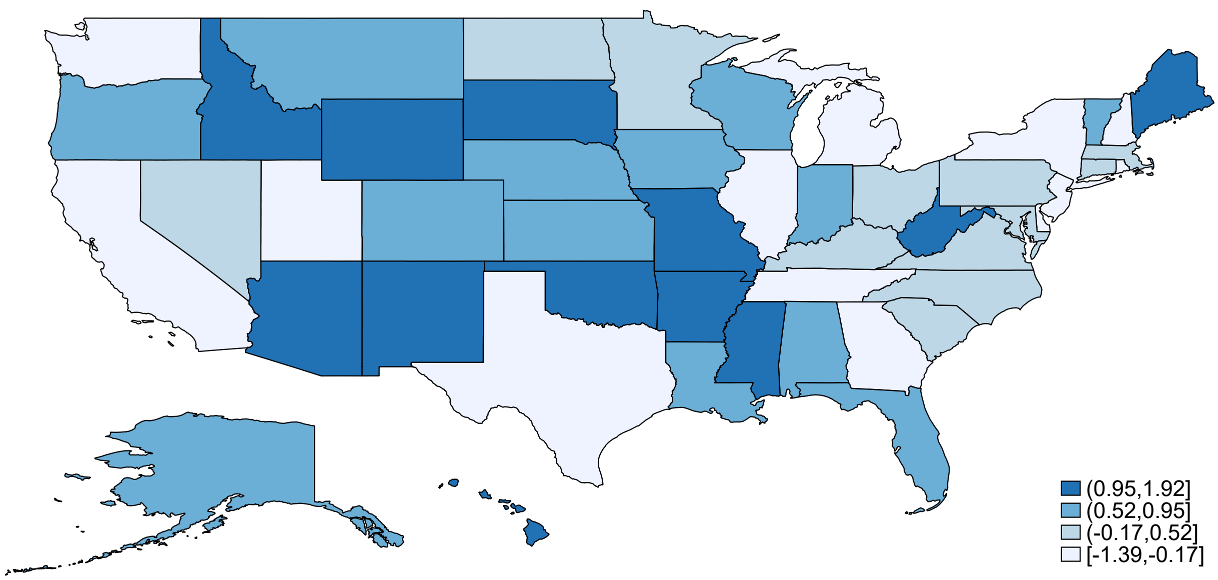


Figure 5: Map of the cumulative change in real income between 2024 and 2028, in percent, across U.S. states. The darker the shade of blue, the smaller the fall in real income (or the bigger the gain).

[21] While the trough in U.S. aggregate GDP occurs in 2029 rather than 2028, sometimes we highlight the 2028 level of the fall because 2028 is the last year that the tariff shock is active and because it presents an easier point of comparison to the real income changes in other countries. Non-U.S. regions do not suffer unemployment (due to our flexible-exchange-rate assumption), and therefore generally experience the maximum impact of the shock (for good or bad) around 2028.

[22] Appendix Figure D.1 gives an equivalent map but for the welfare change from the shock.

While the total real income change of a given state depends on several factors, such as the distribution of a state's expenditures across countries and sectors, its exposure to retaliatory tariffs, its deficits, and its indirect exposure to other U.S. states., we abstract away from most of these factors and build a summary measure of exposure to the shock that solely relies on how each state's expenditures are allocated across region-sectors combined with how tariffs change towards each of these region-sectors.

Denote by $EXP_{ji,s,t}$ the expenditure of region i on the sector s good of region j at time t (including both final consumption and intermediate inputs), and by $EXP_{i,t} \equiv \sum_s \sum_j EXP_{ji,s,t}$ the total expenditure of region i at time t. Denoting with 0 the base year and with 1 the year after that (when the high tariffs are assumed to be in effect), we construct a measure of exposure for a given region as follows:

$$Exposure_i = \sum_{s=1}^{S} \sum_{j=1}^{I} \frac{EXP_{ji,s,0}}{EXP_{i,0}} \frac{t_{ji,s,1} - t_{ji,s,0}}{1 + t_{ji,s,0}}. \tag{6}$$

For example, if a state allocates 3% of its expenditure on Chinese manufacturing, and there is a hypothetical tariff shock where the gross tariff rate on Chinese manufacturing increases by 50%, but all other country-sector tariffs are unchanged, then that state would have an exposure to this shock of 1.5%.

Figure 6 plots the exposure measure in equation (6), in percent, on the x axis, against the real income loss between 2024 and 2028 from the tariff shock, in percent, on the y axis, across the 50 U.S. states. The correlation between the variables is over 77%, indicating that even though the full real income change depends on many variables and general equilibrium interactions in potentially non-linear ways, the exposure measure already captures most of the ways that the impact varies in the cross-section of U.S. states.[23]

The model can also be used to obtain the welfare change due to the shock. The wel-

[23]The exposure measure does not capture how tariff revenue rebates impact states, but since those are redistributed across U.S. states according to population weights (not based on which states import more), then the cross-state distribution of the real income change is largely unaffected by this tariff revenue.

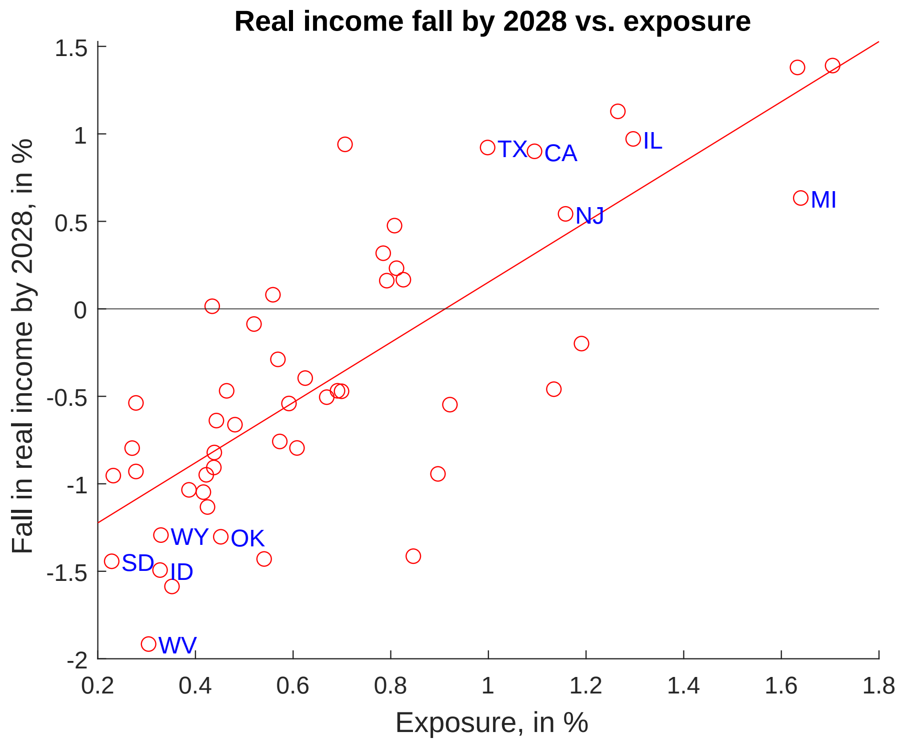


Figure 6: This figure presents a scatter plot of the exposure measure defined in equation (6), in percent, in the x axis, against the real income fall by 2028, in percent, in the y axis, across the 50 U.S. states. Some of the states that gain or lose the most from the shock are labeled with the usual two-letter abbreviations.

fare change is measured as the equivalent variation in consumption required by agents in the base year to be indifferent between the economy where tariffs increase and the economy where they do not. The formula, given in RUV, is a present value sum where we use an annual discount factor of $\beta = 0.95$.

The U.S. suffers an aggregate welfare loss of just around half a basis point. Recall that this welfare loss is for a shock that lasts only four years. If the shock lasted longer or the discount factor was lower, the welfare losses would naturally be altered. Additionally, our model contains a home production sector, which provides a constant utility flow that is unaffected by the tariff shock and serves as a protection mechanism for agents in all sectors against the detrimental effects of the shock. For details on how mobility between sectors affects welfare, see Section 3.6 of RUV.

6 Alternative Assumptions

This section explores how our results change if we make different assumptions regarding the value of the trade elasticity, the duration of the shock, retaliation by the affected countries. Throughout this section, we will refer to Table 1 which contains the aggregate U.S. cumulative real income gains (real income losses are then represented as negative numbers) between 2024 and the last year the high tariffs are active, in percent, from the tariff shock across our three alternative-specification exercises.[24] Panel A varies the σ parameter governing the trade elasticity, Panel B varies the duration of the shock in years, and Panel C varies the extent of retaliation by other countries.

In our baseline, we use a value of the trade elasticity parameter of $\sigma = 6$, a standard level in the trade literature (see, for example, Costinot and Rodriguez-Clare, 2014). However, Boehm et al. (2023) have recently estimated lower values of the trade elasticity. We now discuss the consequences of assuming $\sigma = 1.76$ (the estimate of Boehm et al. for the short run), $\sigma = 2.44$ (the median of the estimates in Boehm et al.), or $\sigma = 3.12$ (the estimate of Boehm et al. for the long run).

The value of σ has very noticeable implications for the effects of the shock. The lower the value of σ, the more relative market power the United States has against its smaller trading partners, and the less it suffers from the tariff shock. In fact, for the three lower values of σ, the United States as a whole actually benefits from the imposition of tariffs. This can be seen in Panel A of Table 1. For our baseline value of $\sigma = 6$, the United States suffers aggregate real income losses of around 0.1% by 2028, for $\sigma = 3.12$ the real income change turns into a gain of roughly 0.5%, while for the lowest value of $\sigma = 1.76$ the United States experiences a real income gain of 1%. We emphasize that values of σ below three are low relative to those commonly used in the literature, and not necessarily the most realistic for this exercise, but we present them here to illustrate the impact of the trade

[24] Appendix Table D.1 gives an equivalent table but for the welfare change from the shock.

Table 1: U.S. aggregate real income change (in percent) across specifications

Panel A: Trade Elasticity		Panel B: Duration		Panel C: Retaliation	
Sigma	Income gain	Years	Income gain	Mirror	Income gain
1.76	1.0065	4*	−0.1147*	0%*	−0.1147*
2.44	0.7182	8	−0.0398	33%	−0.2857
3.12	0.5069	12	0.0384	66%	−0.4377
6.00*	−0.1147*	16	0.0889	100%	−0.5640

Notes: This table displays the aggregate U.S. cumulative real income gains (real income losses are therefore represented as negative numbers) from 2024 to the last year that the high tariffs are active, in percent, across our three alternative specification exercises. Panel A varies the σ parameter governing the trade elasticity, Panel B varies the duration of the shock in years, and Panel C varies the weight put on mirror retaliation as explained in the text. An asterisk denotes the values under the baseline specification, which are $\sigma = 6$, a duration of 4 years, and 0% weight on mirror retaliation (which implies full weight on the retaliation observed in the data which is small to non-existent).

elasticity on the effects of the tariff shock.[25]

Figure 7 displays the percentage change since 2024 in aggregate labor force participation (top left), the cumulative percentage change since 2024 in manufacturing participation (top right), the unemployment generated by the shock in percentage (bottom left), and the cumulative percentage change since 2024 in real GDP for the U.S. as a whole across different values of the trade elasticity. The solid blue line depicts $\sigma = 1.76$, the dashed green line our baseline value of $\sigma = 2.44$, the orange line with circular markers $\sigma = 3.12$, and the burgundy line with crosses $\sigma = 6$.

As σ decreases from 6 to 1.76, the change in aggregate labor force participation reverses direction. With a lower elasticity of substitution, individuals are more likely to enter the labor force to capitalize on the increased profitability of market sector employment. Participation in manufacturing increases less for low values of σ. This shift is tied to the effect of tariffs on the cost of imported inputs. As highlighted by Flaaen and Pierce (2019), such imports are essential for the competitiveness of U.S. manufacturing. Conse-

[25] If the value of the trade elasticity is one, i.e., $\sigma = 2$, then even extremely small countries have optimal unilateral tariffs of 100% (see Costinot and Rodriguez-Clare, 2014), which seems unrealistic.

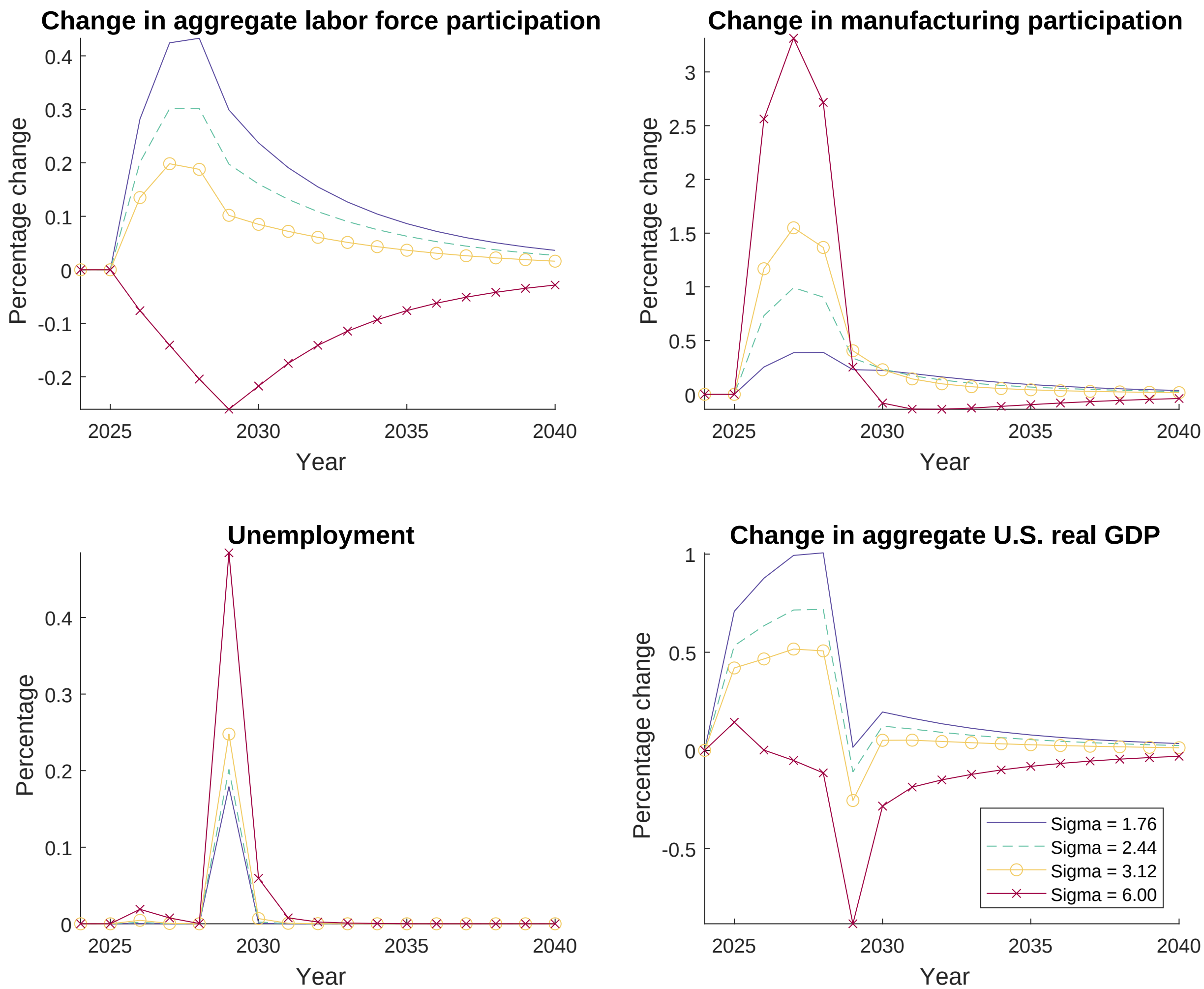


Figure 7: This figure presents the cumulative percentage change since 2024 in aggregate labor force participation (top left), the cumulative percentage change since 2024 in manufacturing participation (top right), the unemployment generated by the shock in percentage (bottom left), and the cumulative percentage change since 2024 in real GDP for the U.S. as a whole across different values of the trade elasticity. The solid blue line depicts a sigma of 1.76, the dashed green line a sigma of 2.44, the orange line with circles a sigma of 3.12, and the burgundy line with crosses a sigma of 6.

quently, tariffs that raise input costs undermine U.S. comparative advantage in manufacturing, reducing labor demand in that sector. While tariffs do lessen import competition in manufacturing, a lower elasticity of substitution limits the ability to replace foreign with domestic inputs and amplifies the impact of the input cost channel, making it more likely that the net manufacturing employment effect is smaller.

We now turn to discussing the impact of the shock's duration. Figure 8 displays the same four outcomes as Figure 7, but now across different values for the duration of the shock (recall that we have solved the model under perfect foresight, so the agents in the model know the size and duration of the shock). A higher persistence turns the decrease in aggregate participation into an increase, as the negative impacts of the unemployment generated when the shock dissipates are extended farther into the future and no longer dissuade agents from supplying labor soon after the tariffs are introduced. Manufacturing employment also increases more when the persistence of the shock increases. As a result of DNWR, unemployment is mostly generated in the years immediately following the tariff reversal.

Next, we consider the effects of retaliation by the other countries. Figure 9 displays the same four outcomes as Figure 7, but now across different options for the extent of retaliation by other countries. For each line, the tariff shock is a convex combination of the amount of retaliation that occurred in the data (which is very small or non-existent, as described in Section 4.2) and mirror retaliation (i.e., other countries impose on the U.S. the same tariff increase that they have suffered). The solid blue line puts 100% weight on actual retaliation, the dashed green line puts 2/3 weight on actual retaliation and 1/3 weight on mirror retaliation, the orange line with circular markers puts 1/3 weight on actual retaliation and 2/3 weight on mirror retaliation, and the burgundy line with crosses puts 100% weight on mirror retaliation.

The higher the weight put on mirror retaliation, the less beneficial the shock is for the United States (as indicated in Panel C of Table 1). Higher weight on mirror retaliation also dampens the boost to manufacturing demand due to domestic protection, weakening the increase in manufacturing participation. Remarkably, the larger the weight on mirror retaliation, the lower is the amount of unemployment generated when the tariff shock disappears. Under the retaliation observed so far (small to non-existent), manufacturing employment and wages increase sharply during the years with high tariffs, due to the positive protectionist effect. Consequently, the wage in manufacturing needs to fall sub-

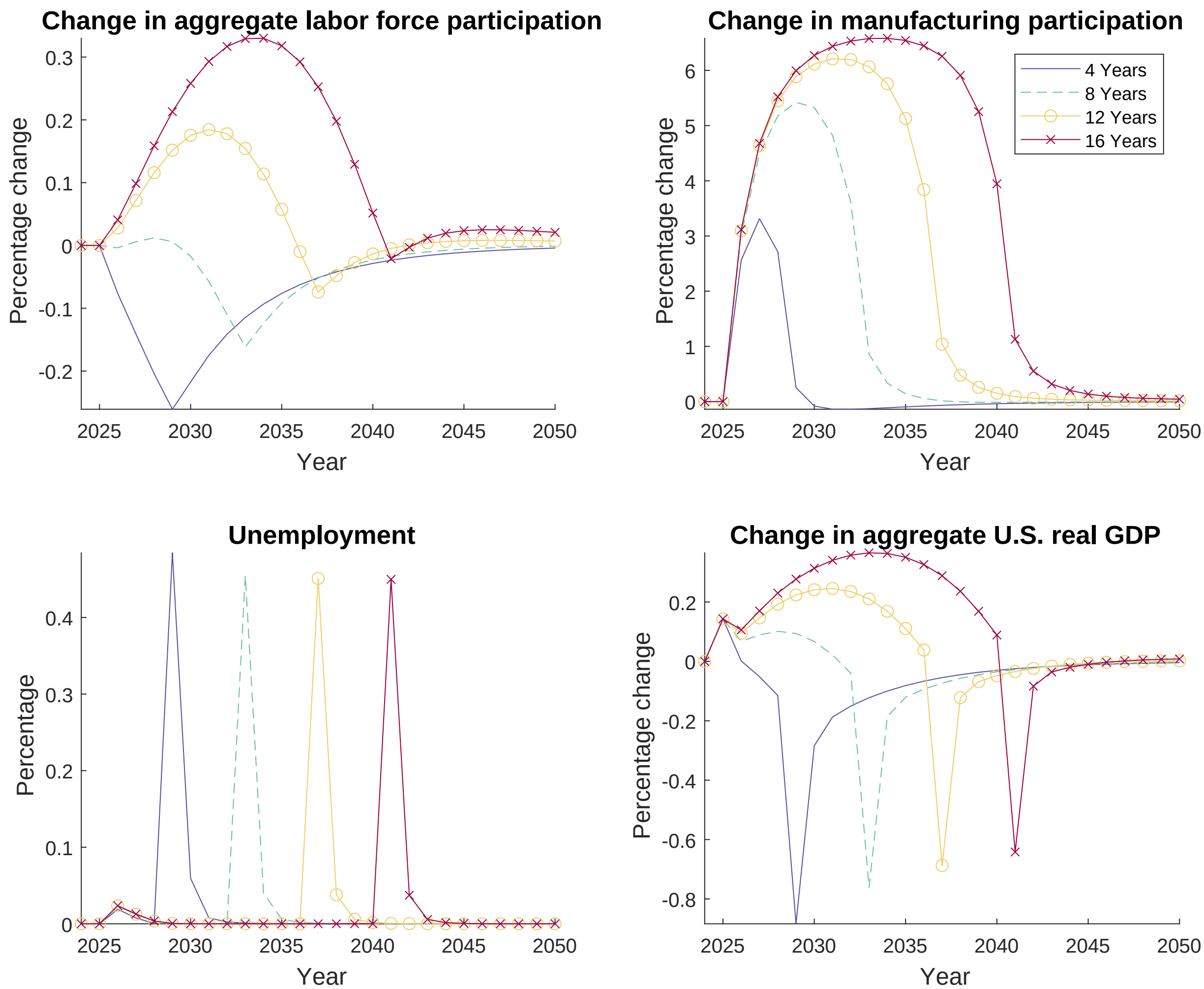


Figure 8: This figure presents the cumulative percentage change since 2024 in aggregate labor force participation (top left), the cumulative percentage change since 2024 in manufacturing participation (top right), the unemployment generated by the shock in percentage (bottom left), and the cumulative percentage change since 2024 in real GDP for the U.S. as a whole across different values for the duration of the shock. The solid blue line depicts a duration of 4 years, the dashed green line 8 years, the orange line with circular markers 12 years, and the burgundy line with crosses 16 years.

stantially when the shock disappears, at which point the manufacturing sectors in many U.S. states hit the DNWR, leading to unemployment. A tariff-generated unemployment of 0.5% in 2029 under the baseline specification turns into a level of just around 0.15% under the mirror retaliation scenario. Thus, perhaps surprisingly, foreign mirror retaliation ameliorates the unemployment effects of the U.S. tariffs.

To further emphasize the point in the previous paragraph while simultaneously illus-

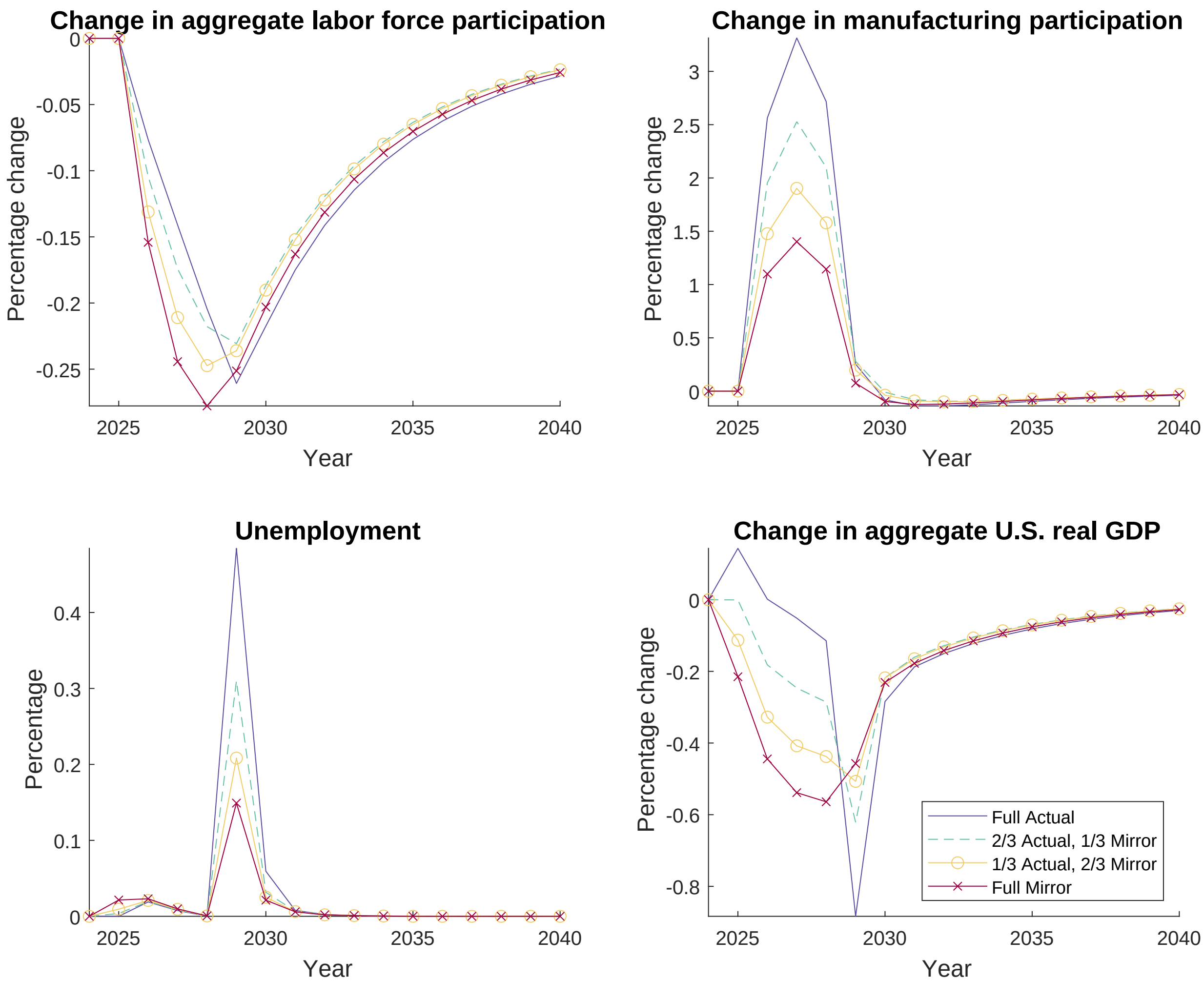


Figure 9: This figure presents the cumulative percentage change since 2024 in aggregate labor force participation (top left), the cumulative percentage change since 2024 in manufacturing participation (top right), the unemployment generated by the shock in percentage (bottom left), and the cumulative percentage change since 2024 in real GDP for the United States as a whole across different options for the extent of retaliation by other countries. For each line, the tariff shock is a convex combination of the amount of retaliation that occurred in the data (as described in Section 4.2) and mirror retaliation (i.e., other countries impose on the U.S. the same tariff increase that they have suffered). The solid blue line puts 100% weight on actual retaliation, the dashed green line puts 2/3 weight on actual retaliation and 1/3 weight on mirror retaliation, the orange line with circular markers puts 1/3 weight on actual retaliation and 2/3 weight on mirror retaliation, and the burgundy line with crosses puts 100% weight on mirror retaliation.

trating the implications of modifying the tightness of the DNWR by changing the annual growth rate of world nominal GDP, we refer to Figure 10. It shows the welfare change from the shock for the United States as a whole, in basis points, on the y-axis for different

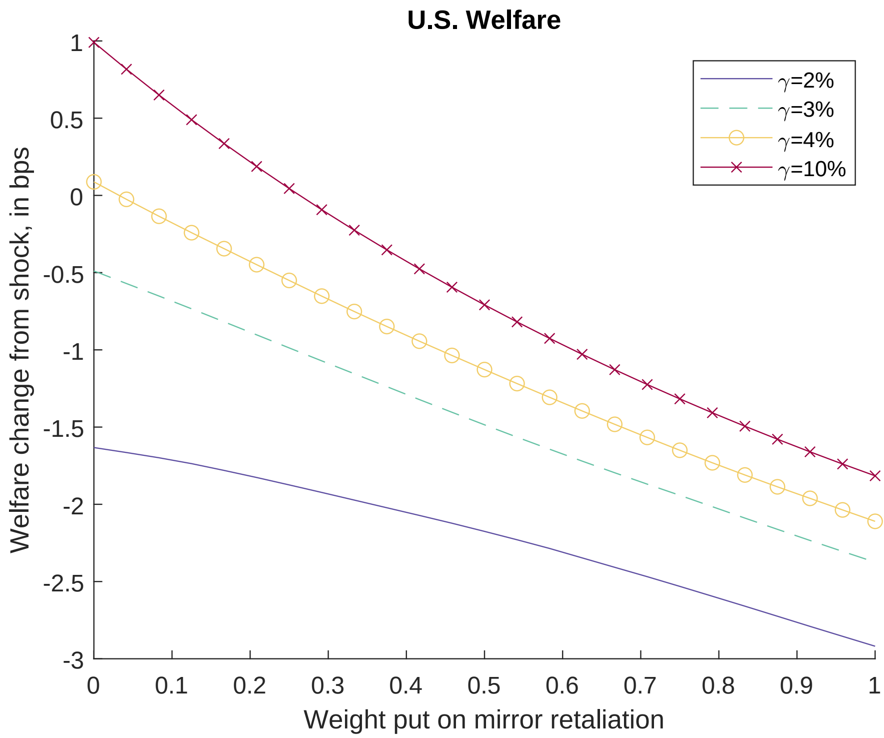


Figure 10: This figure presents the welfare change from the shock for the United States on aggregate, in basis points, on the y-axis for different percentages of the weight put on mirror retaliation (between zero and one), on the x-axis, for four different values of the growth rate of world nominal GDP in dollars (γ). The blue solid line is for $\gamma = 2\%$, the green dashed line is for $\gamma = 3\%$, the yellow line with circles is for $\gamma = 4\%$, and the red line with crosses is for $\gamma = 10\%$ (representing essentially no DNWR).

percentages of the weight put on mirror retaliation (between zero and one), on the x-axis, and for four different values of the growth rate of world nominal GDP in dollars (γ). The blue solid line is for $\gamma = 2\%$, the green dashed line is for $\gamma = 3\%$, the yellow line with circles is for $\gamma = 4\%$, and the red line with crosses is for $\gamma = 10\%$ (representing essentially no DNWR).

As expected, the higher the weight put on mirror retaliation, the greater is the welfare loss. Similarly, the lower is γ, the greater is the welfare loss. This happens because a greater γ gives more room for the wage to adjust downward each period, decreasing the amount of manufacturing unemployment generated when the shock dissipates, and dampening the welfare and real income losses from the shock (without accounting for the unmodeled cost of higher inflation).

More subtly, the slope of the lines in Figure 10 becomes more negative with higher γ. Without DNWR (red line with crosses), the United States gains 1 basis point of welfare from the shock if other countries retaliate as they have done in the data so far, but it loses 1.8 basis points if the other countries do mirror retaliation, for a slope of -2.8. By contrast, with $\gamma = 2\%$ (blue solid line), the United States loses 1.63 basis points if other countries retaliate as they have done in the data so far, but it loses 2.92 basis points if the other countries do mirror retaliation, for a slope of just -1.28. In other words, the higher the amount of DNWR, the smaller is the importance of the weight put on mirror retaliation for the welfare impact of the shock. This occurs because, while greater retaliation makes outcomes worse for the United States through the traditional channels, it also dampens the manufacturing expansion that occurs during the high-tariff years and decreases the amount of unemployment generated when the tariff shock disappears.

We finish this section by briefly discussing the implications of other changes to the model's assumptions. Allowing for migration across U.S. states does not change the results substantially, as the migration elasticities typically estimated for the United States tend to be fairly low (see, e.g., RUV). The results under other potential changes to the model's assumptions, such as fixed exchange rates between the dollar and other currencies, or DNWR applying to all sectors, are available upon request.[26]

7 International Results

In this section, we focus on how the impact of the tariff shock varies across countries.[27] Each country is charged a potentially different tariff. On top of that, countries

[26] In a nutshell, other countries having fixed exchange rates against the dollar makes the shock slightly worse for them, since they then experience some unemployment from the shock. When the DNWR applies in all sectors, more unemployment is generated in the United States when the shock first hits.

[27] So far, we have focused on the U.S. implications of the shock because our framework models the United States in great detail. By contrast, our modeling of other countries is more limited; they do not feature internal regions or costs of moving between sectors. We take the U.S. implications of the model more seriously while still thinking that the implications for other countries are worth discussing.

have differential exposures to the shock determined by their trading patterns and openness to trade. Figure 11 shows the cumulative fall in real income between 2024 and 2028 for all the countries in our sample. Not surprisingly, countries trading more with the United States lose the most, while some countries can gain by having less competition in their export markets, for example, if they are charged the minimum tariff by the United States (examples of this are Great Britain and Saudi Arabia).

As discussed earlier, the real income loss for the United States in 2028 is around 0.1%. Canada and Mexico both lose around 1.6%, Vietnam loses 1.1%, Ireland loses 0.8%, and China loses 0.3%. Canada and Mexico suffer more than China because a larger share of their exports go to the United States and because they are smaller countries with a more limited ability to use tariffs to retaliate against the U.S.

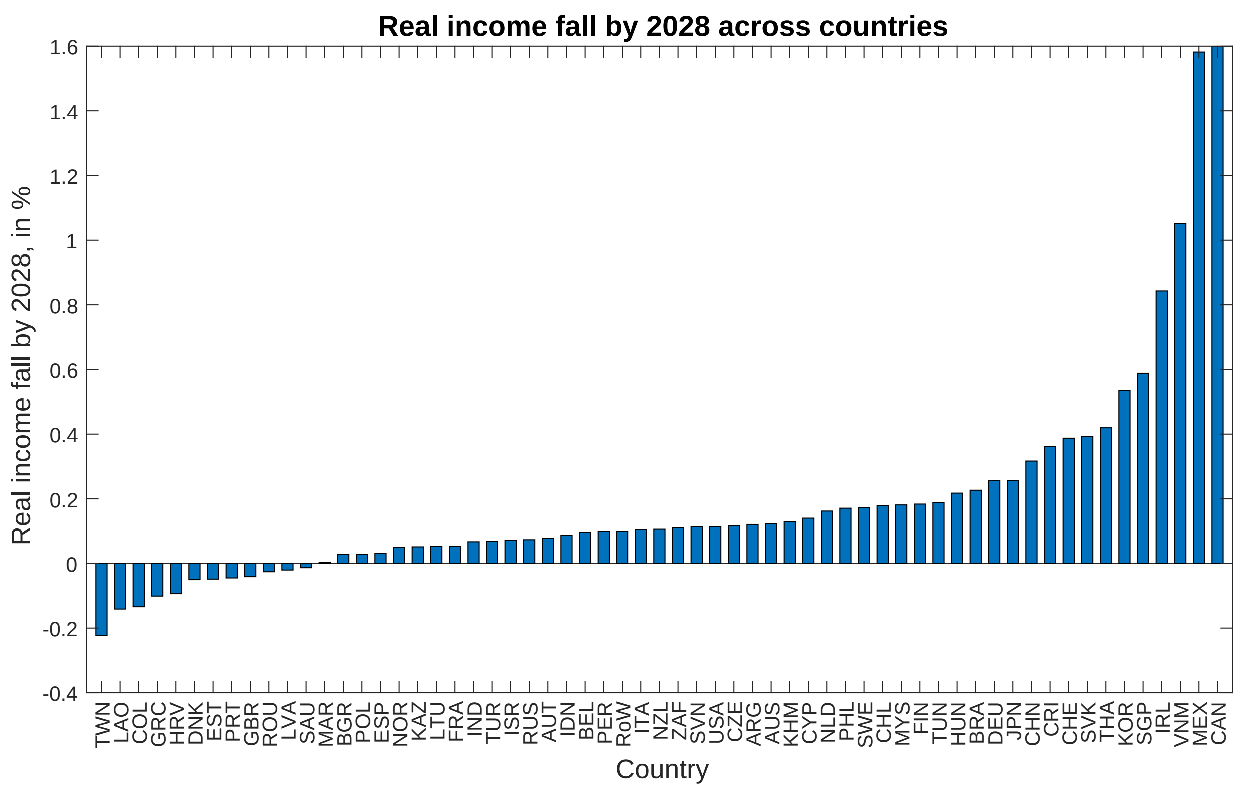


Figure 11: This figure displays the cumulative real income (which coincides with real GDP) fall by 2028, in percent, across countries. For country abbreviation codes, see Appendix B.1.

8 Conclusion

In this paper, we use detailed tariff data and a dynamic trade model with an input-output structure and DNWR to assess the effects of the recently enacted tariff increases. We propose a general method to solve quantitative trade models when the tariff revenue received by a given region can be arbitrarily related to the tariff revenue collected on the region's imports due to potential government redistribution.

We find four key results for the U.S. First, there is a temporary decline in labor force participation as the market sector becomes less efficient and home production becomes comparatively more appealing. Second, there is a temporary increase in manufacturing and agricultural employment. By contrast, there is a temporary reduction in service employment. Third, states highly exposed to trade with the countries most affected by the new tariffs (like Michigan, Texas, and California) see bigger real income losses. Fourth, the impacts of the shock depend on the trade elasticity. If the trade elasticity is low enough, the United States as a whole benefits from the tariff shock, but this comes with a much smaller employment increase in the manufacturing sector.

At the country level, we find that the real income loss from the shock for the United States by 2028 is around 0.1%. Close trading partners of the United States, like Canada, Mexico, and Ireland, suffer substantial real income losses greater than 1%. The overall U.S. real income loss masks huge heterogeneity across states, with certain states suffering real income losses greater than 1.4%.

Importantly, our model does not capture any effects of tariff increases that might stem from uncertainty, geopolitical tensions, interactions with pre-existing distortions (such as income taxes), or the central bank's reaction to the shock, among others.

Finally, we want to highlight some assumptions that might make our model underestimate the short-run consequences of the new tariffs. First, as is standard in quantitative trade models, we assume that technology is Cobb-Douglas, but recent evidence suggests that the elasticity of substitution across inputs is likely to be less than one, especially in the very short run.[28] As shown by Baqaee and Farhi (2019), if factors are not fully mobile across sectors (as is the case in our model due to the costs of moving between sectors), this can lead to significantly larger losses from increases in trade costs. Second, the aggregate nature of our model implies a lot of smoothing of the effects of shocks across different agents. A more granular model could imply larger shocks that could trigger large disruptions, such as bankruptcies that could affect other agents in more granular input-output or credit networks, leading to larger aggregate effects (see, e.g., Acemoglu et al., 2012).

[28]See Boehm et al. (2019) and Atalay (2017).

References

ACEMOGLU, D., V. M. CARVALHO, A. OZDAGLAR, AND A. TAHBAZ-SALEHI (2012): "The network origins of aggregate fluctuations," *Econometrica*, 80, 1977–2016.

ALVAREZ, F. AND R. J. LUCAS (2007): "General equilibrium analysis of the Eaton-Kortum model of international trade," *Journal of Monetary Economics*, 54, 1726–1768.

AMITI, M., S. J. REDDING, AND D. WEINSTEIN (2019): "The Impact of the 2018 Trade War on U.S. Prices and Welfare," NBER Working Papers 25672, National Bureau of Economic Research, Inc.

ATALAY, E. (2017): "How important are sectoral shocks?" *American Economic Journal: Macroeconomics*, 9, 254–280.

BAQAEE, D. R. AND E. FARHI (2019): "The macroeconomic impact of microeconomic shocks: Beyond Hulten's theorem," *Econometrica*, 87, 1155–1203.

BOEHM, C. E., A. FLAAEN, AND N. PANDALAI-NAYAR (2019): "Input linkages and the transmission of shocks: Firm-level evidence from the 2011 Tōhoku earthquake," *Review of Economics and Statistics*, 101, 60–75.

BOEHM, C. E., A. A. LEVCHENKO, AND N. PANDALAI-NAYAR (2023): "The Long and Short (Run) of Trade Elasticities," *American Economic Review*, 113, 861–905.

BOWN, C. P. (2021): "The US–China trade war and Phase One agreement," *Journal of Policy Modeling*, 43, 805–843, the World Economy After Covid-19.

CALIENDO, L., M. DVORKIN, AND F. PARRO (2019): "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock," *Econometrica*, 87, 741–835.

CALIENDO, L., S. S. KORTUM, AND F. PARRO (2025): "Tariffs and Trade Deficits," NBER Working Papers 34003, National Bureau of Economic Research, Inc.

CALIENDO, L. AND F. PARRO (2015): "Estimates of the Trade and Welfare Effects of NAFTA," *Review of Economic Studies*, 82, 1–44.

CANADIAN VEHICLE MANUFACTURERS' ASSOCIATION (2025): "Five Facts About the Canada–U.S. Auto Trade Relationship," PDF report, CVMA, accessed 19 September 2025.

CONTRERAS, J. (2024): "Restricting imports of Mexican vehicles will harm US manufacturers," PIIE RealTime Economics blog, accessed 19 September 2025.

COSTINOT, A. AND A. RODRIGUEZ-CLARE (2014): *Trade Theory with Numbers: Quantifying the Consequences of Globalization*, Elsevier, vol. 4 of *Handbook of International Economics*, 197–261.

DEKLE, R., J. EATON, AND S. KORTUM (2007): "Unbalanced Trade," *American Economic Review*, 97, 351–355.

FAJGELBAUM, P. D., P. K. GOLDBERG, P. J. KENNEDY, AND A. K. KHANDELWAL (2020): "The Return to Protectionism," *The Quarterly Journal of Economics*, 135, 1–55.

FLAAEN, A. AND J. R. PIERCE (2019): "Disentangling the Effects of the 2018-2019 Tariffs on a Globally Connected U.S. Manufacturing Sector," Finance and Economics Discussion Series 2019-086, Board of Governors of the Federal Reserve System (U.S.).

GAULIER, G. AND S. ZIGNAGO (2010): "BACI: International Trade Database at the Product-Level. The 1994-2007 Version," Working Papers 2010-23, CEPII.

GUERRIERI, V., G. LORENZONI, L. STRAUB, AND I. WERNING (2021): "Monetary Policy in Times of Structural Reallocation," *Proceedings of the 2021 Jackson Hole Symposium*.

IGNATENKO, A., A. LASHKARIPOUR, L. MACEDONI, AND I. SIMONOVSKA (2025): "Making America Great Again? The Economic Impacts of Liberation Day Tariffs," Tech. rep., Indiana University.

ITSKHOKI, O. AND D. MUKHIN (2025): "The Optimal Macro Tariff," NBER Working Papers 33839, National Bureau of Economic Research, Inc.

LASHKARIPOUR, A. (2021): "The cost of a global tariff war: A sufficient statistics approach," *Journal of International Economics*, 131.

LIAO, S., I. S. KIM, S. MIYANO, AND H. ZHANG (2021): "Concordance: Product Concordance," available at the Comprehensive R Archive Network (CRAN), `http://CRAN.R-project.org/package=concordance`.

OSSA, R. (2014): "Trade Wars and Trade Talks with Data," *American Economic Review*, 104, 4104–4146.

PEAKE, M. AND A. M. SANTACREU (2020): "The Economic Effects of the 2018 U.S. Trade Policy: A State-Level Analysis," *Review*, 102, 385–412.

RODRIGUEZ-CLARE, A., M. ULATE, AND J. P. VASQUEZ (2025): "Trade with Nominal Rigidities: Understanding the Unemployment and Welfare Effects of the China Shock," *Forthcoming at the Journal of Political Economy*.

SCHMITT-GROHE, S. AND M. URIBE (2016): "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment," *Journal of Political Economy*, 124, 1466–1514.

SCHOTT, P. K. (2008): "The Relative Sophistication of Chinese Exports [with Discussion]," *Economic Policy*, 23, 5–49.

STUMPNER, S. (2019): "Trade and the Geographic Spread of the Great Recession," *Journal of International Economics*, 119, 169–180.

TETI, F. A. (2024): "Missing Tariffs," Tech. Rep. 11590, CESifo Working Papers, Feodora Teti's Global Tariff Database (v_beta1-2024-12).

ULATE, M., J. P. VASQUEZ, AND R. D. ZARATE (2025): "Labor market effects of global supply chain disruptions," *Journal of Monetary Economics*, 149.

Appendix

A Construction of the Global Tariff Database: U.S. Trade War Extension

In this section, we document the construction of the Global Tariff Database: U.S. Trade War Extension underlying our theoretical analysis of the impacts of the recent increases in U.S. tariffs. We begin with an overview of the tariff instruments (Table A.1), describe the rules used to stack them into effective tariff rates, provide some illustrative product-country examples, and conclude with a detailed account of the data construction process. The data are available at Feodora A. Teti's website (`https://feodorateti.github.io/`) and will be updated regularly.

A.1 Overview of U.S. Tariff Instruments (2018–2025)

Tariff Type	Details
Baseline tariff	**Trade relations in normal times**, the baseline tariff equals $\min(\text{MFN}, \text{preferential})$ or Column 2 if no normal trade relations (Cuba, North Korea; Russia and Belarus since 2022).
Safeguards (Sec. 201)	**Solar panels** (30%, GSP excl.) and **washers** (20%, GSP+CAN excl.) imposed 07 Feb 2018. Annual reductions; washers expired 07 Feb 2023, solar extended (to 2026).

Tariff Type	Details
Unfair Trade Practices (Sec. 301)	**China-specific tariffs** covered about $370bn: Lists 1–3 ($250bn) at 25% (Jul–Sep 2018) and List 4A ($120bn) at 15% (Sep 2019), cut to 7.5% (Feb 2020). Biden maintained the regime and added EVs, batteries, critical minerals, solar inputs (Sep 2024), and tungsten, wafers, and polysilicon (Jan 2025).
Airbus Dispute (Sec. 301)	**WTO-authorized retaliation** imposed on selected E.U. goods (18 Oct 2019), later adjusted in 2020–21 and suspended in Mar 2021 under Biden's truce with the E.U. and U.K.
National Security (Sec. 232)	**Steel and aluminum** tariffs of 25% on steel and 10% on aluminum imposed 23 Mar 2018. AUS, BRA, ARG, and KOR exempt from the start (quotas); EU27, CAN, MEX exemptions ended 01 Jun 2018. Turkey steel 50% (Aug 2018–May 2019). Scope later extended to certain derivative products 08 Feb 2020, with tariffs applied to the full product value. CAN+MEX re-exempted permanently May 2019; 10% briefly reimposed on one Canadian aluminum product (16 Aug–01 Sep 2020). Biden: TRQs with EU (Jan 2022), JPN (Apr 2022), and UK (Jun 2022) effectively eliminated tariffs.

Tariff Type	Details
	Trump 2.0: all exemptions ended 12 Mar 2025 (aluminum raised to 25%); 04 Jun both steel and aluminum raised to 50%, U.K. capped at 25%; scope extended 23 Jun and 18 Aug 2025, with tariffs applying only to the steel/aluminum content.[29]
	Cars faced a 25% tariff imposed 03 Apr 2025 (worldwide), with USMCA-compliant vehicles[30] taxed only on non-U.S. content[31]; the UK was later capped at 7.5% (30 Jun 2025).
	Car parts faced a 25% tariff imposed 03 May 2025 (worldwide), with USMCA-compliant parts exempt.
	Copper faced a 50% tariff imposed 01 Aug 2025 (worldwide), applied only to copper content; the UK was exempt.
IEEPA tariffs	**China** faced +10% on all imports (04 Feb 2025), raised to 20% (04 Mar 2025).
	Canada and Mexico faced 25% on non-USMCA compliant goods from 04 Mar 2025;[32] the Canadian rate rose to 35% (01 Aug 2025).

[29] We assume 50% material content for all products subject to content-based tariffs.
[30] USMCA-compliant defined using preference utilization rates from 2017/18 trade data.
[31] About 38% U.S. content for MEX, about 50% for CAN based on PIIE and CVMA sources.
[32] Compliance determined using preference utilization rates (PURs) from 2017/18 trade flows.

Tariff Type	Details
	Brazil was targeted with +40% (12 Aug 2025), with product and sectoral exemptions, including goods covered by the Civil Aircraft Agreement[33].
Liberation Day	A **flat tariff** of +10% imposed on nearly all imports worldwide (05 Apr 2025), with carveouts for all Sec. 232 goods, Annex II products (pharma, semiconductors, energy, critical minerals), Column 2 countries (CUB, PRK, RUS, BLR), and humanitarian exemptions. Semiconductors and electronics were exempted with retroactive effect to 05 Apr 2025 (decision announced 11 Apr 2025). Canada and Mexico were excluded, remaining under their IEEPA tariff regime.
Reciprocal tariffs and deals	**Reciprocal flat tariffs** announced 09 Apr 2025 for 69 partners, with which the US runs bilateral trade deficits.[34] They were designed to **replace** (not stack on) the Liberation Day tariffs. In practice, they took effect only for China on 09 Apr, while for all other partners implementation was suspended, leaving the 10% Liberation Day tariff in place until 07 Aug 2025, when negotiated country-specific reciprocal rates and deals entered into force following the summer talks. Canada and Mexico were excluded, remaining under their IEEPA tariff regime.

[33] Exemptions identified using preference utilization rates (PURs) for Civil Aircraft Agreement coverage.

[34] The reciprocal tariff rate was defined as $\text{Rate} = \frac{\text{U.S. bilateral trade deficit with partner}}{2 \times \text{U.S. imports from that partner}} \times 100$.

Tariff Type	Details
	China was subject to reciprocal tariffs starting 09 Apr 2025, escalating to +84% (09 Apr) and +125% (10 Apr); both sides agreed to roll these back to +10% on 14 May 2025. **United Kingdom** faced a 10% reciprocal tariff on exports, with cars reduced to 7.5% under a quota arrangement (deal signed 30 Jun 2025). The U.K. pledged tariff reductions under the ”Economic Prosperity Deal,” but product coverage remains unclear and was therefore not coded on the U.K. side. **EU27** agreed to a “15–MFN” formula: if MFN $\leq$ 15%, the US reciprocal tariff equals $(15\% - \text{MFN})$; if MFN $>$ 15%, it equals MFN. Carveouts would return aircraft/parts, certain chemicals, drug generics, and natural resources to MFN and exempt the EU from Sec. 232 tariffs, but these remain political announcements rather than binding commitments. On the EU side, the announced elimination of industrial tariffs was incorporated in our database as MFN = 0 for HS Chapters 25–97. **Japan** faced a 15% reciprocal tariff on exports, announced alongside Japanese market-access commitments (autos/trucks, rice, selected agriculture), but these remain political pledges and were not coded on the Japanese side.

Tariff Type	Details
	Vietnam applied a 20% reciprocal tariff on its exports to the US and 40% on goods transshipped through Vietnam; in return, Vietnam pledged 0% tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database. **Indonesia** applied a 19% reciprocal tariff on its exports to the US; in return, Indonesia pledged 0% tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database. **Philippines** applied a 19% reciprocal tariff on its exports to the U.S.; in return, the Philippines pledged 0% tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database. **South Korea** applied a 15% reciprocal tariff on its exports to the U.S.; in return, South Korea pledged 0% tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database. **Israel** unilaterally eliminated tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database.

Tariff Type	Details
	Cambodia unilaterally reduced tariffs to 5% on 19 specified products; in return, Cambodia pledged 0% tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database.
	Zimbabwe unilaterally eliminated tariffs on U.S. exports (announced via Truth Social/X, not formally codified), which we nevertheless included in our database.

Table A.1: Overview of U.S. tariff instruments, 2018–2025

A.2 Stacking Rules for U.S. Tariffs

Table A.1 lists the individual tariff instruments used by the U.S. between 2018–2025. To determine the *effective tariff* for a given product–country–date observation, the following stacking rules apply:

1. **Apply baseline tariff.** MFN or preferential rate, or Column 2 if no NTR (CUB, PRK; since 2022 RUS and BLR).
2. **Stack additional duties.** Add safeguards, Sec. 301, IEEPA, and Sec. 232, subject to exclusions, quotas, or carve–outs.
3. **Overlay Liberation Day tariffs (Apr 2025).** Flat +10% applied on top of baseline and other duties, subject to exemptions (e.g. selected sectors, Column 2 countries, humanitarian goods). For Sec. 232 goods, only the Sec. 232 tariff applies. For content–rule goods, the Sec. 232 duty applies to the covered material content, while the non-content portion remains subject to Liberation Day tariffs.

4. **Overlay Reciprocal tariffs (Aug 2025 onwards).** Replace Liberation Day for 69 "deficit" partners with country–specific rates. As with Liberation Day, Sec. 232 duties apply to covered products. For content–rule goods, Sec. 232 applies to the steel/aluminum/copper content, while the non-content portion is subject to Reciprocal tariffs.

Note: Sec. 232 measures generally do not stack with each other. Goods covered under cars, car parts, or copper are subject only to their specific Sec. 232 duty. The exception is steel and aluminum, which were imposed as distinct measures; goods containing both can face both the steel (25–50%) and aluminum (10–50%) duties.

A.3 Retaliation

Table A.2 summarizes the pattern of retaliatory tariffs imposed by U.S. trading partners in response to the various tariff instruments introduced since 2018. Retaliation was broad during the first Trump administration, with the E.U., Canada, Mexico, Turkey, India, Russia, and especially China imposing countermeasures across steel, aluminum, and a wide range of sensitive exports. Under the Biden administration, most of these measures were suspended following negotiated arrangements, notably the TRQs on steel and aluminum. By contrast, retaliation in the second Trump administration has so far been much more muted: only China has imposed broad new measures, mirroring the IEEPA surcharges on all U.S. imports and matching the Liberation Day tariffs, which led to an escalation of tariffs between the two trade partners. The E.U. reinstated its steel countermeasures from the first Trump administration, while Canada targeted steel, aluminum, and autos; however, these actions were limited in scope and had largely been withdrawn by mid-August 2025. Other partners abstained altogether.

U.S. Tariff Type	Retaliatory Measures
Safeguards (Sec. 201)	No formal retaliation; partners raised concerns in WTO.
Unfair Trade Practices (Sec. 301)	**China** responded symmetrically to Lists 1–3 (2018) and List 4A (2019), covering $\sim$ \$110bn U.S. exports (agriculture, autos, chemicals).
Airbus Dispute (Sec. 301)	The **E.U. and the U.K.** received WTO authorization to counter-retaliate in 2020, but suspended measures after the March 2021 truce.
National Security (Sec. 232)	During the **first Trump administration**, the E.U., Canada, Mexico, Turkey, India, and Russia imposed countermeasures on steel/aluminum and selected U.S. exports (notably agriculture and consumer goods) in response to the Section 232 steel and aluminum tariffs. Under the **Biden administration**, the E.U. and the U.K. suspended their countermeasures following TRQ arrangements. During the **second Trump administration**, the EU reinstated its suspended steel measures (Apr 2025) but refrained from retaliation in other sectors, while Canada imposed new duties on steel, aluminum, and autos (Mar 2025). Other partners did not retaliate.

U.S. Tariff Type	Retaliatory Measures
IEEPA tariffs	During the second Trump administration, **China** mirrored the U.S. action by imposing additional tariffs of 10% and 20% on all U.S. imports. Canada applied surcharges on non-USMCA goods, but withdrew most of them on 1 Sep 2025 following the U.S. increase of fentanyl-related tariffs to 35%, as a gesture of goodwill. Mexico and Brazil did not impose broad countermeasures, although both initiated WTO consultations.
Liberation Day	No dedicated retaliation; most partners waited for reciprocal tariff negotiations.
Reciprocal tariffs and deals	**China** escalated to 125% before rollback. **E.U., U.K., and Japan** negotiated reciprocal deals (industrial tariff elimination, quotas, or caps). **Smaller partners** (Vietnam, Indonesia, Philippines, Korea, Cambodia, Israel, and Zimbabwe) pledged tariff cuts on U.S. exports, generally symbolic.

Table A.2: Overview of retaliatory tariff measures, 2018–2025

A.4 Data Construction

Now that the institutional background is established, we turn to the construction of the dataset underlying the *GTD: US–Trade War*.

Our starting point is the tariff-line level dataset of Bown (2021), which provides U.S. applied tariffs at the HS10 level (HS 2017 classification) and Chinese retaliatory tariffs at the HS8 level (HS 2017) for the first Trump administration. We extend this dataset by hand-coding retaliatory measures implemented by the EU27, Canada, Mexico, Russia, India, and Turkey, harmonized to the respective national tariff-line schedules.[35] This extended dataset covers all tariff instruments in place during 2018–2021 and forms the baseline for the subsequent additions from Trump 2.0 and the Biden administration.

For the years 2022–2025, we proceed in two steps. First, we map the additional tariffs from the first Trump administration that remained in force into the new HS 2022 nomenclature, reflecting the nomenclature change in 2022. Second, we incorporate all subsequent changes, including tariff adjustments under the Biden administration and the new measures introduced during the second Trump administration starting in January 2025.

To account for the 2022 nomenclature change, we aggregate all tariff-line data for 2017–2021 to the HS6 level (simple mean across lines) and convert these HS6 codes into HS 2022 using the official concordance. We then expand back to the tariff-line level by matching the HS6 rates to the full set of national tariff-line product codes in HS 2022.[36]

Additional changes are incorporated by hand-coding all measures from the relevant legal documents (Federal Register in the United States and equivalent national sources abroad). Finally, we update baseline tariffs by including all available MFN and preferential rates for the United States, China, EU27, India, Turkey, Mexico, Canada, and Russia. Following Teti (2024), we draw primarily on MacMap, supplement with WITS, and use HTS for the United States to fill any remaining gaps in MFN and preferential tariffs. For potentially missing tariffs, we apply the algorithm developed by Teti (2024).

Applying this methodology, we obtain for each U.S. trading partner (China, EU27, India, Turkey, Mexico, Canada, and Russia) tariff levels and their changes at the national tariff-line level: for 2017–2021 in HS 2017 and for 2022–2025 (through August 15)

[35] The full set of tariff lines is obtained using the product codes contained in the MFN and preferential tariff files from MacMap, following the download procedure described in Teti (2024).

[36] The full set of tariff lines is obtained using the product codes contained in the MFN and preferential tariff files from MacMap, following the download procedure described in Teti (2024). For the United States, the full set of tariff lines is obtained using the product codes available on the HTS website (`https://hts.usitc.gov/`).

in HS 2022. To construct a single long time series, we aggregate both datasets to the HS6 level and convert the 2022–2025 data back into HS 2017. At this harmonized HS6 level, the data can be combined with the GTD from Teti (2024), to include initial tariff schedules for all other countries.

A.5 Examples of U.S. Import Tariffs

This subsection illustrates how U.S. tariff instruments combine in practice by tracing the tariff evolution for three HS6 products across different trading partners. Figure A.1 presents the case of small passenger cars (HS 8703.22) between 2018 and 2025.

For China, tariffs escalated in several steps. During the first Trump administration, Chinese cars were already subject to a 25% duty under Section 301. In early 2025, ad-

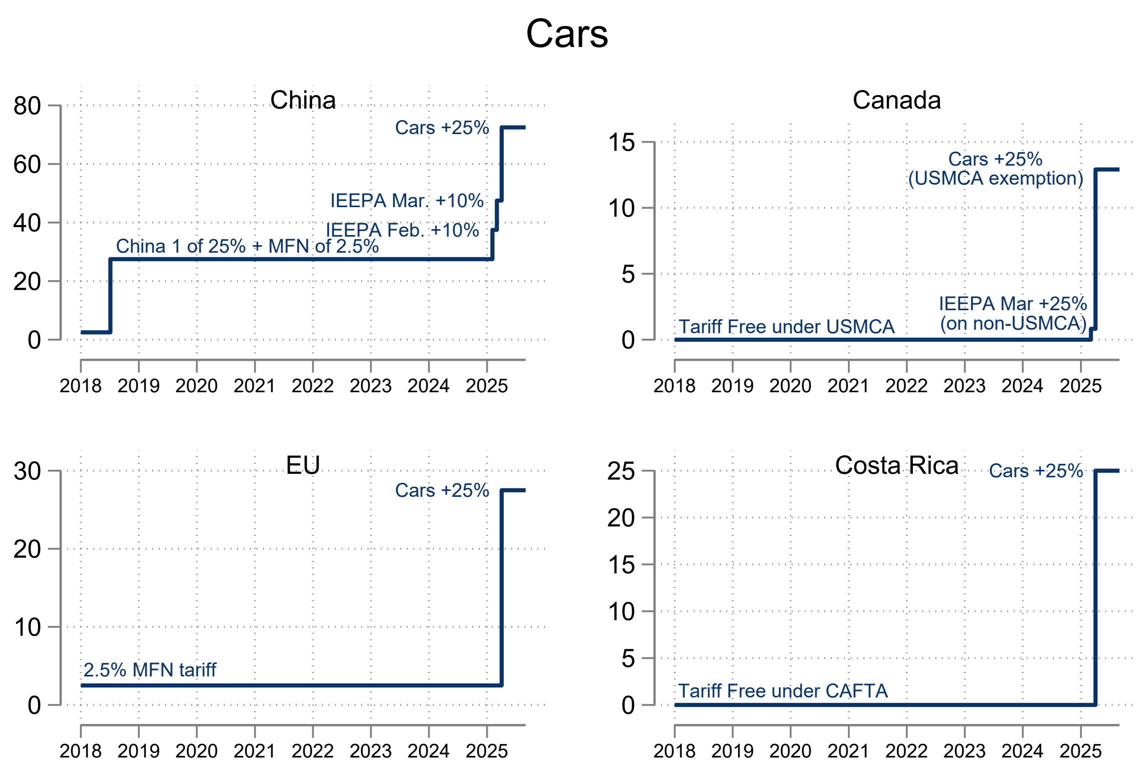


Figure A.1: U.S. import tariffs on passenger cars (HS 8703.22: gasoline cars with 1.0–1.5 liter engines), 2018–2025. Panels report tariff paths separately for imports from China, Canada, the European Union, and Costa Rica.

ditional duties were layered on through the International Emergency Economic Powers Act (IEEPA), with a 10% surcharge in February followed by another 10% in March. Finally, beginning on April 3, 2025, automobiles were explicitly designated as a Section 232 product and faced an additional 25% duty. Because Section 232 tariffs do not stack with Liberation Day or reciprocal tariffs, this 25% duty represents the final layer of escalation for China.

For Canada, both the IEEPA "fentanyl" tariffs and the Section 232 automobile tariffs are, in principle, applicable. In practice, however, most imports are USMCA-compliant. As a result, the effective tariff rose only marginally—from zero under USMCA preferences to 0.8% in March 2025, when the IEEPA rate of 25% took effect but applied solely to non-USMCA-compliant vehicles. Under Section 232, Canadian automobiles benefit from a special exemption: USMCA-compliant vehicles are taxed only on their non-U.S. content, with the 25% duty applied proportionally. Based on industry estimates, we assume Canadian vehicles contain 50% U.S. content, which implies an effective Section 232 tariff of 12.5% on compliant imports. Non-compliant vehicles, by contrast, face the full 25% duty. In August 2025, the IEEPA rate on Canada increased from 25% to 35%. Because Section 232 and IEEPA tariffs are not stacked for Canada (or Mexico), this change did not affect the effective rate on automobiles.

For the European Union and Costa Rica, the tariff path is simpler: both face only the Section 232 automobile duty introduced in April 2025. The difference in final tariff levels stems from differences in baseline tariffs. Costa Rica enters duty-free under CAFTA, so the Section 232 tariff applies on top of a zero baseline, yielding a final rate of 25%. By contrast, the E.U. begins from the MFN duty of 2.5%, so the Section 232 duty raises the total tariff burden to 27.5%.

One further complication arises from the E.U.'s announced "15–MFN" deal. Publicly framed as a major concession, this arrangement capped U.S. reciprocal tariffs at 15% minus the prevailing MFN rate. Although the agreement in principle formally covered only reciprocal tariffs, cars were also presented in public statements as falling under its scope. For automobiles, such a formula would imply an effective tariff of 15%.[37] Yet, despite its political salience, the provision had not been incorporated into the U.S. tariff schedule as of August 15th, and the carve-out for automobiles remains legally unimplemented. Accordingly, we do not reflect the 15-MFN adjustment in our dataset.

Figure A.2 depicts U.S. tariffs on cold-rolled steel coils (HS 7209.15) from 2018 to 2025 across four trading partners.

For China, steel was subject to multiple overlapping measures. A 25% Section 232 duty took effect in March 2018, followed later that year by additional Section 301 tariffs. The 2020 trade truce temporarily reduced the burden by 7.5%, but this proved short-lived.

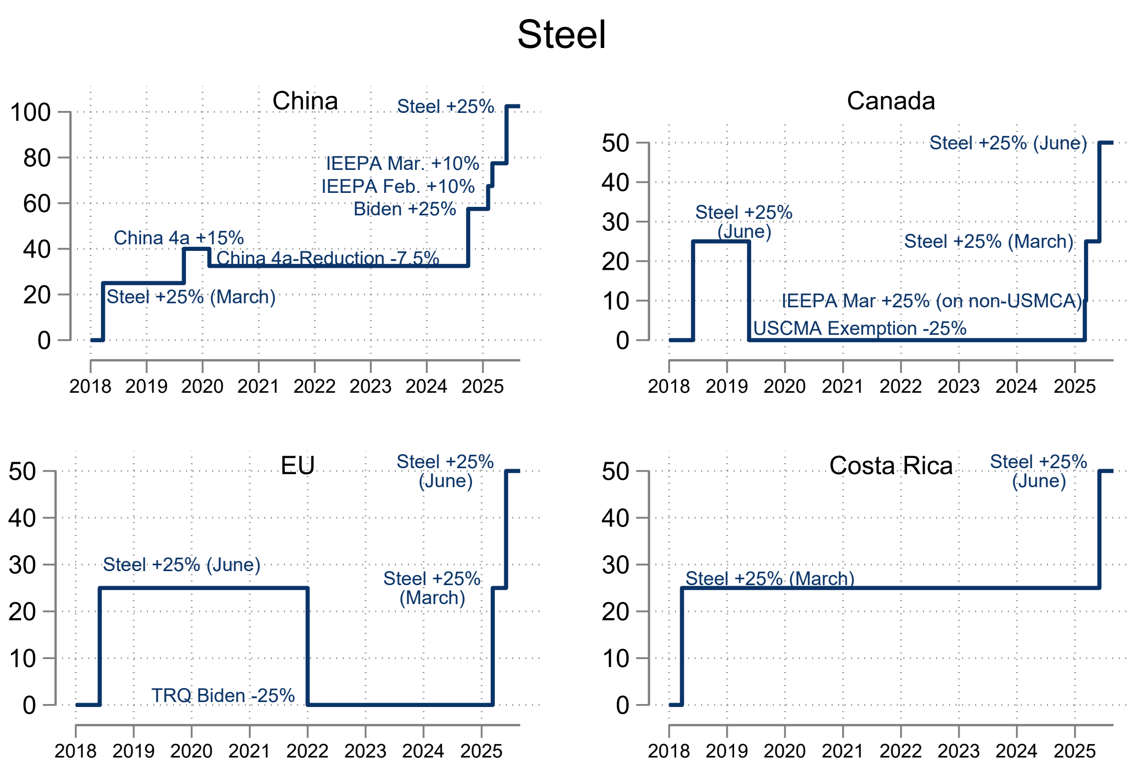


Figure A.2: U.S. import tariffs on cold-rolled steel coils (HS 7209.15: non-alloy steel, 0.5–1 mm thick) across selected trade partners, 2018–2025. Panels report tariff paths separately for imports from China, Canada, the European Union, and Costa Rica.

[37] 2.5% MFN + 12.5% reciprocal tariff.

In September 2024, the Biden administration imposed an additional 25% duty. In early 2025, successive IEEPA surcharges (+10% in February and March) combined with the Section 232 duty lifted the effective tariff above 100%, as IEEPA and Section 232 measures were applied cumulatively.

For Canada, Section 232 tariffs were first imposed in June 2018 but were lifted in May 2019 as part of the resolution of the NAFTA renegotiation and the finalization of the USMCA. In March 2025, Canada became subject to a 25% IEEPA duty, though this applied only to non-USMCA-compliant imports. In the same month, Section 232 duties on steel were reinstated. Unlike the automobile sector—where USMCA rules limit the tariff base to non-U.S. content—there is no comparable exemption for steel. Canadian steel exports were therefore fully subject to Section 232, and the subsequent increase to 50% in June 2025 applied in full.

For the European Union and Costa Rica, steel imports were affected only by Section 232. The EU initially faced the global 25% duty introduced in March 2018, but this was suspended under the tariff-rate quota (TRQ) arrangement negotiated by the Biden administration, which effectively removed the tariff in early 2022. With the expiration of the TRQ in March 2025, the Section 232 duty returned in full and was raised to 50% in June 2025. Costa Rica, by contrast, never benefited from the TRQ arrangement and therefore faced the global Section 232 duty continuously from March 2018, rising from 25% to 50% in June 2025.

Figure A.3 plots U.S. tariffs on photovoltaic cells and solar panels (HS 8541.40) between 2018 and 2025 for China, the European Union, Canada, and Costa Rica. The 30% safeguard duty introduced in 2018 applied only to 4 of the 9 tariff lines within this HS6 category; as a result, the figure reports the simple average across all lines, yielding an effective initial rate of 13.3%.

For China, tariffs accumulated rapidly. An initial safeguard duty averaging 13.3% was imposed in February 2018, with scheduled annual reductions. On top of this baseline,

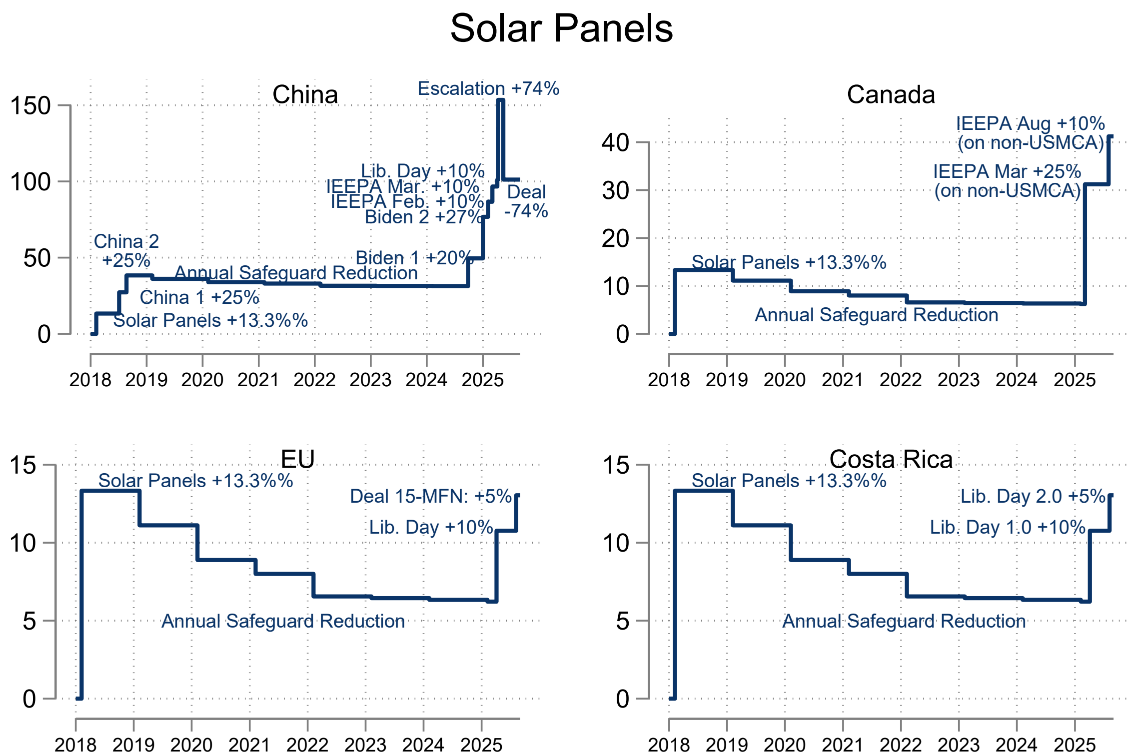


Figure A.3: U.S. import tariffs on photovoltaic cells and solar panels (HS 8541.40) across selected trade partners, 2018–2025. Panels report tariff paths separately for imports from China, Canada, the European Union, and Costa Rica. The tariff changes shown in the figure do not align exactly with the policy announcements described in the text. This discrepancy reflects aggregation bias: (i) only 4 of the 9 tariff lines within the HS6 product were subject to the safeguard duties, and (ii) the product code shifted with the transition from HS 2017 to HS 2022 nomenclature.

China-specific Section 301 tariffs added 25%, followed in September 2024 by a further 20% duty under the Biden administration. In early 2025, IEEPA measures contributed an additional 10% in February and another 10% in March. The Liberation Day measures in April 2025 triggered a sharp escalation of additional 84%, but this was short-lived: under the bilateral deal reached in May, both the reciprocal and Liberation Day tariffs were rolled back.

For Canada, the same safeguard duties applied starting in early 2018, with scheduled annual reductions. In March 2025, Canada became subject to a 25% IEEPA duty on non-USMCA-compliant imports, which was raised to 35% in August. Canadian solar panel imports in 2017–2018 were not USMCA-compliant, and we treat supply chains as fixed over time. Hence Canadian exporters could not adjust to qualify for USMCA preferences, and the IEEPA duties apply in full.

Until 2025, imports from the European Union and Costa Rica were subject only to safeguard duties. In April 2025, both partners became subject to the Liberation Day tariffs. The 10% flat duty entered into force in early April, followed on August 7 by new reciprocal tariffs. For the E.U., this implied an additional 5% duty, bringing the total tariff to 15%, consistent with the 15%-MFN rate agreed under the US–EU deal. For Costa Rica, the applicable rate was likewise 15%, as the country did not negotiate a new agreement

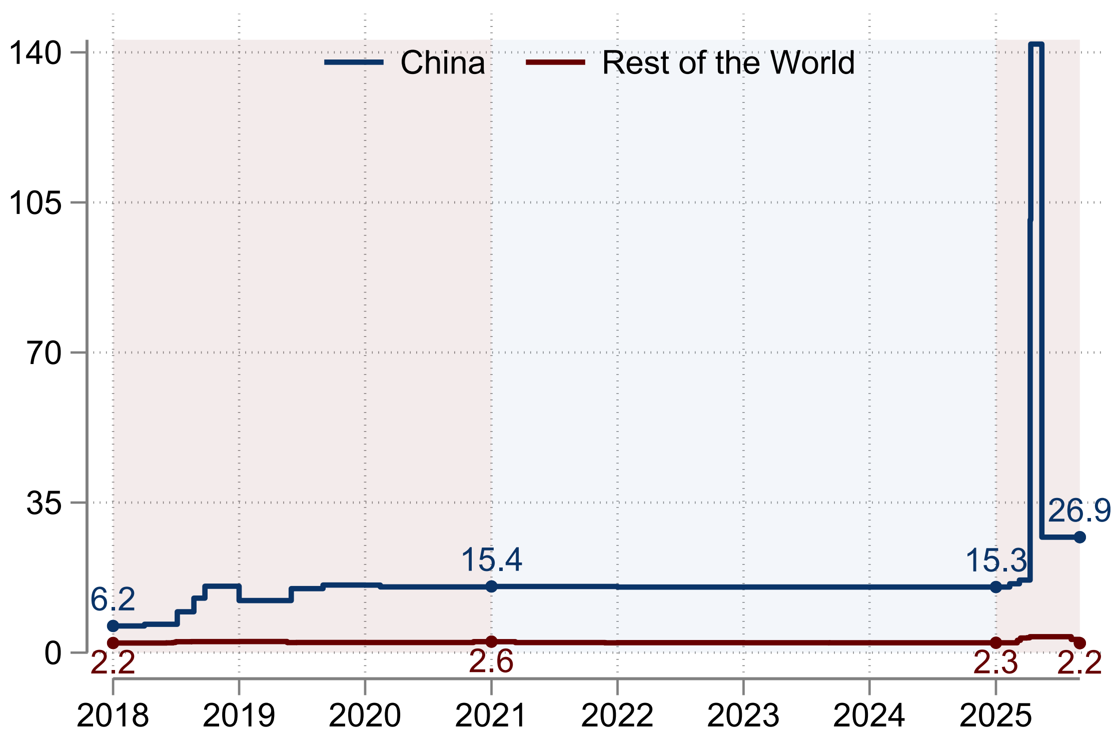


Figure A.4: This figure shows the trade-weighted average daily tariffs (in pp.) that the United States faced between January 1st, 2018 and August 15th, 2025 by trading partner. MFN and preferential tariff rates are from Teti (2024). U.S. tariff rates imposed during the first Trump Administration are from Bown (2021). All other tariff rates were hand-coded based on U.S. Federal Register notices and national legal texts. Trade weights are constructed from CEPII's BACI bilateral trade flows for the year 2017 (Gaulier and Zignago, 2010).

with the United States and instead remained subject to the reciprocal tariff announced in April but suspended for 90 days.

B Additional Details on Data Construction

Our data construction (for all variables except tariffs) follows steps similar to those in Rodriguez-Clare, Ulate, and Vasquez (2025) (RUV) and Ulate, Vasquez, and Zarate (2025) (UVZ), but for an extended list of countries. The most recent data available for calibrating our quantitative model is from 2020. To avoid complications from the COVID-19 shock, we use data from 2019 and assume that the relative sizes of each country, state, and sector closely approximate those in 2024. In this sense is that we consider 2024 as our baseline year. Here we provide a summary of the main features of the data construction and refer the reader to the Online Appendix in RUV for further details.

B.1 Sectors and Countries Used in the Quantitative Analysis

List of sectors. We use a total of 14 market sectors. The list includes 12 manufacturing sectors, one catch-all services sector, and one agriculture sector. We follow RUV and UVZ in the selection of the 12 manufacturing sectors. These are: **1)** Food, beverage, and tobacco products (NAICS 311-312, ICIO sector D10T12); **2)** Textile, textile product mills, apparel, leather, and allied products (NAICS 313-316, ICIO sector D13T15); **3)** Wood products, paper, printing, and related support activities (NAICS 321-323, ICIO sectors D16, D17T18); **4)** Mining, petroleum and coal products (NAICS 211-213, 324, ICIO sectors D05T06, D07T08, D09, D19); **5)** Chemicals (NAICS 325, ICIO sectors D20, D21); **6)** Plastics and rubber products (NAICS 326, ICIO sector D22); **7)** Nonmetallic mineral products (NAICS 327, ICIO sector D23); **8)** Primary metal and fabricated metal products (NAICS 331-332, ICIO sectors D24, D25); **9)** Machinery (NAICS 333, ICIO sector D28); **10)** Computer and electronic products, and electrical equipment and appliance (NAICS

334-335, ICIO sectors D26, D27); **11)** Transportation equipment (NAICS 336, ICIO sectors D29, D30); **12)** Furniture and related products, and miscellaneous manufacturing (NAICS 337-339, ICIO sector D31T33). There is a **13)** Services sector which includes Construction (NAICS 23, ICIO sector D41T43); Wholesale and retail trade sectors (NAICS 42-45, ICIO sectors D45T47); Accommodation and Food Services (NAICS 721-722, ICIO sector D55T56); transport services (NAICS 481-488, ICIO sectors D49-D53); Information Services (NAICS 511-518, ICIO sectors D58T60, D61, D62T63); Finance and Insurance (NAICS 521-525, ICIO sector D64T66); Real Estate (NAICS 531-533, ICIO sector D68); Education (NAICS 61, ICIO sector D85); Health Care (NAICS 621-624, ICIO sector D86T88); and Other Services (NAICS 493, 541, 55, 561, 562, 711-713, 811-814, ICIO sectors D69T75, D77T82, D90T93, D94T96, D97T98). Finally, there is an **14)** agriculture sector (ICIO sectors D01T02, D03).

List of countries: We use data for 50 U.S. states, 59 other countries, and a constructed rest of the world (for a total of 110 regions). The list of countries is: Argentina (ARG), Australia (AUS), Austria (AUT), Belgium (BEL), Brazil (BRA), Bulgaria (BGR), Cambodia (KHM), Canada (CAN), Chile (CHL), China (CHN), Colombia (COL), Costa Rica (CRI), Croatia (HRV), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), India (IND), Indonesia (IDN), Ireland (IRL), Israel (ISR), Italy (ITA), Japan (JPN), Kazakhstan (KAZ), Laos (LAO), Latvia (LVA), Lithuania (LTU), Malaysia (MYS), Mexico (MEX), Morocco (MAR), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Peru (PER), Philippines (PHL), Poland (POL), Portugal (PRT), Romania (ROU), Russia (RUS), Saudi Arabia (SAU), Singapore (SGP), Slovakia (SVK), Slovenia (SVN), South Africa (ZAF), South Korea (KOR), Spain (ESP), Sweden (SWE), Switzerland (CHE), Taiwan (TWN), Thailand (THA), Tunisia (TUN), Turkey (TUR), United Kingdom (GBR), Vietnam (VNM), and the rest of the world (RoW).

B.2 Data for the Construction of the Bilateral Trade Flows

For bilateral trade between countries, we use the OECD's Inter Country Input Output (ICIO) Database. For data on bilateral trade in manufacturing between U.S. states, we combine the Commodity Flow Survey (CFS) with the ICIO database. The CFS records shipments between U.S. states for 43 commodities classified according to the Standard Classification of Transported Goods (SCTG). We follow Caliendo et al. (2019) and Stumpner (2019) and use CFS tables that cross-tabulate establishments by their assigned NAICS codes against SCTG commodities shipped by establishments within each NAICS code.

For data on bilateral trade in manufacturing and agriculture between U.S states and the rest of the countries, we follow RUV and obtain sector-level imports and exports between the 50 U.S. states and the list of other countries from the Import and Export Merchandise Trade Statistics database, which is compiled by the U.S. Census Bureau.

For data on services and agriculture expenditure and production, we use U.S. state-level services GDP from the Regional Economic Accounts of the Bureau of Economic Analysis (BEA), U.S. state-level services expenditure from the Personal Consumption Expenditures (PCE) database of BEA and total production and expenditure in services from ICIO (for other countries). We also use the Agricultural Census and the National Marine Fisheries Service Census to get state-level production data on crops, livestock, and seafood. For other countries, we compute production and expenditure in agriculture from ICIO.

For data on sectoral and regional value-added shares in gross output, we use data from the Bureau of Economic Analysis (BEA) by subtracting taxes and subsidies from GDP data. In the cases when gross output was smaller than value added, we constrain value added to be equal to gross output. For the list of other countries, we obtain the share of value added in gross output using data on value added and gross output data from ICIO.

B.3 Data on Employment and Labor Flows

For the case of countries, we take data on employment by country and sector from the WIOD Socio Economic Accounts (WIOD-SEA) and the International Labor Organization (ILO). For the case of U.S. states, we take sector-level employment (including unemployment and non-participation) from a combination of the Census and the American Community Survey (ACS). As in RUV and UVZ, we only keep observations with ages between 25 and 65, who are either employed, unemployed, or out of the labor force. We construct a matrix of migration flows between sectors within each U.S. state using the Current Population Survey (CPS). Finally, we abstract from international migration and migration between U.S. states.

C Model Equations

The model economy comprises multiple regions (indexed by i or j). There are M regions inside the U.S. (the 50 U.S. states), plus $I - M$ regions (countries) outside of the U.S. (for a total of I regions). We assume that there is no labor mobility across different countries but can allow for mobility across different states of the U.S. There are $S + 1$ sectors in the economy (indexed by s or k), with sector zero denoting the home-production sector and the remaining S sectors being productive market sectors. In each region j and period t, a representative consumer participating in the market economy devotes all income to expenditure $P_{j,t}C_{j,t}$, where $C_{j,t}$ and $P_{j,t}$ are aggregate consumption and the price index respectively. Aggregate consumption is a Cobb-Douglas aggregate of consumption across the S different market sectors with expenditure shares $\alpha_{j,s}$. As in a multi-sector Armington trade model, consumption in each market sector is a CES aggregate of consumption of the good of each of the I regions, with an elasticity of substitution $\sigma_s > 1$ in sector s.

Each region produces the good in sector s with a Cobb-Douglas production function, using labor with share $\phi_{j,s}$ and intermediate inputs with shares $\phi_{j,ks}$, where $\phi_{j,s} +$

$\sum_k \phi_{j,ks} = 1$. TFP in region j, sector s, and time t is $A_{j,s,t}$. There is perfect competition and iceberg trade costs $\tau_{ij,s,t} \geq 1$ for exports from i to j in sector s. Additionally, there are ad valorem tariffs $t_{ij,s,t}$ imposed by country j on imports from country i in sector s at time t. Intermediates from different origins are aggregated in the same way as consumption goods. Letting $W_{i,s,t}$ denote the wage in region i, sector s, at time t, the price in region j of good s produced by region i at time t is then

$$p_{ij,s,t} = \tau_{ij,s,t}(1 + t_{ij,s,t}) A_{i,s,t}^{-1} W_{i,s,t}^{\phi_{i,s}} \prod_k P_{i,k,t}^{\phi_{i,ks}}, \tag{C1}$$

where $P_{i,k,t}$ is the price index of sector k in region i at time t. Given our Armington assumption, these price indices satisfy

$$P_{j,s,t}^{1-\sigma_s} = \sum_{i=1}^{I} p_{ij,s,t}^{1-\sigma_s}, \tag{C2}$$

with corresponding trade shares

$$\lambda_{ij,s,t} \equiv \frac{p_{ij,s,t}^{1-\sigma_s}}{\sum_{r=1}^{I} p_{rj,s,t}^{1-\sigma_s}}. \tag{C3}$$

As mentioned in the main text, it is important to keep track of the revenue that different regions obtain from tariffs. Within the United States, we have the added problem that the tariff revenue collected by a U.S. state might not stay in that state, but might instead be transferred to the federal government that later redistributes that income to other states (in a way that is not necessarily proportional to the amount of tariff revenue they collect themselves). In order to flexibly model this, we assume that the total tariff revenue received by region i at time t is given by:

$$TRR_{i,t} = \sum_j \theta_{ji} TRC_{j,t},$$

where $TRC_{j,t}$ is the tariff revenue collected by region j at time t and θ_{ji} is the (time invariant) share of its tariff revenue that region j sends to region i. The only constrain on these shares is that they need to add to one for a giver sender region when summing across all the receiving regions, i.e. $\sum_i \theta_{ji} = 1 \quad \forall j$. In our quantitative implementation, we will assume that tariff revenue collected is redistributed within the United States according to the share of the population that a given state represents.

In turn, the total revenue collected by region j, $TRC_{j,t}$, is given by:

$$TRC_{j,t} = \sum_s \sum_i \frac{t_{ij,s,t}}{1+t_{ij,s,t}} \lambda_{ij,s,t} EXP_{j,s,t} = \sum_s \psi_{j,s,t} EXP_{j,s,t},$$

where $EXP_{j,s,t}$ is the total expenditure of region j in sector s at time t, including purchases by final consumers and intermediate good purchases, and $\psi_{j,s,t}$ is the share of expenditure in (j,s,t) that is collected as tariff revenue, defined as $\psi_{j,s,t} \equiv \sum_i t_{ij,s,t}/(1+t_{ij,s,t})\lambda_{ij,s,t}$.

Let $R_{i,s,t}$ and $L_{i,s,t}$ denote total revenues and employment in sector s of country i, respectively. Noting that the demand of industry k of country j of intermediates from sector s is $\phi_{j,sk} R_{j,k,t}$ and allowing for exogenous deficits (where $D_{j,t}$ is used to denote the transfers received by region j at time t, with $\sum_j D_{j,t} = 0$), we know that total expenditure by region j in sector s at time t is given by:

$$EXP_{j,s,t} = \alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} + TRR_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t}.$$

Introducing the last two equations into the equation for TRR as a function of TRC and rearranging, we get:

$$\begin{aligned} TRR_{i,t} &= \sum_j \theta_{ji} \sum_s \psi_{j,s,t} \left[\alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} + TRR_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right] \\ &= \sum_j \theta_{ji} \sum_s \psi_{j,s,t} \alpha_{j,s} TRR_{j,t} \end{aligned}$$

$$+ \quad \sum_j \theta_{ji} \sum_s \psi_{j,s,t} \left[\alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right]. \tag{C4}$$

In matrix notation, we can write this as:

$$TRR \;=\; \Theta \Psi A TRR + \Theta \Psi \left[AY + \Phi R \right],$$

where Θ, Ψ, A, and Φ are all matrices whose definitions should be clear from context, Y is a vector that contains as its j-th entry the element:

$$Y_{j,t} = \sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t},$$

and R is a large vector made up of S sectorial vectors, each of which contains as its j-th entry the value of $R_{j,s,t}$. Therefore, we can finally solve for TRR as:

$$TRR \;=\; (\text{eye}(I) - \Theta \Psi A)^{-1} \Theta \Psi \left[AY + \Phi R \right],$$

where $\text{eye}(I)$ is an identity matrix of size I (i.e., the number of regions).

The market clearing condition for sector s in country i can be written as:

$$R_{i,s,t} \;=\; \sum_{j=1}^{I} \frac{\lambda_{ij,s,t}}{1 + t_{ij,s,t}} \left(\alpha_{j,s} \left(\sum_{s=1}^{S} W_{j,s,t} L_{j,s,t} + D_{j,t} + TRR_{j,t} \right) + \sum_{k=1}^{S} \phi_{j,sk} R_{j,k,t} \right). \tag{C5}$$

In matrix notation this becomes:

$$R \;=\; \tilde{\Lambda} \left[A \left(Y + TRR \right) + \Phi R \right],$$

where $\tilde{\Lambda}$ is a matrix whose definition should be clear from the context. Multiplying through and introducing the expression for TRR we obtain:

$$\begin{aligned} R &= \tilde{\Lambda}A\left(\text{eye}(I) + (\text{eye}(I) - \Theta\Psi A)^{-1}\Theta\Psi A\right)Y \\ &+ \tilde{\Lambda}\left(A(\text{eye}(I) - \Theta\Psi A)^{-1}\Theta\Psi + \text{eye}(I \cdot S)\right)\Phi R \end{aligned}$$

So we can finally solve for the revenue vector using the following matrix expression:

$$\begin{aligned} R &= \left[\text{eye}(I \cdot S) - \tilde{\Lambda}\left[A(\text{eye}(I) - \Theta\Psi A)^{-1}\Theta\Psi + \text{eye}(I \cdot S)\right]\Phi\right]^{-1} \\ &\cdot \tilde{\Lambda}A\left[\text{eye}(I) + (\text{eye}(I) - \Theta\Psi A)^{-1}\Theta\Psi A\right]Y. \end{aligned}$$

While this is a massive and notationally cumbersome matrix equation, it is linear and allows us to solve our complex trade and reallocation model with an input-output structure and flexible tariff revenue redistribution in a very computationally efficient manner.

Employment must be compatible with labor demand, which imposes another equilibrium equation given by:

$$W_{i,s,t}L_{i,s,t} = \phi_{i,s}R_{i,s,t}. \tag{C6}$$

Agents can either engage in home production or look for work in the labor market. If they participate in the labor market, they can be employed in any of the S market sectors. We let $c_{i,0,t}$ denote consumption associated with home production in region i, and $c_{i,s,t}$ denote consumption associated with seeking employment in sector s and region i at time t. We assume that $c_{i,0,t}$ is exogenous and does not vary over time, while—as explained further below—$c_{i,s,t}$ is endogenous and depends on real wages, unemployment, and tariff revenue. Additionally, we denote the number of agents participating in region i, sector s, at time t, by $\ell_{i,s,t}$.

Agents are forward looking and face a dynamic problem where they discount the future at rate β. Relocation decisions are subject to sectoral and spatial mobility costs.

Specifically, there are costs $\varphi_{ji,sk}$ of moving from region j, sector s to region i, sector k. These costs are time invariant, additive, and measured in terms of utility. Additionally, agents have additive idiosyncratic shocks for each choice of region and sector, denoted by $\epsilon_{i,s,t}$.

An agent that starts in region j and sector s observes the economic conditions in all labor markets and the idiosyncratic shocks, then earns real income $c_{j,s,t}$ and has the option to relocate. The lifetime utility of an agent who is in region j, sector s, at time t, is then:

$$\mathrm{v}_{j,s,t} = \ln(c_{j,s,t}) + \max_{\{i,k\}_{i=1,k=0}^{I,S}} \{\beta \mathbb{E}(\mathrm{v}_{i,k,t+1}) - \varphi_{ji,sk} + \epsilon_{i,k,t}\}.$$

We assume that the joint density of the vector ϵ at time t is a nested Gumbel:

$$F(\boldsymbol{\epsilon}) = \exp\left(-\sum_{i=1}^{I}\left(\sum_{k=0}^{S}\exp\left(-\epsilon_{i,k,t}/\nu\right)\right)^{\nu/\kappa}\right),$$

where $\kappa > \nu$. This allows us to have different elasticities of moving across regions and sectors. Let $V_{j,s,t} \equiv \mathbb{E}(\mathrm{v}_{j,s,t})$ be the expected lifetime utility of a representative agent in labor market j, s. Then, using γ to denote the Euler-Mascheroni constant, we have

$$V_{j,s,t} = \ln(c_{j,s,t}) + \ln\left(\sum_{i=1}^{I}\left(\sum_{k=0}^{S}\exp\left(\beta V_{i,k,t+1} - \varphi_{ji,sk}\right)^{1/\nu}\right)^{\nu/\kappa}\right)^{\kappa} + \gamma\kappa. \tag{C7}$$

Denote by $\mu_{ji,sk|i,t}$ the number of agents that relocate from market js to ik expressed as a share of the total number of agents that move from js to ik' for any sector k'. Additionally, let $\mu_{ji,s\#,t}$ denote the fraction of agents that relocate from market js to any market in i as a share of all the agents in js. As shown in RUV, these fractions are given by

$$\mu_{ji,sk|i,t} \quad = \quad \frac{\exp\left(\beta V_{i,k,t+1} - \varphi_{ji,sk}\right)^{1/\nu}}{\sum_{h=0}^{S}\exp\left(\beta V_{i,h,t+1} - \varphi_{ji,sh}\right)^{1/\nu}} \tag{C8}$$

$$\mu_{ji,s\#,t} = \frac{\left(\sum_{h=0}^{S} \exp\left(\beta V_{i,h,t+1} - \varphi_{ji,sh}\right)^{1/\nu}\right)^{\nu/\kappa}}{\sum_{m=1}^{I}\left(\sum_{h=0}^{S} \exp\left(\beta V_{m,h,t+1} - \varphi_{jm,sh}\right)^{1/\nu}\right)^{\nu/\kappa}}. \tag{C9}$$

The total number of agents that move from js to ik is given by $\mu_{ji,sk} = \mu_{ji,sk|i,t} \cdot \mu_{ji,s\#,t}$. Participation in the different labor markets evolves according to

$$\ell_{i,k,t+1} = \sum_{j=1}^{I}\sum_{s=0}^{S} \mu_{ji,sk|i,t}\mu_{ji,s\#,t}\ell_{j,s,t} \tag{C10}$$

The aggregate price index in region i at time t is given by:

$$P_{i,t} = \prod_{s=1}^{S} P_{i,s,t}^{\alpha_{i,s}}. \tag{C11}$$

We assume that the income generated in a sector-region is equally shared between all participants in that sector-region. Additionally, the income for agents is not only given by their wage income, but it also includes the tariff revenue received by the region that agents live in. We assume that, within sectors in a region, tariff revenue received (TRR) is split among sectors using labor supply weights. With all of this, the real level of per-capita consumption $c_{i,s,t}$ from participating in market sector s is given by:

$$c_{i,s,t} = \frac{W_{i,s,t}L_{i,s,t} + \frac{\ell_{i,s,t}}{\sum_{k=1}^{S}\ell_{i,k,t}} TRR_{i,t}}{\ell_{i,s,t}P_{i,t}}, \tag{C12}$$

where $P_{i,t}$ is the aggregate price index in region i and $TRR_{i,t}$ is the tariff revenue received by region i at time t.

We denote the number of agents that are actually employed in region i and sector k at time t with $L_{i,k,t}$. In a standard trade model, labor market clearing requires that the labor used in a sector and region be equal to labor supplied to that sector, i.e., $L_{i,k,t} = \ell_{i,k,t}$. We depart from this assumption and instead follow Schmitt-Grohe and Uribe (2016) by allowing for downward nominal wage rigidity, which might lead to an employment level that is strictly below labor supply,

$$L_{i,k,t} \leq \ell_{i,k,t}. \tag{C13}$$

All prices and wages up to now have been expressed in U.S. dollars. In contrast, a given region faces DNWR in terms of its local currency unit. Letting $W^{LCU}_{i,k,t}$ denote nominal wages in local currency units, the DNWR takes the following form:

$$W^{LCU}_{i,k,t} \geq \delta_k W^{LCU}_{i,k,t-1}, \qquad \delta_k \geq 0.$$

Letting $E_{i,t}$ denote the exchange rate between the local currency unit of region i and the local currency unit of region 1 (which is the U.S. dollar) in period t (in units of dollars per LCU of region i), then $W_{i,k,t} = W^{LCU}_{i,k,t} E_{i,t}$ and so the DNWR for wages in dollars entails

$$W_{i,k,t} \quad \geq \quad \frac{E_{i,t}}{E_{i,t-1}} \delta_k W_{i,k,t-1}.$$

Since all regions within the U.S. share the dollar as their LCU, then $E_{i,t} = 1$ and $W^{LCU}_{i,k,t} = W_{i,k,t} \; \forall \; i \leq M$. This means that the DNWR in states of the U.S. takes the familiar form $W_{i,k,t} \geq \delta_k W_{i,k,t-1}$. For the $I - M$ regions outside of the U.S., the LCU is not the dollar, so the exchange-rate behavior impacts how the DNWR affects the real economy. The DNWR in dollars can then be captured using a country-specific parameter $\delta_{i,k}$, i.e.:

$$W_{i,k,t} \geq \delta_{i,k} W_{i,k,t-1}, \qquad \delta_{i,k} \geq 0. \tag{C14}$$

The baseline model assumes that regions outside of the U.S. have a flexible exchange rate with respect to the U.S. (so the DNWR never binds for other countries).[38] This is captured

[38]Changing to a specification where other countries have fixed exchange rates with respect to the United States has small implications for U.S. outcomes.

by setting $\delta_{i,k} = \delta_k \; \forall \; i$. There is also a complementary slackness condition,

$$(\ell_{i,k,t} - L_{i,k,t})(W_{i,k,t} - \delta_{i,k} W_{i,k,t-1}) = 0. \tag{C15}$$

So far, we have introduced nominal elements to the model (i.e., the DNWR), but we have not introduced a nominal anchor that prevents nominal wages from rising so much in each period as to make the DNWR always non-binding. We now want to capture the general idea that central banks are unwilling to allow inflation to be too high because of its related costs. In traditional macro models, this is usually implemented via a Taylor rule, where the policy rate reacts to inflation. Instead, we use a nominal anchor that captures a similar idea in a way that naturally lends itself to quantitative implementation in our trade model. A similar nominal anchor is used in Guerrieri et al. (2021), albeit in the context of a static, closed economy model. In particular, we assume that world nominal GDP in dollars grows at a constant rate γ every year,

$$\sum_{i=1}^{I} \sum_{k=1}^{K} W_{i,k,t} L_{i,k,t} = (1+\gamma) \sum_{i=1}^{I} \sum_{k=1}^{K} W_{i,k,t-1} L_{i,k,t-1}. \tag{C16}$$

The main benefit of this nominal anchor assumption is that it allows us to solve our otherwise-unwieldy model using a fast contraction-mapping algorithm in the spirit of Alvarez and Lucas (2007) that we develop to deal with the complementary slackness condition brought by the DNWR.

Following Caliendo et al. (2019), we can think of the full equilibrium of our model in terms of a temporary equilibrium and a sequential equilibrium. In our environment with DNWR, given last period's nominal world GDP ($\sum_{i=1}^{I} \sum_{s=1}^{S} W_{i,s,t-1} L_{i,s,t-1}$), wages $\{W_{i,s,t-1}\}$, and the current period's labor supply $\{\ell_{i,s,t}\}$, a temporary equilibrium at time t is a set of nominal wages $\{W_{i,s,t}\}$, employment levels $\{L_{i,s,t}\}$, revenues $\{R_{i,s,t}\}$, bilateral trade shares $\{\lambda_{ij,s,t}\}$, tariff revenues received $\{TRR_{i,t}\}$, sectoral aggregate prices $\{P_{i,s,t}\}$, and bilateral prices $\{p_{ij,s,t}\}$ such that equations (C1)-(C6) and (C13)-(C16) hold. In turn, given starting world nominal GDP ($\sum_{i=1}^{I}\sum_{s=1}^{S} W_{i,s,0}L_{i,s,0}$), labor supply $\{\ell_{i,s,0}\}$, and wages $\{W_{i,s,0}\}$, a sequential equilibrium is a sequence for the aforementioned endogenous variables in the temporary equilibrium plus the variables $\{c_{i,s,t},\ V_{i,s,t},\ \mu_{ji,sk|i,t},\ \mu_{ji,s\#,t},\ \ell_{i,s,t},$ $P_{i,t}\}_{t=1}^{\infty}$ such that: (i) at every period t $\{W_{i,s,t}, L_{i,s,t}, R_{i,s,t}, \lambda_{ij,s,t}, TRR_{i,t}, P_{i,s,t}, p_{ij,s,t}\}$ constitute a temporary equilibrium given $\sum_{i=1}^{I}\sum_{s=1}^{S} W_{i,s,t-1}L_{i,s,t-1}$, $\{W_{i,s,t-1}\}$, and $\{\ell_{i,s,t}\}$, and (ii) $\{c_{i,s,t}, V_{i,s,t}, \mu_{ji,sk|i,t}, \mu_{ji,s\#,t}, \ell_{i,s,t}, P_{i,t}\}_{t=1}^{\infty}$ satisfy equations (C7)-(C12).

We are interested in obtaining the effects of the tariff shock as it is introduced in an economy that did not previously expect it. In order to do this, we will use the exact hat algebra methodology of Dekle et al. (2007), extended to dynamic settings by Caliendo et al. (2019). Specifically, we use $\hat{x}_t$ to denote the ratio between a relative time difference in the counterfactual economy ($\dot{x}'_t$) and a relative time difference in the baseline economy ($\dot{x}_t$), i.e. $\hat{x}_t = \dot{x}'_t/\dot{x}_t$ for any variable x. Then we compare a counterfactual economy where the knowledge of the tariff shock is unexpectedly introduced in the year 2025 (and agents have perfect foresight about the path of the shock from then on), with a baseline economy where the tariff shock does not occur.

D Additional Exhibits

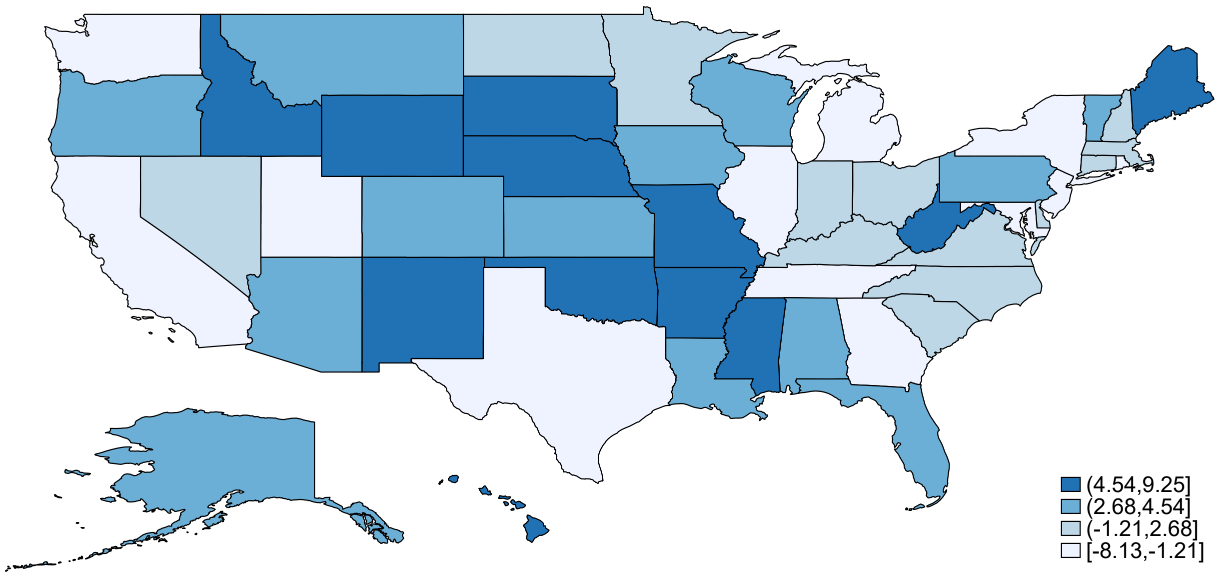


Figure D.1: Map of the welfare change from the shock, in basis points, across U.S. states. The darker the shade of blue, the bigger is the welfare gain (or the smaller is the loss).

Table D.1: U.S. aggregate welfare change (in basis points) across specifications

Panel A: Trade Elasticity		Panel B: Duration		Panel C: Retaliation	
Sigma	Income gain	Years	Income gain	Mirror	Income gain
1.76	6.0803	4*	−0.4892*	0%*	−0.4892*
2.44	4.5842	8	0.6806	33%	−1.1547
3.12	3.3749	12	1.4923	66%	−1.7957
6.00*	−0.4892*	16	2.1184	100%	−2.3747

Notes: This table displays the aggregate U.S. welfare change from the shock, in basis points, across our three alternative specification exercises. Panel A varies the σ parameter governing the trade elasticity, Panel B varies the duration of the shock in years, and Panel C varies the weight put on mirror retaliation as explained in the text. An asterisk denotes the values under the baseline specification, which are $\sigma = 6$, a duration of 4 years, and 0% weight on mirror retaliation (which implies full weight on the retaliation observed in the data which is small to non-existent).