# The Macroeconomic Effects of the U.S.–China Trade War: Tariffs and Retaliation Through Production Networks*

M. Ludovica Ambrosino†
London Business School
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**Abstract**

This paper studies the macroeconomic and distributional effects of the 2017–2019 U.S.–China trade war, tracing how tariffs and counter-tariffs propagate through production networks. I document three empirical findings. First, retaliation reduced employment in exposed industries by about 20% relative to unexposed industries, with no corresponding wage adjustment. Second, these job losses were concentrated among workers in the bottom decile of the earnings distribution. Third, tariff-exposed industries saw no increase in employment or real wages, even as prices rose and real consumption fell. I develop a multi-country, multi-sector New Keynesian model with production networks and household heterogeneity to quantify aggregate outcomes and assess welfare. The model implies that the trade war permanently lowered U.S. GDP by about 0.4% within two years, while financially constrained agents lost almost twice as much as unconstrained ones. A planner concerned with redistribution would have transferred tariff revenue to constrained agents, reducing the welfare cost of the trade conflict by two thirds.

**Keywords:** trade war, tariffs, retaliation, production networks, employment, hand-to-mouth, shift-share, local projections.
**JEL classification:** F13, F14, F16, F62, E24, E32.

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†Contact: Maria Ludovica Ambrosino, London Business School, Regent's Park, London NW1 4SA, United Kingdom; Email:lambrosino@london.edu. Website: marialudovicaambrosino.com.

# 1 Introduction

After decades of falling trade barriers, protectionism has been on the rise since the global financial crisis, and it has brought tariffs back to the centre of economic policy. These measures sit outside the rules of the multilateral trading system, like the World Trade Organization (WTO), and are usually aimed at a single country or a small group of them. The targeted countries tend to respond in kind, with counter-tariffs, and what began as one country's tariff turns into a trade war. As Figure 1 shows, this is a historical pattern: on average, whenever tariffs appear, retaliation appears alongside them. This suggests that the macroeconomic effects of tariffs cannot be fully understood and quantified without studying also the economic impact of any counter-tariff they may have triggered. Yet there is so far little systematic evidence on what counter-tariffs do to the economy that receives them, or on how tariffs and counter-tariffs travel through the production network that carries both. This paper fills that gap by studying the macroeconomic and distributional effects of a trade war with both sides of the conflict traced through the network.

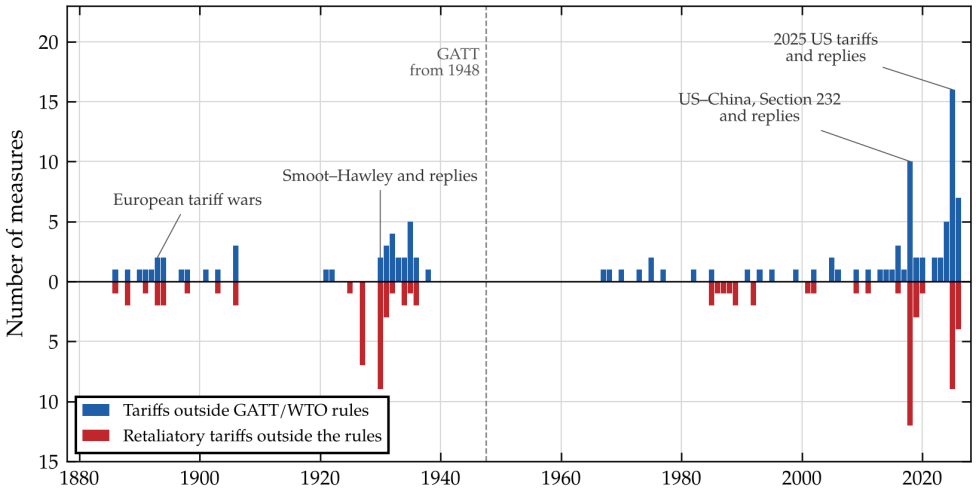



Figure 1: **Tariff wars, 1880–2026.** Number of tariff measures imposed outside the General Agreement on Tariffs and Trade (GATT) or WTO rules (blue, above the axis) and of retaliatory tariffs outside the rules (red, below the axis), by year. The dashed line marks the GATT from 1948. *Source*: Author's dataset of tariffs and retaliatory tariffs, 1880–2026, compiled from historical and official records. US tariff increases follow den Besten, Barnichon, Känzig and Singh (2026, Table A.1). Retaliation against Smoot–Hawley follows Mitchener, Wandschneider and O'Rourke (2022) and Eichengreen and Irwin (2010). Earlier episodes draw on Foreign Relations of the United States (FRUS) and Irwin (2017). GATT/WTO-era episodes draw on GATT/WTO dispute records, the US International Trade Administration's foreign-retaliations records and Bown's PIIE trade-war timeline. Four targeted measures from 2022–25 come from the WTO Trade Monitoring Database..

The 2017–2019 U.S.–China trade war marks an important moment of modern protectionism: the largest increase in U.S. import duties between the 1930s and 2025, answered by the countries it targeted. But did tariffs raise employment, once the counter-tariffs they provoked and their propagation are counted? What did the war cost in the aggregate? And who bore that cost? The answers depend on how far each measure travels along the supply chain. A U.S. car maker, for instance, is exposed to the tariffs directly, through the steel it imports. It is also exposed

indirectly, through the tyres it buys from domestic plants. These plants import steel too, but also synthetic rubber from China, a tariff that reaches the car maker only through the price of its tyres. Retaliation travels the opposite way along the chain. A Chinese tariff on U.S. soybeans cuts the sales of the farms that grow them and, through their purchases, those of the firms that supply them with seed and fertiliser. Through the network, either side of the trade war can reach industries directly or indirectly. The direct link is well documented. The U.S. tariffs passed through almost completely to the prices U.S. buyers paid (Amiti et al., 2019; Fajgelbaum et al., 2020; Cavallo et al., 2021), created no jobs in the industries they protected, and cost little in the aggregate net of their revenue (Fajgelbaum and Khandelwal, 2022). Retaliation has received less attention, and the studies that consider it find modest employment losses in the industries directly hit (Flaaen and Pierce, 2024; Autor et al., 2024). In all of this work, exposure is measured by the share of an industry's own inputs that were taxed, of its own market that was shielded, or of its own exports that met counter-tariffs, so the indirect channel is left out. However, the theory of production networks predicts that a shock to one sector spreads along every supply chain that runs through it (Acemoglu et al., 2012; Baqaee and Farhi, 2019).

To answer these questions, I trace both tariffs and counter-tariffs through the production network, empirically and in a quantitative model. I start by measuring exposure through the full input–output table. Combining the product-level tariff and retaliation schedules with the pre-war table, I follow each tariff forward to the customers of the industries that import and each counter-tariff backward to the suppliers of the industries that export. At the same time, a tariff also raises the price of the imported variety, so buyers may turn to U.S. producers of the taxed products, and I count that possible gain in demand as part of an industry's tariff exposure. However, an industry with many suppliers and large imported-input shares receives a large exposure under any list, and such industries differ from the rest in size and wages. I therefore remove the exposure each industry would have received had each list hit other products of the same country (Borusyak and Hull, 2023). Identification then comes from the timing of the tariffs and counter-tariffs, conditional on fixed effects and expected exposure. I then estimate the effects of the two shocks jointly through local projections (Jordà, 2005) on monthly microdata on trade flows, prices, consumption, employment, hours and earnings.

The paper delivers three main empirical results. The first, and the paper's main contribution, is that retaliation costs jobs: employment in retaliation-exposed industries falls by about 20% relative to unexposed industries within ten months, with no recovery a year later. U.S. exports of retaliated products fell by about 25%, with little redirection towards destinations that did not retaliate, a contraction of the size Fajgelbaum et al. (2020) document for the same episode. Wages did not adjust, so the adjustment took place through employment rather than pay. As exports fell, the prices U.S. exporters received at the border fell with them (Cavallo et al., 2021), and the output that no longer went abroad was sold at home at a lower price: the domestic prices of the retaliated categories fell by about 5%. The lower price did not recover the lost demand; foreign buyers had substituted away from U.S. goods, and exporters could not replace them at home.

Because exposure is measured through the production network, the estimate captures not only the exporters themselves but also their domestic suppliers: when an exporter sells less abroad, it buys less at home, and its suppliers lose demand in turn.

Second, the cost of retaliation was borne by the lowest-paid workers. When I estimate the hours response within each decile of pre-war earnings, the retaliation effect is concentrated entirely in the bottom decile, while the response in deciles two to ten is roughly flat. In the PSID, workers in the bottom decile are disproportionately hand-to-mouth: with little or no liquid wealth, they cannot smooth the loss, which passes directly into their consumption. The trade war therefore increased inequality through employment: every household paid more for tariffed goods, but only the lower end of the earnings distribution lost hours.

Third, the tariffs did not bring jobs back. Employment and real weekly earnings in the industries exposed to the tariffs do not respond: the point estimates are close to zero at every horizon, in line with Flaaen and Pierce (2024) and Autor et al. (2024). This is true whether the tariff is measured by the cost it adds to the industries that use the taxed product or by the sales it brings to the industries that make it: neither side moves employment. This is not because the tariffs had no effect at the border. Imports of tariffed products fell by about 40% within ten months, and only a small fraction of this decline was offset by imports from countries not subject to the tariffs. The prices of the consumption categories exposed to tariffs rose by about 3.5%, while real consumption by about 5%, consistent with the complete pass-through documented at the border (Amiti et al., 2019; Fajgelbaum et al., 2020; Cavallo et al., 2021). Buyers paid more and bought less, but they did not turn to domestic producers in a way that raised domestic employment. The labour-market cost of the trade war was driven not by the tariffs the United States imposed but by those imposed on it.

Finally, as these cross-sectional estimates cannot speak to general-equilibrium effects, I build a multi-country, multi-sector New Keynesian model with the same production network, household heterogeneity, and nominal rigidities in prices and wages. The trade conflict lowers U.S. GDP by about 0.4% within two years, permanently, through employment. Retaliation cuts foreign demand for U.S. agriculture, where employment settles about 4% below its pre-war level, two-thirds of it because of retaliation. Manufacturing, the sector the tariffs were meant to help, ends essentially flat: the cascade of input tariffs and the retaliation on manufactures take back almost all of what the consumer tariff gives. Services, hit by neither tariffs nor retaliation, lose a third of a percent of employment through lower domestic income alone. Further, inequality increases: hand-to-mouth households lose about twice as much consumption as unconstrained households, and the size of the gap depends on who receives the tariff revenue. I then characterise the optimal redistribution of tariff revenue by a planner with redistributive preferences. The allocation of the revenue is the planner's only instrument that alters incidence without altering aggregates: rebating it to hand-to-mouth households lowers the welfare cost of the war by about two-thirds.

**Related literature and contribution.** The paper contributes to three literatures. The first is the empirical work on the 2017–2019 trade war (surveyed in Fajgelbaum and Khandelwal, 2022): near-complete pass-through of the tariffs to U.S. import prices (Amiti et al., 2019; Fajgelbaum et al., 2020; Cavallo et al., 2021), no employment gains in protected industries and losses from retaliation (Flaaen and Pierce, 2024; Autor et al., 2024), and lower local consumption (Benguria and Saffie, 2020; Waugh, 2019). In all of this work the production network enters at most one link deep: exposure is an industry's own tariffed inputs, the protection of its own market and its own retaliated exports (Flaaen and Pierce, 2024), a firm's own imported inputs (Handley et al., 2020), or the China exposure of a firm's direct partners (Huang et al., 2023), and in Autor et al. (2024) the spillovers are geographic rather than through inputs. I measure exposure to both shocks through the full domestic network, reading the Leontief inverse forward for the cost channel and backward for the demand channel, and I am the first to trace retaliation upstream to the suppliers of exporting industries, which is where the employment loss is found. The same design delivers new evidence on who bore the cost. Work on the distributional consequences of trade has focused on the expenditure side, through differences in consumption baskets across the income distribution (Fajgelbaum and Khandelwal, 2016), and evidence for the 2017–2019 war remains limited (Ma et al., 2025). I find that the employment cost of retaliation falls on the bottom of the earnings distribution, among workers who are disproportionately hand-to-mouth (Kaplan et al., 2014): the war was regressive through earnings.

The second is the literature on production networks, in which sectoral shocks become aggregate fluctuations through the Leontief inverse (Acemoglu et al., 2012; Carvalho and Tahbaz-Salehi, 2019) and complementarities between inputs amplify them (Baqaee and Farhi, 2019, 2024). Propagation along supply chains has been estimated for natural disasters (Barrot and Sauvagnat, 2016; Boehm et al., 2019; Carvalho et al., 2021), for conflict (Korovkin and Makarin, 2023) and for trade shocks, where Chinese import competition propagates upstream with network effects larger than the direct ones (Acemoglu et al., 2016) and foreign demand shocks to exporters reach their domestic suppliers (Dhyne et al., 2022). These studies handle the fact that an industry's position determines how much of any shock reaches it with controls for the number of links, control groups several links from the shock, and placebo networks. A trade war allows none of these: exposure is continuous rather than a treatment indicator, and successive waves hit different products at different dates, so expected exposure is time-varying and absorbed by neither fixed effects nor a count of links. I therefore recenter the instruments on counterfactual schedules and conduct inference at the level of the shocks (Borusyak, Hull, and Jaravel, 2022; Borusyak and Hull, 2023; Adão et al., 2019); recentering has so far appeared in this literature as a robustness check (Ferrari, 2023), and here it is the design.

The third is the quantitative literature on tariffs and trade wars. Static general-equilibrium models that use the actual schedule abstract from aggregate demand (Fajgelbaum et al., 2020); New Keynesian models have input–output linkages and retaliation with a representative household (Kalemli-Özcan et al., 2026; Gnocato et al., 2025), or hand-to-mouth households without a network

(Auclert et al., 2025); and multi-sector models with household heterogeneity (Baqaee and Farhi, 2018; Schaab and Tan, 2023; Andreolli et al., 2025) have not been applied to trade policy. This paper brings these elements together, disciplining the model with causal estimates and feeding it the actual calendar of the war. With sticky wages, lost foreign demand becomes lost employment rather than lower wages, which is what separates an aggregate cost of a few hundredths of a percent in market-clearing models from four tenths here, and it is the term on which the planner's answer to the optimal-tariff question (Ossa, 2014; Costinot and Rodríguez-Clare, 2014; Beshkar and Lashkaripour, 2020) turns.

**Outline.** Section 2 describes the data and the policy schedules. Section 3 derives the network exposures from a production-network model, maps them to the data and sets out the identification and the recentering. Section 4 presents the results on trade, prices, consumption, employment, earnings and distributional incidence.[1] Section 5 develops the model, calibrates it to the pre-war baseline and the 2018–2019 implementation calendar and reports the quantitative results, and Section 7 analyses the welfare incidence and characterises the planner's optimal redistribution of tariff revenue. Section 8 concludes.

## 2 Data and Measurement

The empirical analysis combines five data sources, each harmonised into a common BEA industry space so that the policy shock, the trade response, prices and consumption, employment and earnings, and household balance sheets are all measured along the same sectoral partition. The policy shock is built from the statutory tariff and retaliation schedules. Trade flows come from monthly UN COMTRADE, and prices and real consumption from monthly Personal Consumption Expenditures. Employment, hours, and earnings come from the monthly Current Population Survey, and household balance sheets from the Panel Study of Income Dynamics. I describe each source in turn.

### 2.1 Policy shocks

The policy variables come from the statutory tariff and retaliatory-tariff schedules associated with the Section 201, 232 and 301 measures and the corresponding foreign responses. The U.S. lists identify, for each ten-digit Harmonized System (HS10) line and trading partner, the additional *ad valorem* duty and its effective month under each programme. These are the Section 301 lists on China (July, August and September 2018, and September 2019), the Section 232 tariffs on steel and aluminium (March 2018), and the Section 201 safeguards (February 2018); see Table 1, Panel A. The retaliation lists (Table 1, Panel B) identify, for each HS10 line and partner, the effective month of the partner's measure.

[1] The alternative recentering models, the falsification tests and the shift-share inference are in Appendices A and B.

Table 1: **The 2017–2019 U.S. tariff waves and foreign retaliation.** Effective date, statutory basis, products affected, statutory tariff rate, partner targeted, and 2017 trade value (USD billions and share of U.S. total imports).

| Effective | Basis | Products | Rate (%) | Partner | USD bn | % trade |
|---|---|---|---|---|---|---|
| *Panel A. U.S. tariff actions* | | | | | | |
| Feb 2018 | Sec. 201 | Solar PV cells & modules (HS 8541) | 30/15 | World | 8.5 | 0.35 |
| Feb 2018 | Sec. 201 | Large residential washing machines (HS 8450) | 20/50 | World | 1.8 | 0.08 |
| Mar 2018 | Sec. 232 | Steel (HS 7206–7229 & sel. Ch. 73) | 25 | Most countries[a] | 10.2 | 0.42 |
| Mar 2018 | Sec. 232 | Aluminium (HS 7601–7616) | 10 | Most countries[a] | 7.7 | 0.32 |
| Jul 2018 | Sec. 301 | List 1: industrial intermediate & capital goods, machinery, electrical equip., aerospace, medical (818 HS8 lines) | 25 | China | 34.0 | 1.42 |
| Aug 2018 | Sec. 301 | List 2: plastics, chemicals, semiconductors, motorcycles (279 HS8 lines) | 25 | China | 16.0 | 0.67 |
| Sep 2018 | Sec. 301 | List 3: mixed — intermediates (50%), consumer (24%); furniture, lamps, luggage (5,745 HS8) | 10/25 | China | 200.0 | 8.33 |
| Sep 2019 | Sec. 301 | List 4A: apparel, footwear, back-to-school items | 15/7.5 | China | 112.0 | 4.67 |
| *U.S. subtotal* | | | | | **390.2** | **16.3** |
| *Panel B. Foreign retaliation against U.S. exports* | | | | | | |
| Apr 2018 | MOFCOM AD/CVD | Sorghum | 178.6 | China | 1.0 | 0.06 |
| Apr 2018 | MOFCOM 232 ret. | Aluminium scrap, pork, fruits, nuts | 25 | China | 2.4 | 0.16 |
| Jun 2018 | EU rebalancing | Bourbon, motorcycles, jeans, steel/aluminium, peanut butter | 25 | EU | 3.2 | 0.21 |
| Jun 2018 | Mexico 232 ret. | Pork, apples, cheese, bourbon, steel | 15–25 | Mexico | 3.0 | 0.19 |
| Jul 2018 | Canada 232 ret. | Steel, aluminium, agri & consumer products | 25/10 | Canada | 12.8 | 0.83 |
| Jul 2018 | MOFCOM List 1 ret. | Soybeans, autos, lobsters, whiskey | 25 | China | 34.0 | 2.20 |
| Jul 2018 | Russia 232 ret. | Steel-related products | — | Russia | 0.5 | 0.03 |
| Aug 2018 | Turkey 232 ret. | Cars, alcohol, tobacco | — | Turkey | 1.8 | 0.12 |
| Aug 2018 | MOFCOM List 2 ret. | Chemicals, metals, medical devices | 25 | China | 16.0 | 1.03 |
| Sep 2018 | MOFCOM List 3 ret. | Intermediate inputs & capital equipment | 5–10 | China | 60.0 | 3.88 |
| Jun 2019 | MOFCOM List 3 hike | Subset $36 bn of original List 3, rate raised | 25 | China | (36.0)[b] | (2.33) |
| Jun 2019 | India 232 ret. | Almonds, apples, lentils | — | India | 1.4 | 0.09 |
| Sep 2019 | MOFCOM List 4 ret. | Autos plus broad consumer/intermediate basket | 5–25 | China | 75.0 | 4.85 |
| *Retaliation subtotal* | | | | | **211.1** | **13.7** |

*Notes.* Source: PIIE Trump Tariff Tracker. Rate column reports the statutory ad-valorem rate; entries $a/b$ indicate an initial rate $a$ revised to $b$ within the sample. Trade values in 2017 USD bn: imports for Panel A, U.S. exports to the partner for Panel B. The last column is the share of U.S. total 2017 imports (Panel A) and of U.S. total 2017 goods exports, USD 1,546 bn (Panel B). [a] Initial Section 232 exemptions for CAN, MEX, EU, KOR, BRA, ARG, AUS; EU/CAN/MEX added back June 2018; CAN/MEX lifted May 2019. [b] Rate increase on products already counted in the September 2018 List 3 row; not added to the subtotal. Threatened actions that never took effect (Sec. 301 List 4B; Sec. 232 autos; IEEPA Mexico migration) are excluded.

The exposures are built at the six-digit level (HS6), the finest level at which the trade weights and the product-to-industry concordances are available, and an HS6 code typically contains several HS10 lines that entered under different lists, at different dates, or not at all. Rather than dating each code to its first line and assigning it a single statutory rate, I measure the rate its imports actually faced in each month. Using the variety-level import panel in the replication data of Fajgelbaum et al. (2020), I compute, for each partner, HS6 code and month, the mean of the trade-war tariff increase in force across the code's HS10 varieties, weighted by 2017 imports. A code whose varieties were only partly covered, or which entered partly under List 1 at 25 percent and partly under List 3 at 10 percent, therefore carries the weighted rate at each date, and this rate rises as further lines come into force. The retaliation rate is constructed in the same way from the export side of the same data, as the 2017-export-weighted mean across the code's varieties of the retaliatory increase in force, by partner, HS6 code and month.

### 2.2 Trade flows

Trade flows come from the monthly United Nations Comtrade database at the HS6-by-country level for January 2015 to December 2021. Imports are observed by product and source country, and exports by product and destination country. I match these flows directly to the HS6 tariff and retaliation lists, and define the product–country trade balance as exports net of imports. The Comtrade data play two roles in what follows. First, they provide the outcome variable in the direct product-level local projections, where treatment is observed at the HS6 level and the identifying variation is the timing of the tariff waves. Second, I use them to compute pre-war import shares by source country. These provide the country weights that translate product–country policy variation into industry-level exposure, since the BEA input–output table identifies imported inputs only in the aggregate.

### 2.3 Prices and consumption

The expenditure data come from the monthly Personal Consumption Expenditures (PCE) at the category level. For each PCE category, I observe nominal spending and a category-level price index. I bring these into the same industry space as the policy shocks through the PCE-to-NAICS bridge and the NAICS-to-BEA concordance, so that each PCE category-month inherits a measure of upstream tariff exposure and downstream retaliation exposure. Real consumption is constructed within each PCE category by normalising the category price index to its 2001 level and deflating nominal expenditure by the resulting index, which removes differences in category-level inflation from the consumption variable.

### 2.4 Labour-market outcomes

Labour-market outcomes come from the monthly Current Population Survey (CPS). Employment is measured in the basic monthly files, using the harmonised industry codes of the Integrated Public

Use Microdata Series (IPUMS) CPS (Flood et al., 2024). Hours and earnings are measured in the outgoing rotation groups (ORG), the quarter of the CPS sample that is asked about earnings in each month. Hours are the hours actually worked in the reference week at the main job, and earnings are usual weekly earnings at the main job; the sample is restricted to employed workers reporting positive hours and earnings. Real weekly earnings are deflated by the headline Consumer Price Index (CPI). For the distributional analysis, workers are assigned to deciles of their pre-war weekly earnings, measured as the 2014–2016 mean real weekly earnings of the worker's industry-by-occupation cell, so that decile membership is not affected by the trade war itself. The measurement challenge is that the exposure panel is defined in BEA and NAICS industry space, while the CPS records workers by Census industry code. I bridge the two by mapping BEA sectors to six-digit NAICS industries through the official BEA concordance, mapping CPS Census industries to NAICS 2017 through the standard harmonised industry crosswalk, and averaging exposure across the NAICS industries attached to each CPS industry-month observation.

### 2.5 Household balance sheets

To measure household liquidity, I use the Panel Study of Income Dynamics (PSID). The PSID is particularly well suited to this exercise because it reports household balance-sheet variables jointly with the industry of employment of household members. Following Kaplan et al. (2014), I define a household as hand-to-mouth if its liquid assets are less than one month of household income. Liquid assets include checking and savings accounts, certificates of deposit, Treasury bills, bonds, and directly held stocks or mutual funds, net of liquid debt and excluding retirement accounts; monthly household income is annual family income divided by twelve.

I assign households to income deciles in each wave using total family income and PSID sampling weights. I then assign each household to an industry using the Census industry code of its working member, mapped to the harmonised 1990 industry classification and then to the tariff and retaliation exposure groups. This construction yields, for each income decile, the share of households whose primary earner is employed in sectors exposed to the trade war, and the share of hand-to-mouth households inside and outside those sectors. The exercise is descriptive: it does not identify a causal effect of tariffs on balance sheets. It measures whether the workers most exposed to the trade war are also the households least able to smooth the resulting income shock.

## 3 Empirical Framework

The goal is to estimate how industry outcomes respond to U.S. tariffs and to foreign retaliation. Comparing industries more and less exposed to the war does not identify these effects, for three reasons. First, the lists were not drawn at random: products were chosen for their economic and political salience (Fajgelbaum et al., 2020). If the industries that ended up on the lists were already on different trajectories, a naive comparison confounds the effect of the war with those trends. Second, exposure measures built from contemporaneous trade and input–output flows respond to

the war itself, as firms switch suppliers and markets, and are therefore mechanically related to the outcomes. Third, exposure measured through the production network depends on an industry's position in that network. Industries that are central in the input–output structure would appear exposed under almost any schedule, and centrality is correlated with size, trade intensity and cyclicality, which also shape employment and price dynamics.

I address these threats with a recentered network shift-share design. Each industry's exposure combines *predetermined shares*, measured in the 2017 input–output table and trade data, before any tariff was announced, with *exogenous shifts*, the tariff and retaliation rates in force in each month. Fixing the shares before the war removes the feedback from the war to the exposure measure, so that all of the time variation in exposure comes from the schedules. Following Borusyak, Hull, and Jaravel (2022), identification then rests on the shocks rather than on the shares: what matters is which products were hit, when and how hard, not why some industries trade more than others. The remaining concern, that well-connected industries appear exposed whatever the schedule, is addressed by recentering the exposures following Borusyak and Hull (2023). However, the schedules are observed at the level of an HS6 product, but the outcomes are observed for industries and for consumption categories. I derive the mapping between the two from a multi-country, multi-sector economy with Cobb–Douglas technology and intermediate inputs, in the tradition of Leontief (1936) and Acemoglu et al. (2012).

### 3.1 Production, costs and the predetermined shares

Let $m \in N$ index countries, $n$ the United States, $i, j \in J$ sectors, and $(m, j)$ a country-sector node: sector $j$ located in country $m$. Node $(n, i)$ produces with labour and an intermediate-input bundle,

$$Q_{ni} = A_{ni}\, L_{ni}^{\alpha_{ni}}\, X_{ni}^{1-\alpha_{ni}}, \tag{1}$$

where $Q_{ni}$ is the real output, $A_{ni}$ is productivity, $\alpha_{ni}$ the labour share and $X_{ni}$ the bundle. The bundle has two layers. The outer layer combines the input types $j$ that sector $(n, i)$ uses,

$$X_{ni} = \prod_{j \in J} X_{ni,j}^{\Omega_{ni,j}}, \qquad \sum_{j} \Omega_{ni,j} = 1, \tag{2}$$

where $X_{ni,j}$ is the quantity of input type $j$ and $\Omega_{ni,j}$ its weight in the bundle. The inner layer combines, for each type $j$, the varieties of $j$ bought from each country $m$,

$$X_{ni,j} = \prod_{m \in N} X_{ni,mj}^{\Omega_{ni,j,mj}}, \qquad \sum_{m} \Omega_{ni,j,mj} = 1, \tag{3}$$

where $X_{ni,mj}$ is the quantity of good $j$ from country $m$ used by sector $i$ in country $n$, and $\Omega_{ni,j,mj}$ its weight within the type-$j$ sub-bundle; $m = n$ is the domestic variety and $m \neq n$ the imported ones.

Node $(n,i)$ minimises cost subject to producing $Q_{ni}$. Combining (1)–(3) gives the unit cost

$$c_{ni} = \frac{1}{A_{ni}} W_n^{\alpha_{ni}} \left(P_{ni}^X\right)^{1-\alpha_{ni}}, \qquad \log P_{ni}^X = \sum_j \sum_m \Omega_{ni,j}\, \Omega_{ni,j,mj} \log P_{ni,mj}, \tag{4}$$

with $W_n$ the wage, $P_{ni,mj}$ the price node $(n,i)$ pays for good $(m,j)$, inclusive of the tariff when $m \neq n$, and $P_{ni}^X$ the price of the bundle. Cobb–Douglas makes every expenditure share constant. Labour takes a share $\alpha_{ni}$ of revenue and the bundle a share $1-\alpha_{ni}$; input type $j$ takes a share $\Omega_{ni,j}$ of the bundle, and variety $(m,j)$ a share $\Omega_{ni,j,mj}$ of the spending on type $j$.[2] Writing $Y_{ni} \equiv P_{ni}Q_{ni}$ for the dollar value of output, the dollar flow of good $(m,j)$ into node $(n,i)$ is therefore a fixed fraction of that output,

$$P_{ni,mj}\, X_{ni,mj} = a_{ni,mj}\, Y_{ni}, \qquad a_{ni,mj} \equiv (1-\alpha_{ni})\, \Omega_{ni,j}\, \Omega_{ni,j,mj}. \tag{5}$$

The coefficient $a_{ni,mj}$ is dollars of good $j$ from country $m$ per dollar of $(n,i)$'s output. It is the product of three shares: intermediates in output, type $j$ in intermediates, and country $m$ in type $j$. It is also what an input–output table records in each cell, with the first two factors taken from the Use table and the third from the split of the cell between domestic and imported supply. The *tariff share* of sector $i$ in product $j$ is its imported coefficient, the sum of (5) over foreign origins,

$$s_{ij}^T \equiv \sum_{m \neq n} a_{ni,mj} = \frac{x_{ij}^M}{Y_{ni}}, \tag{6}$$

dollars of imported $j$ per dollar of $i$'s output, where $x_{ij}^M$ is the Use-table flow of imported $j$ into $i$. The domestic coefficient $a_{ij}^D \equiv a_{ni,nj}$ is the rest of the flow of $j$ into $i$.

The second share comes from the other side of the same equation. Sector $i$'s output is bought by domestic sectors, by domestic final users, and by foreign buyers. A foreign node $(m,k)$ has the technology of (1)–(3), so by (5) it spends $a_{mk,ni}\, Y_{mk}$ dollars on U.S. good $i$, a fixed fraction of its own output; foreign households spend a fixed fraction of their income on it. Summing these purchases over the sectors and households of each foreign country $m$ gives sector $i$'s exports to $m$, $E_{i,m}$, and summing over destinations its total exports, $E_i = \sum_{m \neq n} E_{i,m}$. The *retaliation share* of sector $i$ is the fraction of its output that these foreign purchases absorb,

$$s_i^{RT} \equiv \frac{E_i}{Y_{ni}} = \sum_{m \neq n} \frac{E_{i,m}}{Y_{ni}}, \tag{7}$$

read from 2017 trade data. It is the sales-side counterpart of the tariff share. The share $s_{ij}^T$ is what

[2] Cobb–Douglas is assumed for convenience; it does not restrict what the cost exposures measure. By Shephard's lemma the first-order change in the unit cost of any constant-returns technology is the expenditure-share-weighted sum of input price changes, with the shares at their initial values, so the cost exposures use 2017 shares and are the same first-order object under any technology; substitution enters costs at second order (Baqaee and Farhi, 2019). Substitution between the domestic and the imported variety of the same product is different: it changes the demand facing the domestic producer at first order, and the protection exposure of Section 3.3 relaxes the inner bundle to allow for it.

sector $i$ buys from abroad per dollar of its output, and $s_i^{RT}$ what it sells abroad per dollar of its output. Each destination's term in (7) is the part of that share that a tariff by country $m$ can reach. A U.S. tariff on product $j$ raises the cost of $x_{ij}^M$ and enters sector $i$ through $s_{ij}^T$; a foreign tariff on product $i$ lowers the foreign purchases $E_{i,m}$ and enters through $s_i^{RT}$. The two matrices $A^D = [a_{ij}^D]$ and $S^T = [s_{ij}^T]$, with buyers in rows and sellers in columns, carry the whole domestic structure: row $i$ lists what sector $i$ buys, column $j$ lists who buys product $j$.[3]

### 3.2 Market clearing and the Leontief inverse

A tariff on steel raises the cost of the sectors that buy steel. Those sectors sell to others, machinery to construction, stampings to carmakers, and pass the increase on; their customers pass it on in turn. A retaliatory tariff on soybeans works in the other direction: the farm sells less, so it buys less seed, fertiliser and freight, and those suppliers buy less from theirs. In both cases the shock does not stop at the sector that trades the tariffed product, and a sector's exposure is the sum of what reaches it along every chain of domestic transactions. The Leontief inverse computes that sum (Leontief, 1936).

Each domestic sector's output is either sold to final users, households, government, investment and foreign buyers, or used as an input by another domestic sector,

$$Y_{nj} = F_{nj} + \sum_i a_{ij}^D Y_{ni}, \qquad \text{or in matrix form} \qquad Y = F + (A^D)^\top Y. \tag{8}$$

This is a fixed point, not an identity: to deliver $F$ the economy must also produce the inputs that $F$ requires, the inputs those inputs require, and so on. Its solution is

$$Y = (L^D)^\top F, \qquad L^D \equiv (I - A^D)^{-1}, \tag{9}$$

and because labour has a positive share in every sector the spectral radius of $A^D$ is below one, so that

$$L^D = I + A^D + (A^D)^2 + \cdots, \tag{10}$$

the direct purchase, the first round of inputs, the second, and every further round. The element $L_{ik}^D$ is the dollar increase in the output of $k$ required by a one-dollar increase in the final demand for $i$. Read along a row, $L^D$ lists the sectors whose costs feed into $i$; read down a column, the sectors whose sales depend on $i$. The same object is the propagation operator of the production-network literature (Acemoglu et al., 2012; Carvalho and Tahbaz-Salehi, 2019; Baqaee and Farhi, 2019) and of the input-cost studies of the trade war (Flaaen and Pierce, 2024).

Two properties of the inverse should be kept in mind. First, it holds the 2017 input mix and customer base fixed, so it measures the shock that reached a sector, not the sector's response to it: substitution away from tariffed suppliers or towards untargeted destinations, and the general-equilibrium movement of wages, exchange rates and final demand, are what the estimated coeffi-

[3] Appendix D writes out the stacked system.

cients capture. Second, it uses only the domestic block $A^D$. Foreign sectors appear as the origin of the tariff and as the destination of retaliated exports, but not as relays between two domestic sectors.[4]

### 3.3 Tariff exposure

**The sector-level tariff.** Let $\tau_{h,m,t}$ be the additional *ad valorem* duty in force in month $t$ on HS6 line $h$ imported from origin $m$, measured as described in Section 2. Let $\mathcal{P}_j$ be the set of lines of sector $j$ that appear on any U.S. list. The tariff on product $j$ in month $t$ is the 2017-import-weighted mean of the duties on those lines, across all origins,

$$\bar{\tau}_{j,t} \;=\; \sum_{h\in\mathcal{P}_j}\sum_{m}\frac{M_{h,m}}{M_j^{\mathcal{P}}}\,\tau_{h,m,t}, \qquad M_j^{\mathcal{P}} \equiv \sum_{h\in\mathcal{P}_j}\sum_{m} M_{h,m}, \tag{11}$$

where $M_{h,m}$ is 2017 U.S. imports of line $h$ from $m$.[5] The series $\bar{\tau}_{j,t}$ is a step function. It is zero before the first list that reaches the sector, rises at each wave by the rate times the share of the sector's tariffed imports that the wave covers, and moves with the subsequent increases and exemptions of the lines it contains.

**From the product to the buyer.** The Use table reports how much imported $j$ sector $i$ uses, $s_{ij}^T$, but not from which origin. Following Acemoglu et al. (2016), I assume that every buyer sources product $j$ from each origin in proportion to aggregate U.S. imports of $j$,

$$a_{ni,mj} = s_{ij}^T\,\frac{M_{j,m}}{M_j}, \qquad m \neq n, \tag{12}$$

under which the duty paid by sector $i$ on its imported $j$ is $s_{ij}^T\,\bar{\tau}_{j,t}$: the origin composition enters once, through $\bar{\tau}_{j,t}$, and the buyer's input–output coefficient multiplies it.

**Direct and network exposure.** With wages and foreign border prices held fixed, a tariff raises the price of imported $j$ by $\tau$ and, from (4), the unit cost of sector $i$ by its imported-input shares times the tariffs,

$$z_{i,t}^T = \sum_j s_{ij}^T\,\bar{\tau}_{j,t}. \tag{13}$$

[4] A relay through a foreign sector, say a U.S. exporter whose Chinese customer cuts its purchases because that customer's own exports to the United States were tariffed, would require the international input–output tables and the imported coefficients by origin. The 2018–19 measures targeted direct bilateral trade, so the first-round incidence is on the links the domestic table records, and the relay channel is left for future work.

[5] The weight $M_{h,m}/M_j^{\mathcal{P}}$ in (11) can be read in two steps: how much of the sector's tariffed imports line $h$ accounts for, and how much of line $h$ comes from origin $m$; the data give the two shares separately and I multiply them. Origins that were not tariffed carry a zero rate, so a line imported mostly from untargeted countries contributes little. Normalising instead over all lines of the sector, so that the shift also scales with the share of the sector's imports the lists cover, leaves the estimates of Section 4 essentially unchanged (Appendix B). I use the rate rather than $\log(1+\tau)$. At the highest rate in the schedule, 25 percent, the two differ by 2.7 percentage points, a scale difference that the estimated coefficient absorbs.

This is sector $i$'s *direct* exposure, the increase in its cost per dollar of output from its own imported inputs. Domestic prices move with domestic costs, so the full change in $i$'s cost also includes the cost increases of its domestic suppliers, $d\log c_{i,t} = \sum_j a^D_{ij}\, d\log c_{j,t} + z^T_{i,t}$. Solving this system with (9) gives the *network* tariff exposure,

$$Z^T_{i,t} \;=\; \sum_j L^D_{ij}\, z^T_{j,t}, \tag{14}$$

the tariffed imported inputs of $i$, of $i$'s domestic suppliers, of their suppliers, and so on, per dollar of $i$'s output. By (10), the first term is the direct exposure, the second adds each supplier's direct exposure weighted by its sales to $i$, and the remaining terms add the longer chains. The network exposure is at least as large as the direct one in every sector, and larger whenever a domestic supplier uses a tariffed input.

**Protection exposure.** A tariff on product $j$ does two things. It raises the cost of every sector that uses imported $j$, which (14) measures, and it raises the price of the foreign variety of $j$ relative to the domestic one, which protects the domestic producer of $j$ in its home market. A steel tariff hurts carmakers through their input bill and helps steel mills through their sales. Under the Cobb–Douglas inner bundle of (3) the second channel is absent at first order: a buyer keeps a fixed share of its spending on type $j$ for each origin, so it buys fewer imported units at the same outlay and leaves its purchases of domestic $j$ unchanged. Allowing substitution between the two varieties, with a constant elasticity $\theta_\ell$ in the inner bundle, leaves the cost exposure as it is, since by Shephard's lemma the first-order change in cost is the share-weighted sum of price changes, and adds a demand shock to the domestic producer. Each buyer of $j$ shifts spending towards the domestic variety by $(\theta_\ell - 1)\,\omega^M_{ij}$ times the rise in the relative price of the import, with $\omega^M_{ij}$ the import share of $i$'s purchases of $j$; the relative price rises by the tariff net of the domestic producer's own cost increase, $\bar\tau_{j,t} - Z^T_{j,t}$, the effective rate of protection (Corden, 1966). Under (12) every buyer's import share equals the import penetration of $j$, $IS_j = M_j/(M_j + Y_{nj} - E_j)$, and households substitute in the same form with their own elasticity $\sigma_C$, so summing over domestic buyers the producer of $j$ gains $(\theta_\ell - 1)\,(Y_{nj} - E_j)\,IS_j\,(\bar\tau_{j,t} - Z^T_{j,t})$ dollars of demand: its import-competing domestic sales times the effective tariff, with $(\theta_\ell - 1)$ on the firm part and $(\sigma_C - 1)$ on the household part, a common factor henceforth. The gain travels upstream exactly as retaliation does, and per dollar of output sector $i$'s *network protection exposure* is

$$Z^P_{i,t} \;=\; \frac{1}{Y_{ni}} \sum_k L^D_{ki}\,(Y_{nk} - E_k)\,IS_k\,(\bar\tau_{k,t} - Z^T_{k,t}), \tag{15}$$

with $(\theta_\ell - 1)$ factored out as the normalisation, as the foreign demand elasticity is in (18); the estimated coefficient carries its scale and its sign. The term $k = i$ is the own-market protection measure of Flaaen and Pierce (2024), the industry's own tariff times the import share of its market, here net of its own input-cost increase; the remaining terms are the protection of $i$'s domestic

customers, carried back to $i$ through the column of the Leontief inverse. $Z^T$ and $Z^P$ are built from the same shifts with different shares, and the theory gives them opposite signs: a dollar of tariffed inputs raises cost, a dollar of protected sales raises demand. In the data they are also collinear, since the industries that use tariffed inputs are largely the industries whose own products the lists shielded. The labour-market regressions therefore use their sum, $Z^{T+P}_{i,t} = Z^T_{i,t} + Z^P_{i,t}$, the tariff exposure of sector $i$ per dollar of output with both channels counted; the two components are the same tariff reaching the industry through its input bill and through its sales, and Appendix C reports the two separately.

### 3.4 Retaliation exposure

**The sector-level retaliation rate.** Let $\tau^*_{h,m,t}$ be the additional duty imposed by partner $m$ on U.S. exports of line $h$ in month $t$. The retaliation rate on sector $k$'s product is the export-weighted mirror of (11), over the set $\mathcal{P}^*_k$ of the sector's lines that appear on any partner's retaliation list,

$$\bar{\tau}^*_{k,t} \;=\; \sum_{h\in\mathcal{P}^*_k} \sum_m \frac{E_{h,m}}{E^{\mathcal{P}}_k}\, \tau^*_{h,m,t}, \qquad E^{\mathcal{P}}_k \equiv \sum_{h\in\mathcal{P}^*_k} \sum_m E_{h,m}, \tag{16}$$

with $E_{h,m}$ the 2017 U.S. exports of line $h$ to destination $m$. Destinations that did not retaliate carry a zero rate, so the series is the rate on the retaliated part of the sector's exports, weighted by how much of it went to the partners that retaliated.

**What a foreign tariff does to U.S. sales.** Retaliation is a demand shock, not a cost shock. A buyer in country $m$ with the technology of (1) spends a fixed share of its budget on U.S. product $k$, tariff included. After the tariff it pays $P_{nk}(1+\tau^*_{m,k})$ per unit, buys fewer units, and the wedge accrues to $m$'s treasury; the revenue that reaches the U.S. producer falls from $E_{k,m}$ to $E_{k,m}/(1+\tau^*_{m,k})$, that is, by $\log(1+\tau^*_{m,k}) \approx \tau^*_{m,k}$ in logs. Summing over destinations, sector $k$ loses $E_k\,\bar{\tau}^*_{k,t}$ dollars of export revenue. The unit elasticity is a normalisation. With a foreign demand elasticity $\sigma$, the loss is $\sigma$ times larger. How far exports actually fell per unit of retaliation is an empirical question, which the product-level estimates of Section 4.5 answer directly. The exposure measures the shock per unit of that elasticity, and the local-projection coefficient on it carries the scale.

**Direct and network exposure.** Per dollar of its output, sector $k$'s direct exposure is its retaliation share times the retaliation rate,

$$z^{RT}_{k,t} = s^{RT}_k\; \bar{\tau}^*_{k,t}. \tag{17}$$

The loss travels upstream, and market clearing says how. Exports are part of final demand, so the retaliation lowers $F$ by $\Delta F_k = -E_k\bar{\tau}^*_{k,t}$ in every retaliated sector. A sector that sells less produces less and, by (5), buys less from each domestic supplier in proportion to its input coefficients; the suppliers, in turn, buy less from theirs. Differencing (9) with the shares fixed, $\Delta Y = (L^D)^\top \Delta F$,

and the output that sector $i$ loses per dollar of its output is the *network* retaliation exposure,

$$Z^{RT}_{i,t} \;=\; -\frac{\Delta Y_{ni}}{Y_{ni}} \;=\; \frac{1}{Y_{ni}} \sum_k L^D_{ki}\, E_k\, \bar{\tau}^*_{k,t}. \tag{18}$$

It reads down column $i$ of the Leontief inverse: the retaliated exports of $i$ itself (the term $k = i$, with $L^D_{ii} \geq 1$), of $i$'s domestic customers, of their customers, and so on, converted into dollars of $i$'s output and divided by $i$'s output. The propagation is done in dollars rather than in shares, because the loss a supplier suffers depends on the size of the customer that stops buying, not only on that customer's exposure rate. Weighting by $E_k$ gives each customer its weight in the supplier's sales. The result is the share of sector $i$'s output embodied in retaliated exports, in the sense of Johnson and Noguera (2012), times the retaliation rate. It is bounded by the largest rate in the schedule.

The three exposures differ in direction and in nature. The tariff exposure is a cost increase that travels downstream, from the importer of the tariffed input to the sectors that buy from it, and identifies the price and quantity responses to higher input costs. The protection and retaliation exposures are demand shocks that travel upstream, of opposite sign: a gain in demand that runs from the domestic producer of the tariffed product to the sectors that supply it, and a loss in demand that runs from the exporter of the retaliated product to the sectors that supply it; they identify the responses to gained and to lost sales. All three are built from the 2017 Use table and 2017 trade flows, which are fixed, and from the tariff schedules, which supply all of the time variation. All three are computed for the 403 BEA sectors and carried to Census industries and PCE categories through the BEA-to-NAICS and NAICS-to-industry concordances, averaging across the sectors mapped to each unit.[6]

### 3.5 Identification and recentering

The exposures of the previous two subsections share the form

$$Z_{i,t} = \sum_k W_{ik}\, \bar{\tau}_{k,t}, \tag{19}$$

with $W^T = L^D S^T$, $W^{RT}_{ik} = L^D_{ki} E_k / Y_{ni}$ and, for the protection exposure, $W^P_{ik} = L^D_{ki}(Y_{nk} - E_k) I S_k / Y_{ni}$ applied to the effective rates $\bar{\tau}_{k,t} - Z^T_{k,t}$. The effective rate is not an outcome: $Z^T_{k,t}$ is itself a share-weighted sum of the product rates, so $Z^P_{i,t} = \sum_j \left[W^P (I - L^D S^T)\right]_{ij} \bar{\tau}_{j,t}$ is a shift-share in the same rates with predetermined shares $W^P(I - L^D S^T)$, and its recentering mean comes from the same draws. In every case predetermined shares are applied to product-level shifts, the duties on imported inputs, on tariffed output and on exported goods. The shares are the imported-input and export intensities of each industry, direct and through the network, and they respond to the trade war itself, as buyers substitute away from tariffed inputs and exporters redirect sales. Shares

[6] For the consumption outcomes the unit is a PCE category, a bundle of final goods rather than a producing industry: its cost exposure is the tariffed-input content of the goods in the category, including the duty on the category's own imported goods, per dollar of their input bill. Protection does not enter it, since it changes the sales of domestic producers rather than their unit costs, which is what the category's price follows; see Section 4.1.

measured during the war would already reflect how industries adjusted to it, so an exposure built on them would move with the outcome. Fixing the shares in 2017, the last year before the first list, closes that channel: the exposure measures the duties an industry faces given its pre-war structure, all of its variation over time comes from the shifts, and identification rests on the shifts being as good as random, conditional on observables, in their timing and in the products they cover (Borusyak, Hull, and Jaravel, 2022).

To see why an instrument is needed, consider the simple regression of an industry's outcome on the U.S. and foreign duties on its own product, with industry and month fixed effects. It compares industries whose products were taxed with the rest, and it has two problems. The first is endogeneity. The coefficient is causal only if receiving a tariff or a counter-tariff is unrelated to the other shocks moving the industry's outcome, and the lists were not drawn at random: the United States chose products tied to Chinese industrial policy and spared those on which its buyers depended (Bown and Kolb, 2021; Fajgelbaum et al., 2020), and China chose farm goods for their political weight (Fetzer and Schwarz, 2021), so the taxed industries may differ from the rest for reasons that also drive their outcomes. The second is missing indirect exposure. A duty on steel appears in the rate of the steel industry but not in that of the carmakers who buy steel, and the same holds for the fertiliser makers who supply the soybean farms that China taxed.

The experiment that would remove the first problem is one in which, within each wave, the United States assigns duties across the partner's products at random, independently of the trends of the industries that use those products, directly or through their links to the industries that do. Industries then differ in exposure only because the inputs they or their suppliers use happened to be drawn, and because they were drawn in one wave rather than another. Retaliation is the foreign version of this experiment. That the partner responds, and when it first does so, follows from the U.S. list; within its response, which U.S. export products it hits, how hard, and in which month, is random, so that soybeans being taxed in one month and fish in another is unrelated to the trends of the industries that make those products or supply their makers.

My design approximates this experiment conditional on observables, fixed effects and the re-centering. The first step is the exposure itself. By the production-network model of Sections 3.1 to 3.4, a duty on one input raises an industry's cost in proportion to how much of that input it uses, directly and through its suppliers, raises the demand facing the domestic producer of the tariffed product in proportion to its import-competing sales, and a foreign duty on one exported good lowers its demand in proportion to how much of its output that good embodies; the industry is treated by every product the lists touch, each weighted by its place in the industry's cost or sales, and the exposure in (19) is that treatment. Using it rather than the own-product rate removes the second problem by construction, since the carmakers now carry the steel duty in proportion to the steel in a car, and on the tariff side it counts both channels the own-product rate conflates, the cost of tariffed inputs and the protection of tariffed output; Section 4.2 estimates their sum and Appendix C the two separately. It also changes the identifying condition for the first problem: the duty on product $k$ need not be unrelated to the shocks of the sector that makes $k$, but to the

exposure-weighted average of the shocks hitting the industries that use $k$, for the cost exposure, that make $k$ and supply its maker, for the protection exposure, or that supply its exporters, for the retaliation exposure. A duty on steel imposed because of distress in steel violates this condition only if the distress also predicts the outcomes of machinery, construction and the other users of steel.

The second step is the conditioning. Industry fixed effects, in a regression on cumulative changes, absorb industry-specific growth over the sample, and with it the trend of Chinese import competition that the users of tariffed inputs face in their own markets and the trend decline in farm income that the suppliers of retaliated farms were already on. Month-year effects absorb shocks common to all industries, the dollar and the aggregate cycle among them. What the fixed effects leave is a shock specific to the exposed industries and dated within the war, and here the argument rests on the reasons the lists were drawn. On the tariff side those reasons are properties of the product and of its Chinese supply, while the industries reached are its U.S. users, and a product's priority in Chinese industrial policy says little about whether U.S. machinery or construction were about to turn up or down. On the retaliation side the reason is where a product is grown, while the industries reached are the farms' suppliers of seed, fertiliser and freight, whose demand the electoral map of soybean counties does not forecast. Appendix B looks for the patterns that would appear if these conditions failed: a pre-trend test and balance tests on the shifts and on the recentered exposure for the choice of products, a placebo that replays the lists three years earlier for their timing, and robustness to the agricultural shocks of 2018–19 that fell on the retaliated sectors from outside the war.

The third step is the recentering. Random shifts and fixed shares do not deliver a clean comparison on their own in a network framework, because the shares determine how much of any schedule reaches an industry: a sector with large imported-input shares and many domestic suppliers is exposed under almost any list, so its expected exposure $\mu_{i,t} \equiv \mathbb{E}[Z_{i,t}]$ varies with its trade and network position and with everything correlated with them, including size and cyclicality. Borusyak and Hull (2023) show that the bias in the coefficient on $Z$ runs entirely through $\mu_{i,t}$. I compute $\mu_{i,t}$ from $S = 500$ counterfactual schedules that hold the timing and size of each wave fixed and redraw the products it covers from those the partner traded in 2017, as described in Appendix A, and average over the draws and the actual schedule,

$$\mu_{i,t} = \frac{1}{S+1}\Big[Z_{i,t} + \sum_{s=1}^{S} Z_{i,t}^{(s)}\Big]. \tag{20}$$

The recentered exposure $Z_{i,t} - \mu_{i,t}$ is how much more of the war reached an industry than its position would have sent there under any list. The assumption that remains is that the actual choice of products, relative to that expected exposure, is unrelated to the shocks above, and Appendix B reports balance tests on the shifts and on the recentered exposure, which would show if it failed.

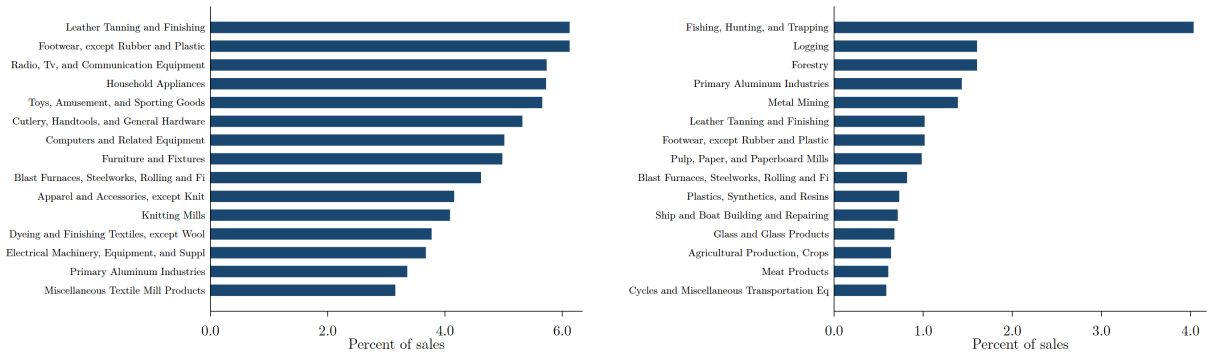
The local projections of Section 4 include $\mu_{i,t}^{T+P}$ and $\mu_{i,t}^{RT}$ as regressors next to $Z_{i,t}^{T+P}$ and $Z_{i,t}^{RT}$, so that an imperfect assignment model is not imposed with a unit weight (Borusyak and Hull, 2023,

§3.3), and the total shares $\bar{s}_i^{T+P}$ and $\bar{s}_i^{RT} = \sum_k W_{ik}^{RT}$ interacted with month-year effects, because the shares do not sum to one and the exposure a given total share delivers varies with the mean shift of the month (Borusyak, Hull, and Jaravel, 2025, Appendix A.1). Section 3.6 describes the shifts, and inference treats the shifts as the random object.

### 3.6 Patterns in the data

Three features of the exposures and the shifts discipline what follows.

*Exposure is continuous and uneven.* Figure 2 shows the most exposed Census industries, each at the month its own exposure peaks and, on the tariff side, with cost and protection combined: leather and footwear, toys, communication equipment, computers and household appliances, at 8 to 10 percent of sales; on the retaliation side fishing, logging and forestry, primary aluminium, metal mining and crops, at 1 to 4 percent. The design uses the continuous series rather than a treated-versus-control split.




(a) Tariff exposure (b) Retaliation exposure

Figure 2: **The most exposed industries.** The fifteen Census industries with the largest network exposure to tariffs (Panel a) and to retaliation (Panel b), in percent of sales, each measured in the month in which its own exposure peaks. The exposures of Section 3.3 are monthly series, zero before the first wave and rising with each list, step-up and exemption; the bars are a snapshot of each series at its peak, and the regressions use the full series. Tariff exposure is the combined cost-and-protection exposure used for the labour-market outcomes.

Table 2 splits each exposure, at the level of the BEA sector and for the cost chain alone on the tariff side, into the part that comes from a sector's own tariffed inputs or own retaliated exports and the part that reaches it through the network. On the tariff side the network adds forty percent of output-weighted exposure. On the retaliation side it adds half: 364 sectors carry some exposure, and 144 of them are exposed mostly through their customers.

*The shifts are spread across many sectors.* Table 3 describes the sector rates. At the peak of the war 232 sectors carry a tariff and 219 a retaliation rate; the tariff rates have a median of 0.8 percentage points and a ninetieth percentile of 8.6, the retaliation rates a median of 0.1 and a ninetieth percentile of 2.4, so that retaliation is the more skewed of the two. Weighting each sector by its contribution to the exposure of all industries, the effective number of shifts is about 80 on the tariff side and 86 on the retaliation side. Appendix B reports the balance of the raw and the

Table 2: Direct and indirect components of the network exposures, BEA sectors.

| | Total | Direct | Indirect | Indirect share |
|---|---|---|---|---|
| *A. Summary, output-weighted means over all sectors* | | | | |
| Tariffs, input-cost chain | 0.197 | 0.118 | 0.080 | 0.40 |
| Retaliation | 0.067 | 0.035 | 0.032 | 0.48 |
| *B. Ten most exposed sectors, tariffs (direct = own tariffed inputs, indirect = suppliers')* | | | | |
| Upholstered household furniture | 2.32 | 2.16 | 0.16 | 0.07 |
| Motor and generator manufacturing | 1.57 | 1.32 | 0.25 | 0.16 |
| Rubber and plastics hoses and belting | 1.56 | 1.44 | 0.12 | 0.08 |
| Railroad rolling stock | 1.55 | 1.17 | 0.38 | 0.24 |
| Seafood product preparation and packaging | 1.54 | 1.28 | 0.25 | 0.17 |
| Curtain and linen mills | 1.46 | 1.23 | 0.24 | 0.16 |
| Textile and fabric finishing | 1.41 | 1.17 | 0.24 | 0.17 |
| Telephone apparatus | 1.26 | 1.17 | 0.09 | 0.07 |
| Coffee and tea manufacturing | 1.24 | 1.12 | 0.13 | 0.10 |
| Motor vehicle transmission and power train parts | 1.22 | 1.00 | 0.22 | 0.18 |
| *C. Ten most exposed sectors, retaliation (direct = own exports, indirect = customers')* | | | | |
| Oilseed farming | 4.08 | 3.14 | 0.94 | 0.23 |
| Pulp mills | 3.32 | 3.16 | 0.16 | 0.05 |
| Fishing, hunting and trapping | 2.92 | 2.91 | 0.01 | 0.00 |
| Motorcycle, bicycle and parts | 1.75 | 1.53 | 0.22 | 0.13 |
| Iron, gold, silver and other metal ore mining | 1.46 | 1.03 | 0.43 | 0.29 |
| Forestry and logging | 1.45 | 0.65 | 0.80 | 0.55 |
| Alumina refining and primary aluminium | 1.24 | 0.12 | 1.11 | 0.90 |
| Other crop farming | 1.12 | 0.94 | 0.18 | 0.16 |
| Analytical laboratory instruments | 1.12 | 1.11 | 0.00 | 0.00 |
| Irradiation apparatus | 1.11 | 1.10 | 0.01 | 0.01 |

Notes: exposures in percent of sales at the peak month of each exposure, 403 BEA sectors. Tariffs: the propagated input-cost chain of (14), split into the sector's own tariffed inputs and the tariffed inputs of its domestic suppliers carried through the Leontief inverse; own-market protection excluded. Retaliation: the sector's own retaliated exports per dollar of output times its rate, and the retaliated exports of its domestic customers reaching it through the Leontief inverse. Indirect share = indirect / total. Panel A weights by 2017 output.

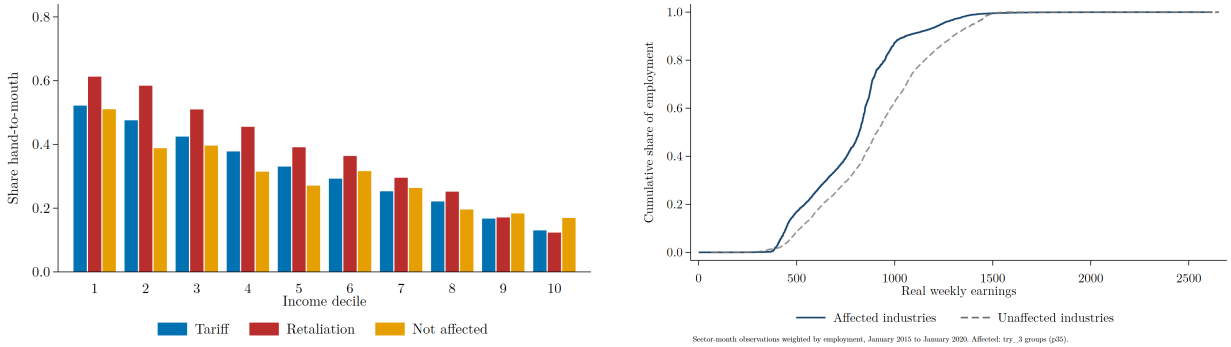
recentered rates on pre-war sector characteristics.

Table 3: The shifts: sector tariff and retaliation rates.

| Side | Sample | Sectors $> 0$ | Mean | SD | p10 | p50 | p90 | Max |
|---|---|---|---|---|---|---|---|---|
| Tariffs $\bar{\tau}_{k,t}$ | Peak month | 232 | 2.75 | 3.77 | 0.00 | 0.79 | 8.57 | 17.62 |
| Tariffs $\bar{\tau}_{k,t}$ | War average | 232 | 1.53 | 2.11 | 0.00 | 0.43 | 4.55 | 9.59 |
| Retaliation $\bar{\tau}^*_{k,t}$ | Peak month | 219 | 0.77 | 1.68 | 0.00 | 0.12 | 2.35 | 14.51 |
| Retaliation $\bar{\tau}^*_{k,t}$ | War average | 220 | 0.54 | 1.00 | 0.00 | 0.14 | 1.38 | 7.70 |
| Effective number of shocks: tariffs 80.5, retaliation 85.9 | | | | | | | | |

Notes: rates in percentage points across the 403 BEA sectors, estimation window only. Peak month = the month with the highest mean rate; war average = 2018m1–2020m3. The exposure share of sector $k$ in an industry is its contribution to that industry's network exposure, using the labour-market tariff share matrix (input-cost chain plus protection) and the retaliation share matrix; $s_k$ averages it across Census industries, weighting industries by 2017 employment, and is normalised to sum to one. Sectors $> 0$ counts sectors with a nonzero rate. Effective number of shocks $= 1/\sum_k s_k^2$.

*Exposure tracks worker and household vulnerability.* The sectors exposed to the war employ workers lower in the wage distribution and households with less liquid wealth. In the PSID, the share of hand-to-mouth households among those whose primary worker is in an affected sector is about 30% in tariff-affected and 40% in retaliation-exposed sectors, against about 20% elsewhere, and the gap holds through the eighth decile of the income distribution (Figure 3, Panel a); in the CPS, the employment-weighted wage distribution of affected sectors lies to the left of the rest, with the gap in the lower tail (Panel b). The workers most exposed to the war are those with the least liquid wealth to absorb a labour-income shock and the lowest wages to begin with.




(a) Share of hand-to-mouth by income decile

(b) Wage distribution

Figure 3: **Exposure and vulnerability.** Panel (a): share of hand-to-mouth households (defined as in Kaplan et al., 2014) by income decile, separately for households whose primary worker is employed in trade-war-affected sectors and in unaffected sectors (PSID, 2003–2021). Panel (b): employment-weighted cumulative wage distribution for tariff- and retaliation-affected sectors against unaffected sectors, January 2017 to January 2020 (CPS–ORG). In both panels the affected-sector distribution lies above (Panel a) or to the left (Panel b) of the unaffected one in the lower part of the distribution.

# 4 Results

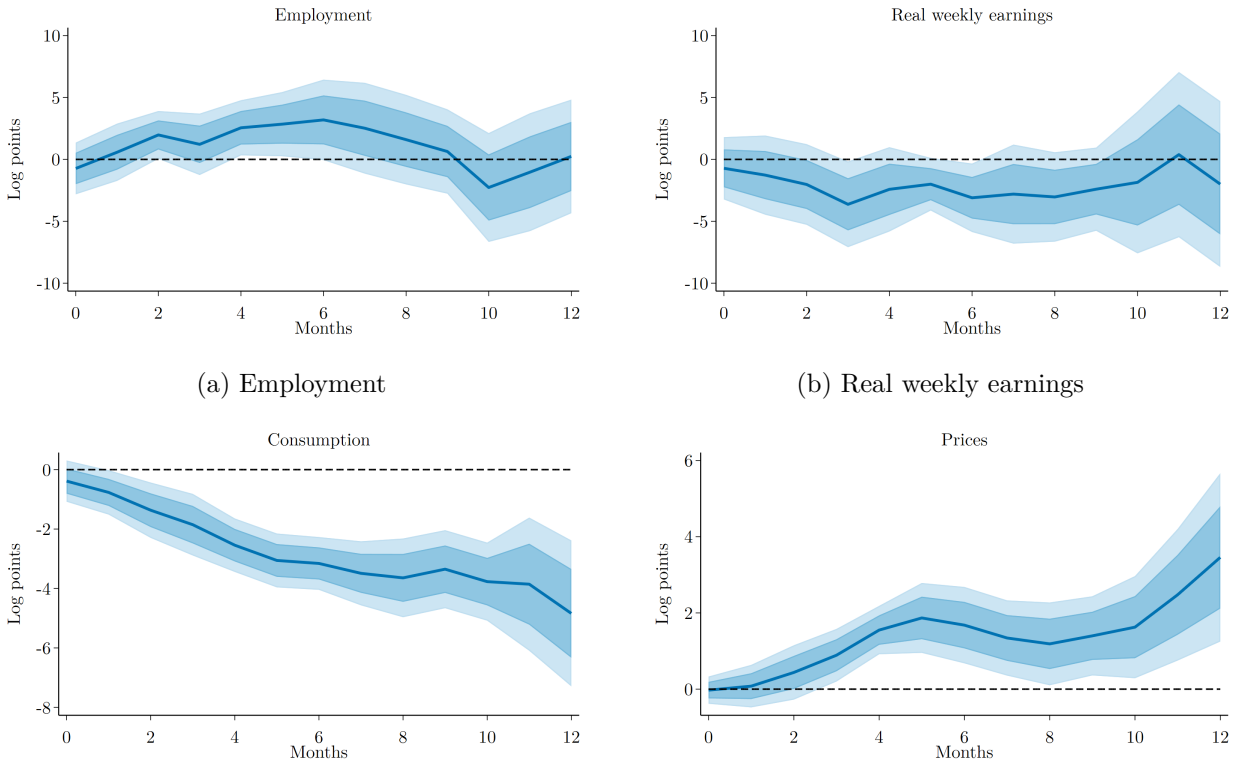
This section reports the empirical results. I first set out the shift-share local projection that translates the policy shocks into industry- and category-level responses, then report the responses to tariffs and to retaliation, for employment, real weekly earnings, real consumption and prices, and the distributional incidence across the earnings distribution. For completeness, I then report a product-level event-study difference-in-differences on the trade flows the policy directly targeted, where treatment is observed without measurement error, whose estimates are in line with the existing literature.

## 4.1 Shift-Share Local Projection Design

For every outcome whose unit of observation is the industry-month panel rather than the product-country panel (prices, real consumption, employment, real weekly earnings and hours), I propagate the policy variation through the production network and identify the dynamic response with a shift-share local projection. The estimating equation is

$$\log y_{i,t+h} - \log y_{i,t-1} \;=\; \alpha_{ih} + \alpha_{th} + \beta_h \, Z_{i,t}^{T+P} + \delta_h \, Z_{i,t}^{RT} + \gamma_h^{T} \, \mu_{i,t}^{T+P} + \gamma_h^{RT} \, \mu_{i,t}^{RT} + \alpha_{th}^{T} \, \bar{s}_i^{T+P} + \alpha_{th}^{RT} \, \bar{s}_i^{RT} + \varepsilon_{i,t+h}, \tag{21}$$

where $h = 0, 1, \ldots, 12$ indexes the horizon in months, $\alpha_{ih}$ and $\alpha_{th}$ are industry and calendar-month fixed effects at horizon $h$, $Z_{i,t}^{T+P} = Z_{i,t}^{T} + Z_{i,t}^{P}$ is the tariff exposure of Section 3.3, the cost chain plus protection per dollar of output, $Z_{i,t}^{RT}$ the network retaliation exposure, $\mu_{i,t}^{T+P} = \mu_{i,t}^{T} + \mu_{i,t}^{P}$ and $\mu_{i,t}^{RT}$ their recentering means, and $\bar{s}_i^{T+P} = \sum_k \left[W^T + W^P (I - L^D S^T)\right]_{ik}$ and $\bar{s}_i^{RT} = \sum_k W_{ik}^{RT}$ the industry's total shares, the sums of the share matrices of (19) over sellers. For the consumption outcomes, which face the cost channel only, $Z^{T+P}$, $\mu^{T+P}$ and $\bar{s}^{T+P}$ are replaced by the cost exposure per dollar of the input bill, its mean and its share. The shares are incomplete: they do not sum to one, because some inputs and sales of each industry are never touched by the lists. Borusyak, Hull, and Jaravel (2022) show that in this case the exposure $Z_{i,t}$ moves with how much of an industry's trade is subject to the lists at all, not only with which sectors were targeted, and that an industry's total share is correlated with its size, trade intensity and cyclicality. The total shares are fixed over time and on their own would be absorbed by the industry effects; they enter interacted with the month-year effects because the mean of the shocks varies over time and so does the exposure that a given total share delivers (Borusyak, Hull, and Jaravel, 2025, Appendix A.1). This removes the component of $Z_{i,t}$ that comes from the level of an industry's exposure to any schedule, so that $\beta_h$ and $\delta_h$ are identified by the allocation of the shocks across sellers. Both shocks and both recentering means enter every regression. The coefficients of interest, $\beta_h$ and $\delta_h$, trace the response of $\log y_{i,t}$ to a unit of network exposure to tariffs and to retaliation, in log units per unit of exposure. The panel runs from January 2010 to February 2020 for employment, earnings and the PCE series. The pre-war window identifies the war against ordinary industry dynamics, and the sample stops in February 2020 because from March 2020 the pandemic moved employment, hours




(a) Employment

(b) Real weekly earnings

(c) Real consumption

(d) Prices

Figure 4: **Local projection estimates: Tariffs.** Coefficients $\beta_h$ from equation (21) on the network tariff exposure, in log units per unit of exposure, horizons 0 to 12 months. Panels (a) and (b): employment and real weekly earnings by Census industry, exposure $Z^{T+P}$, the cost chain plus protection per dollar of output. Panels (c) and (d): real PCE and PCE prices by category, cost exposure per dollar of the input bill. Every regression includes the retaliation exposure, both recentering means and both total shares interacted with month effects; the retaliation coefficients are in Figure 5. Shaded areas are 68 and 90% confidence bands, standard errors clustered by month; sector-clustered standard errors in Appendix B, Table 17.

and consumption by amounts far larger than any plausible effect of the trade war, and in a pattern, concentrated in services, that is correlated with the network exposures; extending the horizon into the pandemic would attribute part of that collapse to the tariffs.

The recentering means $\mu_{i,t}^{T+P}$ and $\mu_{i,t}^{RT}$ and the total-share controls are those of Section 3.5, so that $\beta_h$ and $\delta_h$ are identified by the exposure the actual schedule produced rather than by an industry's position in the network. Standard errors are clustered by calendar month, the dimension along which the schedules move; Appendix B reports the Adão et al. (2019) sector-clustered standard errors and null-imposed confidence sets, together with the placebo, the pre-trend tests and the balance tests.

## 4.2 Tariffs

Panels 4a and 4b of Figure 4 report the response of employment and real weekly earnings to the tariff exposure, the increase in an industry's input costs that the lists produced directly and through

its domestic suppliers. The employment coefficient lies within two standard errors of zero at every horizon ($t$ between $-0.9$ and 1.9), with confidence bands that bracket gains and losses of economic size, and real weekly earnings are flat throughout ($t$ between $-1.8$ and 0.1). Industries exposed to the tariffs neither gained nor lost employment relative to unexposed industries.[7]

Panels 4c and 4d show where the tariffs did register. The prices of the consumption categories exposed to tariffed goods rise slowly over the first months and more clearly from the fourth. After twelve months they are 3.5% higher ($t = 2.6$), while real consumption of the same categories falls by 4.8% over the same horizon ($t = -3.2$). This is the pattern that pass-through of an input-cost shock implies: domestic buyers pay more and consume less. The tariff was passed on rather than absorbed.

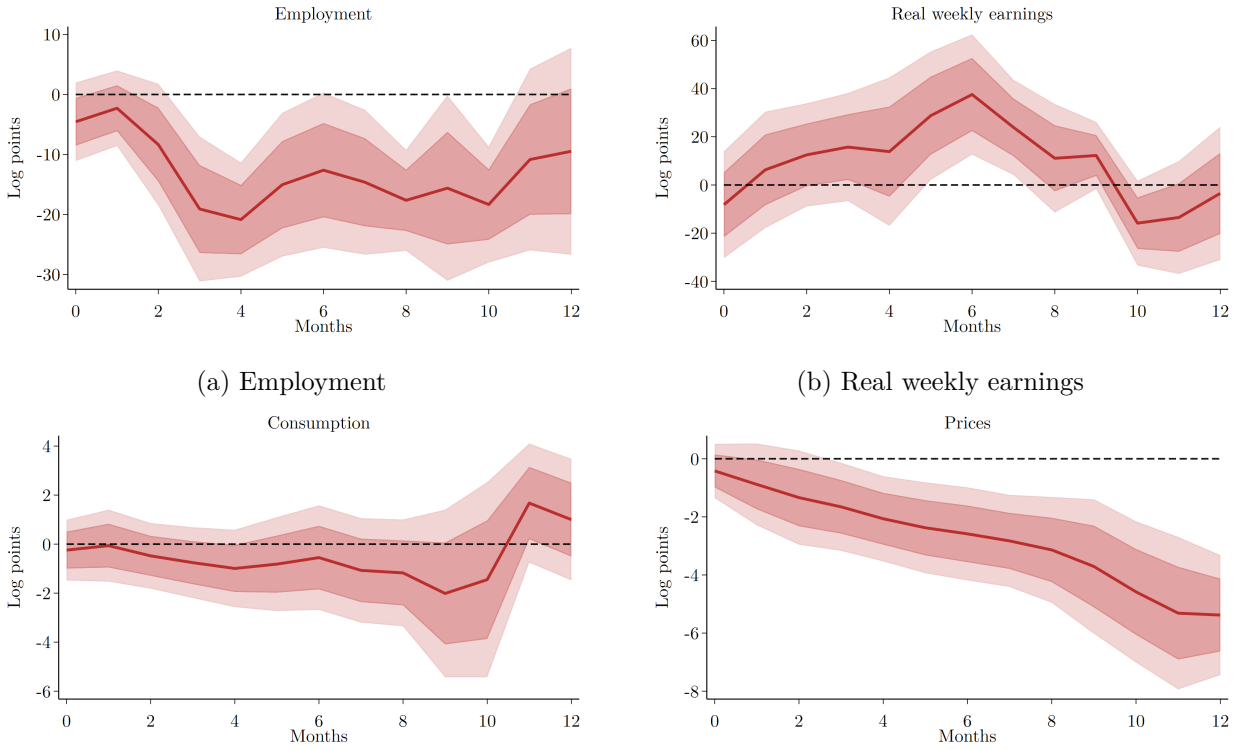
Taken together, the two pairs of panels locate the step at which the substitution argument fails. The argument is that a tariff, by making imports expensive relative to what the country makes itself, moves demand from the foreign to the domestic variety. It runs in three steps: the tariff raises the price of the imported variety above the domestic one, buyers turn to domestic producers, and those producers hire. The first step holds. The duty appears in domestic prices, and the trade-flow estimates of Section 4.5 show imports of the tariffed products falling. The second step does not carry through to the third. The products on the lists are predominantly intermediate and capital goods, for which no domestic supplier at the required scale exists within the horizon of the estimates. Buyers therefore paid the duty and passed it on. Entered together or separately (Appendix C), neither the cost of tariffed inputs nor the protection of tariffed output moves employment or earnings; no gain appears in any exposed industry. The finding is consistent with the complete pass-through at the border documented by Amiti et al. (2019), Fajgelbaum et al. (2020) and Cavallo et al. (2021). It is also consistent with the absence of employment gains in the industries the tariffs were meant to help, found by Flaaen and Pierce (2024) and Autor et al. (2024). What the network exposure adds is that this absence extends to the customers of the industries that import.

### 4.3 Retaliation

Panels 5a and 5b of Figure 5 report the response to retaliation, a shock to foreign demand for an industry's output and for that of its domestic customers. Employment falls from the second month, reaches about $-20\%$ by the third, and has not recovered at twelve months.[8] Real weekly earnings are volatile and imprecisely estimated: Panel 5b shows a short-lived positive movement at six months, and nothing persistent. The placebo test in Appendix B also produces a significant wage movement at this horizon, of the opposite sign, so I do not interpret it. The adjustment

[7] Appendix C enters the cost chain and the protection exposure as separate regressors. The separated coefficients are are opposite sign and unstable across samples, but not statistically signficant.

[8] The spring 2019 floods delayed planting across the corn and soybean belt eight to eleven months after the July 2018 retaliation, within the horizon of the local projections. Appendix B shows that they do not account for the loss: the response is in place by the fourth month, before the floods, and the coefficients are unchanged when the flood months are dropped from the outcomes, when agriculture is allowed its own flood-window effect, or when crop and livestock production are removed (Table 14).




(a) Employment

(b) Real weekly earnings

(c) Real consumption

(d) Prices

Figure 5: **Local projection estimates: Retaliatory tariffs.** Coefficients $\delta_h$ from equation (21) on the network retaliation exposure $Z^{RT}$, in log units per unit of exposure, horizons 0 to 12 months, from the same regressions as Figure 4. Panels as in Figure 4. Shaded areas are 68 and 90% confidence bands, standard errors clustered by month; sector-clustered standard errors in Appendix B, Table 17.

therefore takes place on the extensive margin, through employment, rather than through pay. This is the central finding of the paper: the labour-market response to the trade war runs through retaliation rather than through the tariffs the United States imposed, and in the direction opposite to the policy's stated aim.[9]

The estimate is the effect of retaliation inclusive of the federal response to it. From September 2018 the Market Facilitation Program paid farmers for the retaliation on each commodity, with the rate set per commodity to offset it, so the payments are collinear with the shock by construction and cannot be separated from it. What the regression identifies is the employment loss that remained after the assistance, which is the object the paper's question calls for and a lower bound on the loss without it. The model treats the two consistently: the payments are the share of tariff revenue rebated to hand-to-mouth households in the calibration of Section 6, so that the aggregate cost there is also the cost net of the federal response.

The mechanism is the one the production-network derivation of Section 3.3 predicts, and the estimates trace it step by step. The retaliation exposure is large for industries that sell, directly or through their domestic customers, to the foreign buyers who stopped buying once their governments imposed retaliatory duties. Exports of the retaliated products fall, by about a quarter within ten months according to the product-level estimates of Section 4.5, so foreign demand for the output of these industries, and for the output of the domestic suppliers that feed them, contracts. Producers respond on the price margin: the domestic prices of the retaliated categories fall (Panel 5d), as producers sell at home the output that no longer has a foreign buyer. The lower price does not recover the lost demand, since the real consumption response in Panel 5c is small and imprecise. With revenue down, prices already cut, and wages that do not fall, the margin that remains is employment, and that is where the adjustment appears, consistent with the nominal-rigidity benchmark of Section 5.

Retaliation produces the opposite pattern on prices. Panel 5d shows that the prices of the categories exposed to retaliation *fall*, by 5%, while the real consumption response in Panel 5c is small and imprecise. This asymmetry follows from the nature of the two shocks. A U.S. tariff raises the cost of goods purchased *inside* the United States and feeds into the domestic price index; retaliation removes foreign demand for U.S. output, and the supply that no longer goes abroad is sold at home at a lower price. The first-order effect of retaliation on the U.S. economy is on producer revenue, and the domestic price response is the sign of that revenue loss, not of a cost increase. The muted consumption response reflects the small weight of retaliated goods in the household basket. The price decline is in line with the evidence on the markets for retaliated products: Cavallo et al. (2021) document declines in the prices of U.S. exports subject to retaliation.

Together, the two figures deliver one half of the policy story: the tariff works on the price side the way a tax on inputs does, prices rise and consumption falls, and retaliation shows up at home as cheaper goods, not dearer ones.

[9] Retaliation fell on fewer sectors than the tariffs, so the estimate draws on a smaller set of shifts. Appendix B.6 re-estimates it with the most exposed sectors' shifts removed (Table 15).

### 4.4 Distributional incidence

Retaliation destroyed jobs in the industries it reached. This subsection measures where in the earnings distribution the loss of hours falls.

**The hours response by earnings decile.** I estimate the local projection on the monthly Current Population Survey at the level of the individual worker, from January 2015 to January 2020. Workers are ranked before the war, in the deciles $d$ of pre-war weekly earnings defined in Section 2, so that a worker's position in the distribution is fixed before any tariff was announced and cannot respond to the shock. For each decile $d$ and horizon $h$ I estimate, on the workers of that decile,

$$\log h_{n,t} = \alpha^d_{ih} + \alpha^d_{th} + \beta^d_h Z^{T+P}_{i(n),t-h} + \delta^d_h Z^{RT}_{i(n),t-h} + \gamma^{T,d}_h \mu^{T+P}_{i(n),t-h} + \gamma^{RT,d}_h \mu^{RT}_{i(n),t-h} + \alpha^{T,d}_{th} \bar{s}^{T+P}_{i(n)} + \alpha^{RT,d}_{th} \bar{s}^{RT}_{i(n)} + \varepsilon^d_{n,t}, \tag{22}$$

where $h_{n,t}$ is the weekly hours of employed worker $n$ in month $t$ and $i(n)$ is the worker's industry. The exposures, recentering means and total shares are those of equation (21), the total shares interacted with the month effects as there, dated $h$ months before the outcome because the survey does not follow workers over time. The regressions include industry and calendar-month fixed effects, survey weights, and standard errors clustered by month. The coefficients of interest are $\delta^d_h$, the response of hours in decile $d$ to the retaliation exposure of the worker's industry $h$ months earlier. Figure 6 reports them decile by decile.

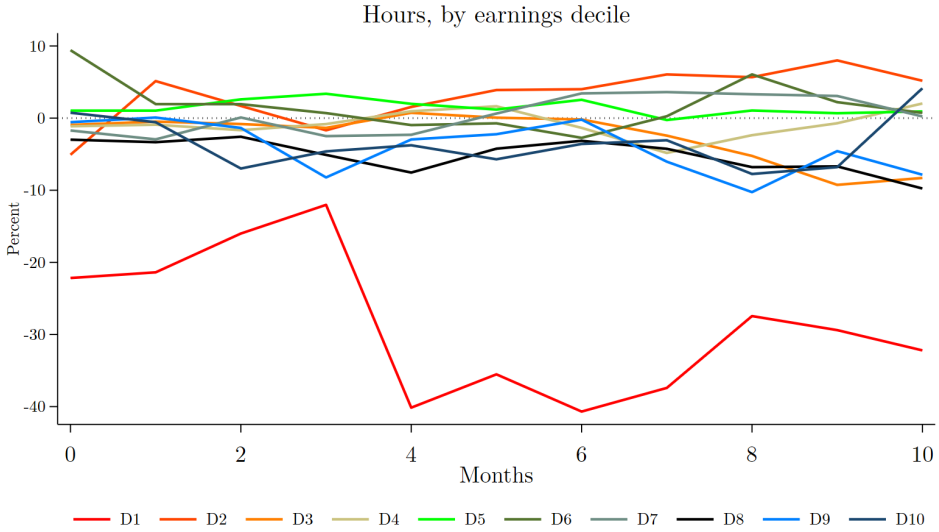



Figure 6: **Hours response to retaliation, by pre-war earnings decile.** Coefficients on the network retaliation exposure from local projections of log weekly hours of employed workers in the monthly Current Population Survey, January 2015 to January 2020, estimated separately within each decile of pre-war weekly earnings (Section 2). Decile 1 is the lowest. Exposure is measured at the worker's industry $h$ months earlier; industry and month fixed effects, both recentering means and both total shares included, survey weights, standard errors clustered by month. Horizons 0 to 10 months.

The response is concentrated at the bottom. Workers in the lowest decile lose on the order of 30% to 40% of their hours over the policy horizon, while the response in every other decile is statistically and economically indistinguishable from zero. The aggregate employment loss of Section 4.3 is therefore not spread across the workforce of the exposed industries; it falls on their lowest-paid workers.

The concentration follows from where retaliation landed and from how the exposed industries adjust. The retaliated sectors, agriculture, fishing, food processing and primary metals, employ a large share of low-paid, hourly and seasonal labour. These are the margins an employer cuts first when sales fall and prices cannot be lowered enough to recover them: hours of production workers rather than salaried positions, and temporary and seasonal contracts rather than permanent ones. For these workers the hours cut is an income loss that is not insured. The PSID evidence of Section 3.6 shows that they are disproportionately hand-to-mouth, with liquid assets below one month of income, so the loss passes into their consumption with little smoothing. The consumption response in turn reaches beyond the exposed sectors: lower spending by these households lowers demand for the local goods and services they buy, a second round that the network exposure, built on input–output linkages, does not measure. These are the facts the model of Section 5 is built to account for. The cross-sectional estimates identify who loses and through which margin, but not the aggregate loss, the demand spillovers to unexposed sectors, or the welfare cost of a labour-income shock that falls on households without a buffer. The model carries the same two heterogeneities, the sectoral concentration of retaliation and the concentration of hand-to-mouth workers in the same sectors, into general equilibrium, and quantifies them.

### 4.5 Direct effects on imports and exports

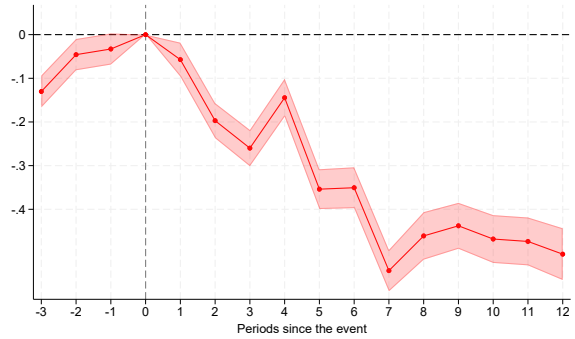
For completeness, this subsection reports the direct effect of the lists on the trade flows they targeted. The estimates are in line with the existing literature on the episode and serve as the policy first stage for the results above.

For these flows the schedules are written at the same level as the outcome, an HS6 product, a partner country and a month, so treatment is observed directly and no instrument is needed. I estimate an event-study difference-in-differences,

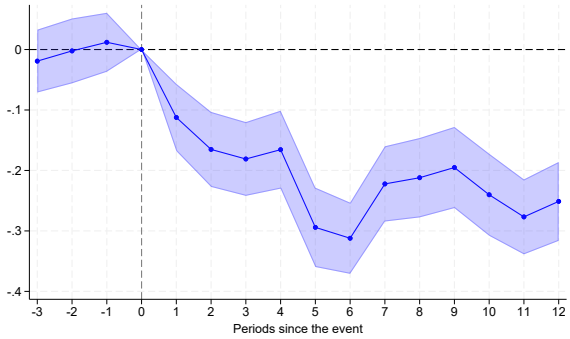
$$\log y_{pm,\,t+h} - \log y_{pm,\,t-1} \;=\; \alpha_{pm} \;+\; \delta_t \;+\; \sum_{\ell \neq -1} \beta_{h\ell}\, \mathbf{1}\{t - g_{pm} = \ell\} \;+\; \varepsilon_{pm,\,t+h}, \tag{23}$$

where $y_{pm,t}$ is U.S. imports of product $p$ from source $m$, U.S. exports of $p$ to destination $m$, or the product-country trade balance; $g_{pm}$ is the month in which the relevant duty took effect for the pair; and $\alpha_{pm}$ and $\delta_t$ are product-country and month fixed effects. Horizons run from three months before to ten months after implementation, and standard errors are clustered by policy date. Because the waves took effect on several dates, pairs enter treatment at different times, and a two-way fixed-effects regression would compare pairs treated later with pairs treated earlier, the comparisons that de Chaisemartin and D'Haultfœuille (2020) show can carry negative weights. I therefore report the

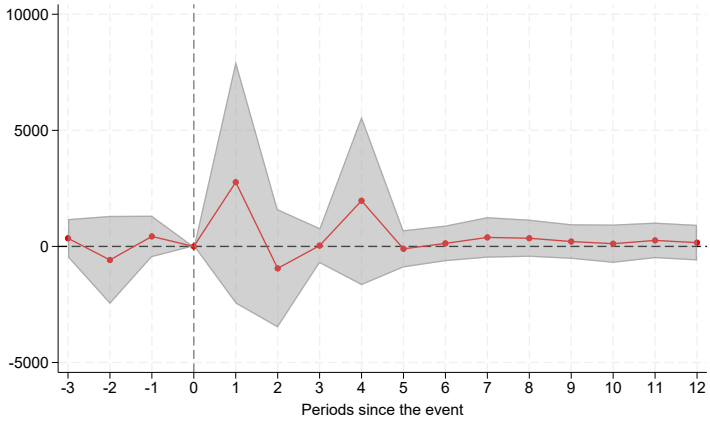
heterogeneity-robust estimator of de Chaisemartin and D'Haultfœuille (2020), which uses only not-yet-treated pairs as controls; the flat pre-trends in Figure 7 support the parallel-trends assumption it requires.




(a) Imports of tariffed products




(b) Exports of retaliated products




(c) Product-country trade balance

Figure 7: **Direct effects on imports, exports and the trade balance.** Estimates of $\beta_{h\ell}$ from equation (23) at the HS6-by-country-by-month level, heterogeneity-robust estimator of de Chaisemartin and D'Haultfœuille (2020). Panel (a): U.S. imports of tariffed products from the tariffed source. Panel (b): U.S. exports of retaliated products to the retaliating destination. Panel (c): the product-country trade balance. Horizon in months relative to the month the duty took effect. Shaded areas are 90% confidence intervals.

Imports of tariffed products fall by about 40% over the ten months following implementation, U.S. exports to retaliating destinations fall by about 25%, and the product-level trade balance shows no offsetting improvement. These magnitudes are consistent with the prior literature on the same episode rather than new: Amiti et al. (2019) and Fajgelbaum et al. (2020) document border-price pass-through and trade-flow contractions of comparable size. These estimates serve as the policy first stage. They establish that the tariff and retaliation lists moved the flows they directly targeted, so the absence of a corresponding employment or earnings response in the estimates above cannot be attributed to a failure of the policy to bind. Appendix E examines whether the contractions reflect a true reduction in U.S. trade with the world or a redirection towards non-listed partners.

### 4.6 Taking stock

The estimates line up into two chains of events. On the tariff side, the duty took effect at the border: imports of the tariffed products fell by about 40%, with some redirection towards other sources over time. The cost travelled downstream through the production network, into the prices of the consumption categories that use the tariffed inputs, which rose, and into real consumption of those categories, which fell. It did not affect the labour market: employment and earnings in the exposed industries did not move, whether the tariff is counted as a cost to the industries that use the taxed product or as sales to those that make it; neither channel differs from zero. On the retaliation side, the chain ran the other way. Exports of the retaliated products fell by about a quarter, with no redirection to other destinations. The industries that lost the sales, and their domestic suppliers, lowered prices, but the lower prices did not bring the demand back. With revenue down and wages that do not fall, the adjustment landed on employment, which fell by about 20% in the exposed industries. Within them, it landed on the hours of the lowest-paid workers, who are the households least able to absorb an income loss. The incidence of the war is therefore regressive, and it is regressive through employment.

However, in these results, the component common to all industries, the aggregate response of demand, prices and employment, is absorbed by the time fixed effects. They say who lost and through which margin; they cannot say how much the economy lost, nor how the losses in exposed sectors spilled into the rest. To recover the aggregate and to account for these results jointly, the next section builds a multi-country, multi-sector New Keynesian model with production networks and hand-to-mouth households, disciplines it with the estimates above, and feeds it the calendar of the war.

## 5 Model

The estimates of Section 4 are relative: they identify the effect of being more exposed to the war than another industry, while the response common to all industries, of aggregate demand, prices, wages and employment, is absorbed by the time fixed effects. Two questions are therefore left open. What did the war cost the economy as a whole, how much of that cost came from the tariffs and how much from the retaliation, and how was it shared across households? And what could policy have done about it, a question that needs a welfare criterion and a planner against which to measure the outcome. Answering them requires a general-equilibrium model, disciplined by the cross-sectional estimates so that it reproduces what they identify and used to recover what they cannot.

The model is a three-country, three-sector New Keynesian economy with production networks. Trade and production follow Kalemli-Özcan et al. (2026), with every sector buying inputs from every sector in every country, so that a tariff travels through the model's supply chain along the same links as in Section 3. Labour enters production as in Andreolli et al. (2025), as a sector-specific bundle of two skills. To this structure I add household heterogeneity. The United States

has unconstrained and hand-to-mouth households, supplying high- and low-skill labour, with the low-skill share of each sector set to the sectoral concentration of hand-to-mouth workers in the PSID, and nominal wages that are stickier for the low-skilled. Heterogeneity of this kind is new to the quantitative analysis of a trade war: existing models of the episode combine production networks and retaliation with a representative household, or heterogeneous households without a network. The rest of the section states the model, keeping to the equations needed to read the results; the primitives, derivations, equilibrium conditions and solution method are in appendix F, in the same order.

### 5.1 Environment

The world consists of three countries, $n, m \in \{\text{US}, \text{RoW}, \text{CHN}\}$, the United States, an aggregated rest of the world and China, each with three sectors, $i, j \in \{1, 2, 3\}$: manufacturing, services, and agriculture, which includes food processing. The partition is chosen so that the two sides of the war map onto distinct sectors. Manufacturing absorbs the Section 232 and 301 tariffs, agriculture absorbs the Chinese retaliation, which fell almost entirely on U.S. farm exports, and services is the unexposed sector that carries most of U.S. value added and through which the aggregate-income channel operates. Time is discrete and a period is one quarter. The United States carries the index $n = 1$.

The United States is populated by a unit mass of households. A measure $1-\mu$ are *unconstrained* households, indexed $h = H$, who own the firms, trade the international bond and supply high-skill labour. The remaining measure $\mu \in (0, 1)$ are *hand-to-mouth* households, indexed $h = L$, who hold no assets, receive no profits and supply low-skill labour. Each foreign country is populated by a representative household supplying a single labour input. $E_{n,t}$ denotes units of country $n$'s currency per dollar, with $E_{1,t} \equiv 1$, so that a rise in $E_{3,t}$ is a dollar appreciation against the renminbi. A good produced in $m$ and sold in $n$ converts at $E_{n,t}/E_{m,t}$.

**The network.** Four sets of constant weights describe expenditure patterns. On the consumption side, $\Gamma^{\text{sec}}_{n,i}$ is the share of country $n$'s consumption expenditure falling on sector $i$ and $\Gamma^{\text{src}}_{n,i,m}$ the share of that sector-$i$ expenditure sourced from country $m$, whose diagonal element is the home share. On the production side, $\Omega^{\text{sec}}_{n,i,j}$ is the share of the intermediate spending of sector $(n, i)$ falling on goods of sector $j$, and $\Omega^{\text{src}}_{n,i,j,m}$ is the share of that input spending sourced from country $m$. The first index is the purchasing sector and the second the input sector. Each set sums to one over its last index. The $\Omega$ weights are the model's counterpart of the technical coefficients of Section 3. Here $\Omega^{\text{sec}}$ is the input mix of each sector and $\Omega^{\text{src}}$ its origin composition, so a tariff on an input travels through the model's supply chain along the same links that carry it in the exposures. All four are taken from the OECD Inter-Country Input–Output tables for 2015 (OECD, 2022), aggregated to three countries and three sectors following Kalemli-Özcan et al. (2026); appendix F.1 defines each tensor.

**Tariffs.** Country $n$ levies two ad valorem tariffs on imports of sector-$i$ goods from $m \neq n$: $\tau^{C}_{n,m,i,t}$ when the good is bought by households for consumption and $\tau^{X}_{n,m,i,t}$ when it is bought by firms as an intermediate input; domestic sales are untaxed. With $P_{m,i,t}$ the producer-currency price of sector-$i$ output in country $m$, the prices paid in country $n$ are

$$\tilde{p}^{C}_{n,m,i,t} = \frac{E_{n,t}}{E_{m,t}}(1+\tau^{C}_{n,m,i,t})P_{m,i,t}, \qquad \tilde{p}^{X}_{n,m,i,t} = \frac{E_{n,t}}{E_{m,t}}(1+\tau^{X}_{n,m,i,t})P_{m,i,t}. \tag{24}$$

Keeping the two instruments separate lets the same good be taxed at different rates according to its use, which the lists did: $\tau^{C}$ is a consumer price that households can substitute away from, $\tau^{X}$ a production cost that propagates through the network.

## 5.2 Preferences

Households of type $h \in \{H, L\}$ in the United States rank sequences of consumption and hours according to

$$\mathcal{U}^{h}_{0} = \sum_{t=0}^{\infty} \beta^{t} \log(\tilde{C}^{h}_{t}), \qquad \tilde{C}^{h}_{t} = C^{h}_{t} - \chi^{h}\frac{(N^{h}_{t})^{1+\eta_{h}}}{1+\eta_{h}}, \qquad C^{h}_{t} = \prod_{i}\Big(\frac{C^{h}_{i,t}}{\Gamma^{\text{sec}}_{1,i}}\Big)^{\Gamma^{\text{sec}}_{1,i}}, \tag{25}$$

with $\beta$ the discount factor, $N^{h}_{t}$ hours, $\chi^{h}$ a disutility scale and $\eta_{h}$ a type-specific inverse Frisch elasticity. Preferences are of the Greenwood–Hercowitz–Huffman class: hours enter through $\tilde{C}^{h}$, so the marginal rate of substitution between consumption and hours, $\chi^{h}(N^{h}_{t})^{\eta_{h}}$, is independent of consumption and labour supply carries no wealth effect. The sectoral aggregate is Cobb–Douglas with the expenditure shares of the network as weights.

**Consumption bundles.** Within each sector, consumption is a constant-elasticity aggregate over origins,

$$C_{n,i,t} = \Big[\textstyle\sum_{m}\big(\Gamma^{\text{src}}_{n,i,m}\big)^{1/\theta_{C\ell,n}} c^{(\theta_{C\ell,n}-1)/\theta_{C\ell,n}}_{n,m,i,t}\Big]^{\theta_{C\ell,n}/(\theta_{C\ell,n}-1)}, \tag{26}$$

where $c_{n,m,i,t}$ is country $n$'s purchases of sector-$i$ goods produced in $m$ and $\theta_{C\ell,n}$ the Armington elasticity, which differs across importers. Expenditure minimisation gives the sectoral and aggregate consumer price indices and the demand for each origin,

$$(P^{C}_{n,i,t})^{1-\theta_{C\ell,n}} = \sum_{m}\Gamma^{\text{src}}_{n,i,m}(\tilde{p}^{C}_{n,m,i,t})^{1-\theta_{C\ell,n}}, \qquad P^{C}_{n,t} = \prod_{i}(P^{C}_{n,i,t})^{\Gamma^{\text{sec}}_{n,i}}, \qquad c_{n,m,i,t} = \Gamma^{\text{src}}_{n,i,m}\Big(\frac{\tilde{p}^{C}_{n,m,i,t}}{P^{C}_{n,i,t}}\Big)^{-\theta_{C\ell,n}} C_{n,i,t}. \tag{27}$$

The consumption tariff enters the price level through the first expression and redirects demand across origins through the third, with a strength set by $\theta_{C\ell,n}$.

**Unconstrained households** choose consumption, hours and bond holdings $a_t$ subject to

$$\sum_i P^C_{1,i,t} C^H_{i,t} + a_t = W^H_t N^H_t + (1 + i_{1,t-1}) a_{t-1} + \frac{\Pi_t + (1 - \omega_T) T_t}{1 - \mu}, \tag{28}$$

where $i_{1,t}$ is the U.S. nominal rate, $W^H_t$ the high-skill wage, $\Pi_t$ the profits of U.S. firms and $T_t$ tariff revenue, of which a share $\omega_T$ is rebated to hand-to-mouth households. Their optimality conditions are the Euler equation $\tilde{C}^H_{t+1} P^C_{1,t+1} = \beta(1 + i_{1,t}) \tilde{C}^H_t P^C_{1,t}$ and, when wages are flexible, the labour-supply condition $\chi^H (N^H_t)^{\eta_H} = W^H_t / P^C_{1,t}$.

**Hand-to-mouth households** hold no assets, so their budget constraint is an identity,

$$\sum_i P^C_{1,i,t} C^L_{i,t} = W^L_t N^L_t + \frac{\omega_T T_t}{\mu}. \tag{29}$$

Their consumption equals current income period by period: whatever happens to their hours passes one for one into their consumption, and their marginal propensity to consume out of income is one. This is the channel through which the hours loss of Section 4.4 becomes a consumption loss.

### 5.3 Firms

Each sector $(n, i)$ produces gross output with labour and an intermediate bundle,

$$Y_{n,i,t} = \left[ \alpha^{1/\theta_X}_{n,i} L^{(\theta_X - 1)/\theta_X}_{n,i,t} + (1 - \alpha_{n,i})^{1/\theta_X} X^{(\theta_X - 1)/\theta_X}_{n,i,t} \right]^{\theta_X / (\theta_X - 1)}, \tag{30}$$

where $\alpha_{n,i}$ is the labour weight and $\theta_X$ the elasticity of substitution between labour and materials. The bundle $X_{n,i,t}$ is built in two tiers that mirror the network weights: a constant-elasticity aggregate across input sectors $j$ with weights $\Omega^{\text{sec}}_{n,i,j}$ and elasticity $\theta_{Xh}$, and within each input sector an aggregate across origins $m$ with weights $\Omega^{\text{src}}_{n,i,j,m}$ and elasticity $\theta_{X\ell,n}$. Cost minimisation gives the price of the bundle and the sector's real marginal cost,

$$\left(P^X_{n,i,j,t}\right)^{1-\theta_{X\ell,n}} = \sum_m \Omega^{\text{src}}_{n,i,j,m} \left(\tilde{p}^X_{n,m,j,t}\right)^{1-\theta_{X\ell,n}}, \qquad \left(P^X_{n,i,t}\right)^{1-\theta_{Xh}} = \sum_j \Omega^{\text{sec}}_{n,i,j} \left(P^X_{n,i,j,t}\right)^{1-\theta_{Xh}}, \tag{31}$$

$$\left(mc_{n,i,t} P_{n,i,t}\right)^{1-\theta_X} = \alpha_{n,i} \left(W^{\text{sec}}_{n,i,t}\right)^{1-\theta_X} + (1 - \alpha_{n,i}) \left(P^X_{n,i,t}\right)^{1-\theta_X}, \tag{32}$$

with $W^{\text{sec}}_{n,i,t}$ the wage index the sector pays. The input tariff enters through $\tilde{p}^X$ in the first expression and reaches marginal cost through the second. Because the bundle of each sector contains the output of every other sector, a tariff on one input raises the marginal cost of its direct buyers, then of their buyers, and so on. This is the propagation that the exposures of Section 3 measure. In the limit in which the three elasticities $\theta_X$, $\theta_{Xh}$ and $\theta_{X\ell,n}$ go to zero, the log change in marginal cost is the $\Omega$-weighted sum of the log changes in input prices, and the fixed point of (32) across sectors is the Leontief propagation of equation (14). Away from that limit firms can substitute, across origins,

across inputs and towards labour, and the three elasticities govern how much of an input tariff is a cost increase and how much is escaped. Comparing (31) with (27) shows the asymmetry between the two instruments: a consumption tariff is met by one margin of substitution, an input tariff by three, each small in the calibration.

**Labour.** In the United States, sectoral labour is a constant-elasticity aggregate of the two skills,

$$L_{1,i,t} = \Big[(\alpha_i^H)^{1/\theta_{HL}}(L_{i,t}^H)^{(\theta_{HL}-1)/\theta_{HL}} + (\alpha_i^L)^{1/\theta_{HL}}(L_{i,t}^L)^{(\theta_{HL}-1)/\theta_{HL}}\Big]^{\theta_{HL}/(\theta_{HL}-1)}, \tag{33}$$

$$(W_{1,i,t}^{\text{sec}})^{1-\theta_{HL}} = \alpha_i^H (W_t^H)^{1-\theta_{HL}} + \alpha_i^L (W_t^L)^{1-\theta_{HL}}, \tag{34}$$

with $\alpha_i^L = 1 - \alpha_i^H$ the low-skill weight of sector $i$ and $\theta_{HL}$ the elasticity of substitution between skills. Since each household type supplies one skill, the weights $\alpha_i^L$ convert a sectoral shock into a distributional one: a contraction concentrated in sectors with a high $\alpha_i^L$ falls on hand-to-mouth households. Abroad, labour is a single input and $W_{n,i,t}^{\text{sec}} = W_{n,t}$. Labour moves freely across sectors; the only frictions in the model are the nominal ones introduced next.

### 5.4 Nominal rigidities

Varieties within each sector are supplied by monopolistically competitive firms that pay a quadratic cost, with sector-specific scale $\delta_{n,i}$, of changing their price. Prices satisfy the Phillips curve

$$(\pi_{n,i,t} - 1)\pi_{n,i,t} = \frac{\theta_R - 1}{\delta_{n,i}}(mc_{n,i,t} - 1) + \beta(\pi_{n,i,t+1} - 1)\pi_{n,i,t+1}, \tag{35}$$

with $\pi_{n,i,t} \equiv P_{n,i,t}/P_{n,i,t-1}$ and $\theta_R$ the elasticity of substitution across varieties. A subsidy offsets the markup, so the steady state is efficient and $\theta_R$ governs only the slope. Sectors differ in $\delta_{n,i}$, which determines which sectors absorb a shock through prices and which through quantities.

In the United States each skill is supplied as a continuum of labour varieties whose wages are set subject to a quadratic adjustment cost with skill-specific scale $\delta_W^h$. The nominal wage of skill $h$ satisfies

$$(\pi_t^{W,h} - 1)\pi_t^{W,h} = \frac{\theta_{R,W} - 1}{\delta_W^h}\left(\frac{\chi^h (N_t^h)^{\eta_h} P_{1,t}^C}{W_t^h} - 1\right) + \beta(\pi_{t+1}^{W,h} - 1)\pi_{t+1}^{W,h}, \qquad h \in \{H, L\}, \tag{36}$$

with $\pi_t^{W,h} \equiv W_t^h / W_{t-1}^h$. The term in brackets is the gap between the desired real wage, the marginal rate of substitution of (25), and the actual one; with $\delta_W^h = 0$ the flexible labour-supply condition is recovered. Away from that limit, firms hire what they need at posted wages, and hours are demand-determined in the short run. A fall in the demand for a sector's output is met by a fall in employment rather than in pay, which is what Section 4.3 finds. Because $\delta_W^L > \delta_W^H$, the two skill markets clear differently, the high-skill one partly through the wage and the low-skill one through hours. Foreign wages are flexible.

### 5.5 Foreign economies, government and policy

**Foreign economies.** The representative household in country $n \in \{\text{RoW}, \text{CHN}\}$ ranks sequences according to

$$\mathcal{U}_{n,0} = \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_{n,t}^{1-\sigma}}{1-\sigma} - \chi_n \frac{L_{n,t}^{1+\eta}}{1+\eta} \right], \tag{37}$$

with $\sigma$ the coefficient of relative risk aversion, $\eta$ the inverse Frisch elasticity, and consumption aggregated across sectors as in (25) at the weights $\Gamma_{n,i}^{\text{sec}}$ and across origins as in (26) with its own elasticity $\theta_{C\ell,n}$. The household holds the dollar bond, receives the profits $\Pi_{n,t}$ of its firms and the tariff revenue $T_{n,t}$ of its government, and faces, in local currency,

$$\sum_i P_{n,i,t}^C C_{n,i,t} + E_{n,t}\mathcal{B}_{n,t} = W_{n,t}L_{n,t} + \Pi_{n,t} + T_{n,t} + E_{n,t}(1 + i_{1,t-1})\mathcal{B}_{n,t-1}, \tag{38}$$

where $\mathcal{B}_{n,t}$ is its net holding of the bond in dollars, whose local-currency return equals $1 + i_{n,t-1}$ through the parity condition below.

Foreign preferences are separable, so the term $C_{n,t}^{\sigma}$ keeps the wealth effect on labour supply that (25) removes, and foreign wages are flexible, so the labour-supply condition holds period by period. Foreign firms have the technology and price setting of Sections 5.3 and 5.4 with a single labour input.

**Government.** A unit bought from $m$ costs the buyer $\tilde{p}$ as in (24), of which $(E_{n,t}/E_{m,t})P_{m,i,t}$ accrues to the producer and the remainder to the government. U.S. tariff revenue is therefore

$$T_t = \sum_{m \neq 1} \sum_i \frac{\tau_{1,m,i,t}^C}{1 + \tau_{1,m,i,t}^C} \tilde{p}_{1,m,i,t}^C c_{1,m,i,t} + \sum_{m \neq 1} \sum_{i,j} \frac{\tau_{1,m,j,t}^X}{1 + \tau_{1,m,j,t}^X} \tilde{p}_{1,m,j,t}^X x_{1,i,j,m,t}, \tag{39}$$

with the analogous expression for each foreign country. Each government rebates its revenue in full as a lump-sum transfer within the period; budgets balance and no debt is issued. In the United States a share $\omega_T$ of the revenue goes to hand-to-mouth households and the rest to unconstrained households, as in (28) and (29). Since the consumer cost of a tariff falls on both household types while its revenue is returned to either, $\omega_T$ determines how much of the burden each group bears; its value is set in Section 6 from the farm-support payments the revenue financed.

**Monetary policy and asset markets.** Each central bank follows the rule

$$1 + i_{n,t} = (1 + i_{n,t-1})^{\rho_n} \left[ \frac{1}{\beta} (\pi_{n,t}^C)^{\phi_{\pi,n}} (P_{n,t}^C)^{\phi_{p,n}} \left( \frac{Y_{n,t}}{\bar{Y}_{n,t}} \right)^{\phi_{y,n}} \right]^{1-\rho_n}, \tag{40}$$

with $\pi_{n,t}^C$ consumer-price inflation and $\bar{Y}_{n,t}$ the level of output treated as potential; the small price-level term is needed for determinacy under permanent shocks. The only internationally traded asset is a one-period dollar bond in zero net supply, subject to a cost linear in the country's net

position, so that

$$\frac{1+i_{n,t}}{1+i_{1,t}} = \frac{E_{n,t+1}}{E_{n,t}}\Big(1-\psi\frac{\mathcal{B}_{n,t}}{P^{C}_{1,t}}\Big), \qquad n \neq 1, \tag{41}$$

where $\mathcal{B}_{n,t}$ is country $n$'s net foreign asset position, which evolves with its balance of payments. The cost is a stationarity device that pins the steady-state distribution of net foreign assets at zero.

**The tariff experiment.** The war is modelled as a sequence of unanticipated changes, each believed permanent on arrival. Each quarter from 2018Q1 carries, on every bilateral sectoral leg, the day-weighted average of the statutory rates in force, and the last quarter carries the September 2019 schedule; no parameter of the shock process is free. At each announcement agents observe the new tariff vector and believe it will remain in place forever, so that beliefs are revised only at the announcement dates and the expectation errors at those dates are the only surprises in an otherwise deterministic model. The specification delivers the actual implementation calendar rather than a geometric decay, and replaces the front-loading that a fully anticipated permanent shock imposes with a build-up whose shape is set by the historical dates. The single-announcement case is retained as a comparison.

### 5.6 Equilibrium

Given initial conditions and a tariff vector, an equilibrium is a sequence of prices and quantities in which households and firms satisfy their optimality conditions, prices and wages follow (35) and (36), goods markets clear sector by sector and labour markets skill by skill, government budgets balance, the bond market clears with (41), and monetary policy follows (40). The war is a sequence of such equilibria: at each announcement agents believe the new tariff vector permanent, the plan starts from the state the previous plan delivered and converges to the steady state of its own tariffs, and the realised path is the splice of the plans at the announcement dates. The pre-war steady state, at the most-favoured-nation tariffs, is the calibration point. Appendix F.7 gives the definitions and the solution algorithm.

## 6 Calibration

The model is calibrated at a quarterly frequency. Table 4 lists the parameters and their sources. The network, the sectoral labour shares, the hand-to-mouth shares and the tariff levels are read from the data; the elasticities, durations and Frisch elasticities are taken from the literature; the remaining parameters take standard values. Two parameters are chosen within a range, China's Armington elasticity and the relative skill wage.

The household block is calibrated from the PSID, the source of the paper's distributional evidence. Following Kaplan et al. (2014), a household is hand-to-mouth if its liquid assets are worth less than one month of income, which gives $\mu = 1/3$. The sectoral weights $\alpha_i^L$ come from the same data and the same industry mapping that underlie the exposures. Each PSID household is

assigned to the industry of its primary earner, and the industry is mapped to one of the three sectors through the crosswalk used for the tariff and retaliation exposures. The share of the sector's hours supplied by hand-to-mouth households is the sector's low-skill share, which is highest in agriculture and lowest in services. The shares are scaled up towards $\mu$: their employment-weighted mean is 0.30, and the rest of the gap is closed by the hours per worker of the two types. The CES weights are then set so that the model reproduces these hours shares at the calibration steady state given the relative wage. This inversion depends on the endogenous skill premium and is solved as a fixed point; appendix F.3 gives the mapping and the sensitivity of the weights to the premium. The relative wage is set so that the per-capita income of unconstrained households is 1.25 times that of hand-to-mouth households; because the former work about fifteen percent more hours, this requires a wage ratio of only 1.086. The two types also differ in labour supply and wage rigidity, in the direction the evidence suggests. Hand-to-mouth hours respond 1.3 to 1.5 times as much as unconstrained hours to the same demand shock (Patterson, 2023), and the wages of lower-paid hourly workers are adjusted rarely and almost never cut (Grigsby et al., 2021). A flat low-skill labour-supply schedule and a stickier low-skill wage capture both.

On the production side, firms cannot substitute between imported inputs and other factors at quarterly horizons, so $\theta_X = \theta_{Xh} = 0.2$ (Boehm et al., 2019; Atalay, 2017); U.S. firms switch across sources at the impact trade elasticity of 0.7 (Boehm et al., 2023) and foreign firms at 1.5. The U.S. consumption elasticity of 4 (Fajgelbaum et al. (2020)), China's elasticity is set at 2. Price durations follow Nakamura and Steinsson (2008) and are mapped into adjustment costs at $\theta_R = 10$; the wage costs imply durations of about one year for high-skill and two years for low-skill wages. All central banks follow the same rule, with smoothing of 0.85, an inflation response of 1.5 and a small price-level term, and an output-gap response of 0.125 in the United States and China and zero in the rest of the world. The cost of holding the international bond is the debt-elastic premium of Schmitt-Grohé and Uribe (2003), the device that makes net foreign assets stationary, set at 0.001. The share of tariff revenue rebated to hand-to-mouth households is the ratio of Market Facilitation Program payments to customs duties over 2018–19, about 0.35,[10] times the low-skill share of agricultural labour income. The latter is the fraction of those payments that accrues to hand-to-mouth households in the model, and the product gives 0.232. The same payments are embedded in the retaliation estimates of Section 4.3, which are net of them, so that the empirical and the model-based costs of retaliation measure the same object.

The calibration steady state is not a free-trade allocation. Every cross-border goods leg carries the most-favoured-nation duty, the non-discriminatory rate applied to all partners before the war, set at 2%, the U.S. trade-weighted applied rate; services are untaxed. At this steady state customs revenue is 0.19% of GDP, against 0.2% in the data. The war is the set of increments over that baseline in Table 5. These are value-weighted averages of the Section 301 and 232 schedules and of the retaliation lists from the Peterson Institute tracker (Bown and Kolb, 2021), computed separately

[10]The Market Facilitation Program was the USDA scheme, announced in July 2018 and renewed in 2019, that paid direct compensation to producers of the commodities hit by retaliation, soybeans above all, financed through the Commodity Credit Corporation. Its two rounds paid out about $23 billion.

Table 4: Calibration (quarterly)

| Parameter | Value | Source |
|---|---|---|
| *Households* | | |
| $\beta$ | 0.99 | 4% annual real rate. |
| $\mu$ | 1/3 | Hand-to-mouth share; PSID, Kaplan et al. (2014). |
| $s_i$ | [0.422, 0.273, 0.664] | Low-skill hours share by sector (manufacturing, services, agriculture); PSID hand-to-mouth share by industry of the primary earner. The CES weights $\alpha_i^L$ = [0.412, 0.265, 0.655] reproduce these shares at the calibration steady state (appendix F.3). |
| $W^H/W^L$ | 1.086 | Per-capita income ratio of 1.25 between types; PSID. |
| $\eta_H,\ \eta_L$ | 1.5, 0.5 | Inverse Frisch elasticities by type; Patterson (2023). |
| $\theta_{HL}$ | 0.5 | Skill substitution within a sector. |
| $\sigma,\ \eta$ | 2, 1 | Foreign risk aversion and inverse Frisch; Kalemli-Özcan et al. (2026). |
| *Technology and trade* | | |
| $\Gamma,\ \Omega$ | ICIO | OECD Inter-Country Input–Output tables, 2015 (OECD, 2022); three countries, three sectors. |
| $\Gamma^{\text{src}}_{\text{CHN,Agri,US}}$ | 0.05 | China's sourcing of agricultural final goods from the U.S.; the ICIO value of 0.004 raised so that the retaliation lists carry weight. |
| $\alpha_{n,i}$ | [0.30, 0.60, 0.35] | Value-added share of gross output by sector; ICIO. |
| $\theta_X,\ \theta_{Xh}$ | 0.2, 0.2 | Labour–materials and across-input substitution; Boehm et al. (2019), Atalay (2017). |
| $\theta_{X\ell,n}$ | [0.7, 1.5, 1.5] | Input Armington (U.S., RoW, China); Boehm et al. (2023), Kalemli-Özcan et al. (2026). |
| $\theta_{C\ell,n}$ | [4, 1.5, 2] | Consumption Armington (U.S., RoW, China); Fajgelbaum et al. (2020), Kalemli-Özcan et al. (2026), chosen. |
| *Nominal rigidities* | | |
| $\theta_R,\ \theta_{R,W}$ | 10, 10 | Variety elasticities; set only the Phillips-curve slopes. |
| $\delta_{n,i}$ | [33, 150, 37.5] | Price-adjustment cost (manufacturing, services, agriculture); Nakamura and Steinsson (2008) durations. |
| $\delta_W^H,\ \delta_W^L$ | 75, 130 | Wage-adjustment cost by skill; Grigsby et al. (2021). |
| *Policy and international* | | |
| $\rho_n,\ \phi_{\pi,n},\ \phi_{p,n}$ | 0.85, 1.5, 0.01 | All central banks; Taylor (1993), Clarida et al. (2000). |
| $\phi_{y,n}$ | [0.125, 0, 0.125] | Output-gap response (U.S., RoW, China). |
| $\psi$ | 0.001 | Debt-elastic premium; Schmitt-Grohé and Uribe (2003). |
| $\omega_T$ | 0.232 | Share of tariff revenue rebated to hand-to-mouth households; Market Facilitation Program payments over customs duties, 2018–19. |
| $\bar{\tau}$ | 0.02 | Pre-war tariff on goods, zero on services; U.S. trade-weighted applied MFN rate. |
| $\bar{\tau}^{\text{peak}}$ | by leg | Terminal tariff increments by leg, Table 5; Bown and Kolb (2021) timeline, value-weighted. |

Table 5: Tariff calibration at the September 2019 peak: increments over the 2% MFN baseline

| Leg | Trade flow (importer, source, sector) | $\Delta\tau^C$ | $\Delta\tau^X$ | Underlying schedule |
|---|---|---|---|---|
| 1 | US from China, Manufacturing | 18.0 | 24.0 | Section 301 Lists 1–4A at peak |
| 2 | US from RoW, Manufacturing | 0.5 | 2.0 | Section 232 steel and aluminium |
| 3 | China from US, Agriculture | 12.0 | 30.0 | Soybean, pork, sorghum retaliation |
| 4 | China from US, Manufacturing | 13.0 | 13.0 | Broad Chinese retaliation lists |
| 5 | RoW from US, Manufacturing | 1.5 | 0.75 | Section 232 EU/Canada/Mexico retaliation |
| 6 | RoW from US, Agriculture | 1.2 | 0.6 | Mexico pork, EU/Canada food lists, India |

*Notes.* Percentage points, added to the 2% MFN baseline that applies to every cross-border goods leg in both channels; services are untaxed. Value-weighted over all imports in the relevant flow. Legs 1–2 are the U.S. tariff block, legs 3–6 the retaliation block.

on the consumer and the intermediate component of each bilateral sectoral leg and evaluated at the September 2019 peak. Figure 8 shows the quarterly path, each quarter carrying the day-weighted average of the rates in force; the calendar from which it is built is in appendix F.6.

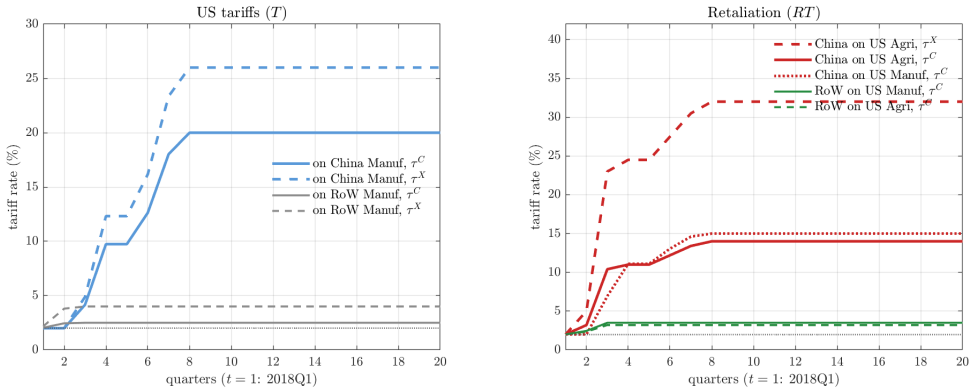



Figure 8: **The implemented tariff path.** Applied ad valorem rates by leg and channel, quarter by quarter, from 2018Q1, over the 2% MFN baseline. Agents observe each step when it is implemented and treat the resulting configuration as permanent; the eight steps are the eight information sets of definition 1.

**Moment matching.** As a check on the calibration, I also estimate the three trade elasticities and the hand-to-mouth Frisch elasticity by minimum distance (Christiano et al., 2005), minimising $J(\theta) = \sum_k [(m_k(\theta) - \hat{m}_k)/\hat{\sigma}_k]^2$. The targeted moments are the long-run fall in tariffed imports and in exports to China, the effective dollar appreciation, and the paper's twelve-month local-projection coefficients for retaliation-exposed employment, tariff-exposed employment and earnings. Output, inflation and incidence are left untargeted. China's Armington elasticity is identified, at 1.5 to 1.7 with a standard error of 0.4 to 0.7, through exports to China and the retaliation-employment coefficient (Andrews et al., 2017). The other three parameters remain at their calibrated values. The over-identification test does not reject the model, and the untargeted output loss is the same at every estimate as in the baseline.

### 6.1 Quantitative Results

The war is fed to the model as the eight quarterly announcements of Section 6, each believed permanent on arrival. I report the joint response and, where the split matters, the response to the U.S. legs and to the retaliation legs alone; the two add up to the joint response to a close approximation.

**Aggregates.** The war lowers U.S. GDP by 0.4%, permanently (Figure 9): output falls in steps as the waves land, reaches a trough of half a percent when the schedule is complete, and settles four tenths below its pre-war level. The mechanism is a permanent-income shock met by sticky wages. Each wave tells households that the goods they buy are permanently dearer and the goods they sell abroad permanently in less demand; with nothing to smooth, consumption falls at once by about as much as income, and because output combines labour and materials in near-fixed proportions and firms meet lower demand at posted wages, hours fall one for one with output. The price level barely moves, a tenth of a percent at the peak, for a tariff of this size, because the tariffed Chinese varieties are a twentieth of consumption, lower demand pulls domestic costs the other way, and the dollar appreciates and cheapens every import the lists did not touch. The policy rate moves by a few basis points: the contraction is the shock, not the monetary response to it.

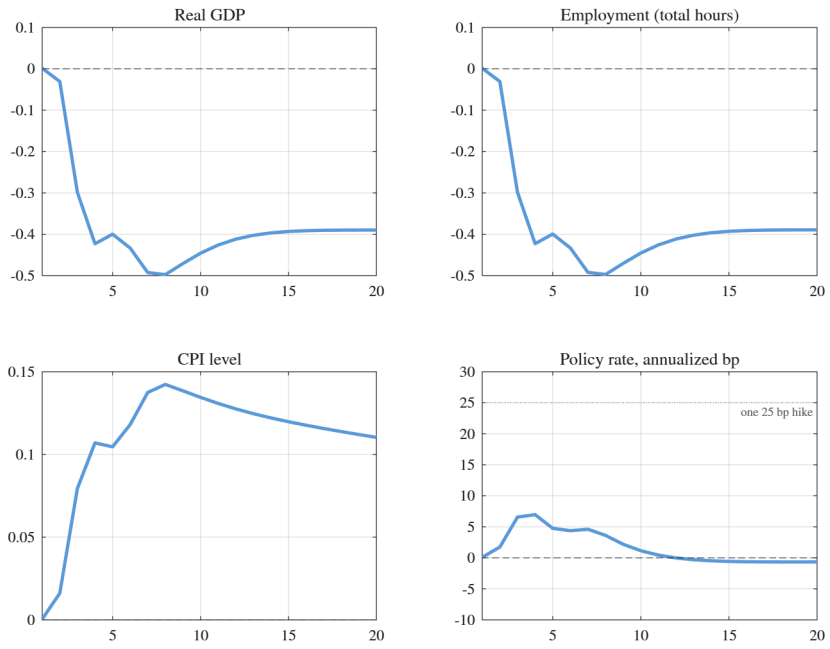



Figure 9: **Aggregate response to the trade war.** Real GDP, total hours and the consumer price level in percent deviation from the pre-war steady state; the policy rate in annualised basis points. Joint shock, quarters from 2018Q1 on the horizontal axis.

**Sectors.** The two instruments pull different levers, and Figure 10 shows which. Retaliation is a concentrated demand shock: China buys a tenth of U.S. agricultural output and removes that demand with nothing to replace it, and under sticky wages the lost revenue lands on employment, which falls by 4% in agriculture, two thirds of it because of retaliation, in line with the estimates of Section 4. Services export nothing and buy no tariffed inputs, yet lose a third of a percent of employment through lower domestic income alone; this is the spillover that no exposure regression can see. Manufacturing, the sector the tariffs were meant to help, ends flat. The consumer tariff redirects some demand to U.S. varieties, but they are a tenth of the manufacturing basket, and against that gain stand the input tariff, which raises the cost of intermediates firms cannot substitute away from, the retaliation on U.S. manufactures, and the fall in aggregate income. Under the U.S. tariff alone manufacturing employment ends two tenths higher, under retaliation alone two tenths lower, and the net is close to zero: the null employment result of Section 4, generated inside the model together with its cause. The sign is specific to this war; with more intermediates on the lists or a broader retaliation it would be negative.

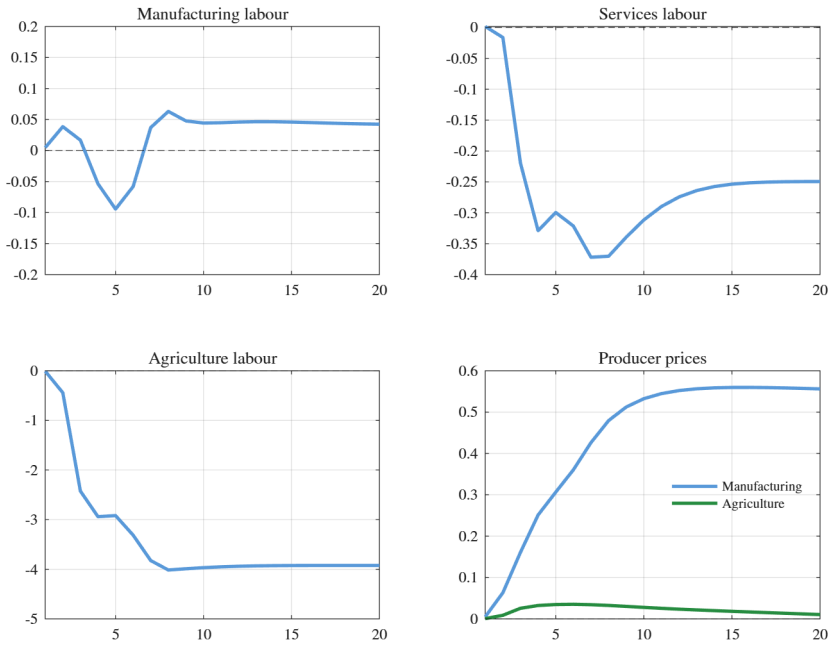



Figure 10: **Sectoral response.** Employment in manufacturing, services and agriculture, and producer prices in manufacturing and agriculture, in percent deviation from the pre-war steady state. Joint shock.

**Households.** Hand-to-mouth households lose almost twice as much consumption as unconstrained households, 0.6 against 0.3 percent in the long run (Figure 11), for three reasons. Their skill is concentrated in the sectors retaliation hit; their labour market clears through quantities, so their hours fall by twice as much while their wage falls by less than half as much; and they consume their income, so the hours loss reaches consumption in full, while unconstrained households smooth

part of theirs through the bond and receive most of the revenue. The ratio of hand-to-mouth to unconstrained hours responses, 1.8, is untargeted and sits above the 1.3 to 1.5 that Patterson (2023) estimates for a generic demand shock. The model reproduces the composition channel but not the within-sector concentration of the loss on the lowest paid, since it cuts the hours of both skills in proportion within a sector.

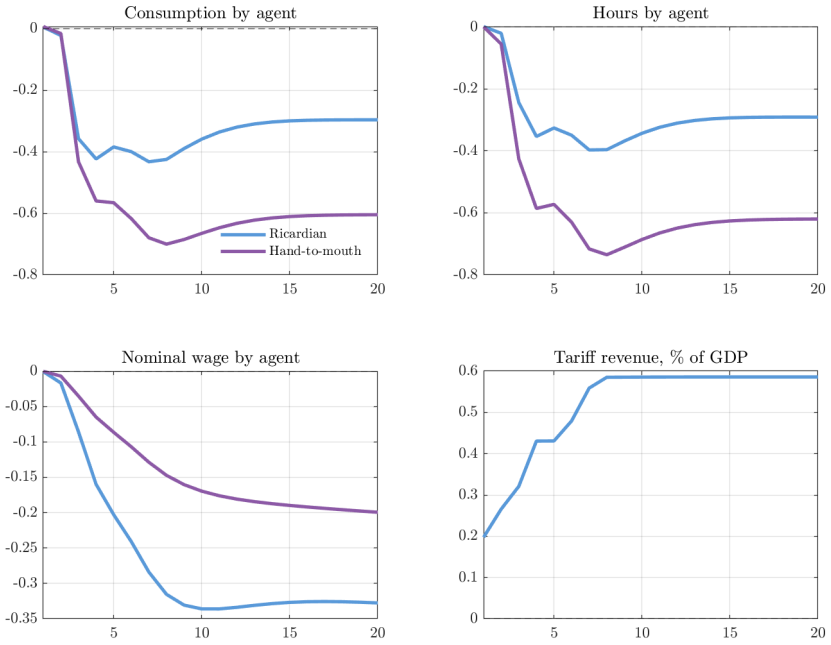



Figure 11: **Incidence by household type.** Consumption, hours and nominal wages of unconstrained (blue) and hand-to-mouth (purple) households in percent deviation from the pre-war steady state, and tariff revenue in percent of GDP. Joint shock.

The external account, the foreign economies and the comparison of the model with the evidence are in appendix G: imports of tariffed Chinese manufactures fall by 30% against 32% in the data, exports to China by 17% against 18%, and the dollar ends 0.8% stronger against the renminbi, about half the appreciation attributed to the tariffs in the episode. Appendix H reports three further experiments: a monetary rule that responds to the output gap rather than inflation, which gives a milder recession; the 2025 schedule run as a second war, sharper but less costly because a broader tariff raises more revenue and moves the terms of trade further while retaliation costs the same; and a productivity boom in services added to the 2025 war, which deepens the contraction before reversing it, with the gain accruing to unconstrained households.

# 7 Welfare

## 7.1 The measure

I measure the cost of the war to each household as a consumption equivalent, the constant proportional change in pre-war consumption that would leave the household as well off as it is along the realised path, including its continuation at the eventual steady state. Hours are valued at their pre-war level, since under sticky wages a fall in hours is rationing rather than leisure. With period utility $u^h(C) = \log(C - \bar{D}^h)$, $\bar{D}^h$ the pre-war disutility of hours, and $V_C^h$ and $\bar{V}_C^h$ the discounted values of the realised and the pre-war consumption paths,

$$\zeta^h = \frac{\tilde{\bar{C}}^h}{\bar{C}^h}\left[\exp\Big((1-\beta)(V_C^h - \bar{V}_C^h)\Big) - 1\right], \tag{42}$$

with the analogous expression for the foreign households. The U.S. aggregate weights the two households by pre-war consumption, the twenty-quarter measure truncates at $T = 20$, and the consumption change of each household is attributed to the items of its budget constraint, hours, the wage rate, the rebate, profits and net saving, in consumption-equivalent units that sum to the total.

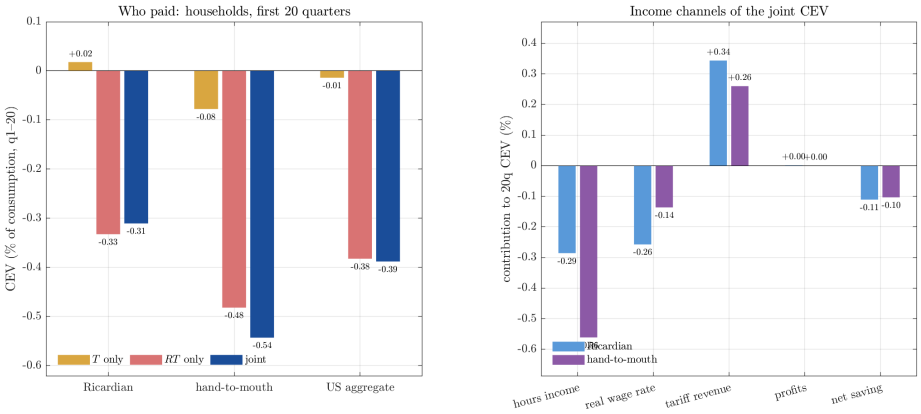



Figure 12: **Welfare.** Left: consumption-equivalent cost of the first twenty quarters for the unconstrained household, the hand-to-mouth household and the U.S. aggregate, under U.S. tariffs alone, retaliation alone and the joint war. Right: income channels of the two households' loss in the joint war.

Table 6: Welfare: consumption-equivalent variation, percent of pre-war consumption, realised path, first twenty quarters. World is dollar-GDP weighted.

| | Unconstrained | Hand-to-mouth | US | RoW | China | World |
|---|---|---|---|---|---|---|
| Own tariffs only | +0.02 | −0.08 | −0.01 | +0.00 | −0.15 | −0.03 |
| Retaliation only | −0.33 | −0.48 | −0.38 | −0.01 | +0.02 | −0.08 |
| Joint war | −0.31 | −0.54 | −0.39 | −0.00 | −0.13 | −0.11 |

Table 7: Channels of the U.S. consumption loss, joint war, first twenty quarters, consumption-equivalent units (percent).

| | Unconstrained | Hand-to-mouth |
|---|---|---|
| Hours | −0.29 | −0.56 |
| Wage rate | −0.26 | −0.14 |
| Tariff rebate | +0.34 | +0.26 |
| Profits | 0.00 | 0.00 |
| Net saving and price level | −0.11 | −0.10 |
| Total | −0.31 | −0.54 |

The war costs the United States four tenths of a percent of consumption, permanently, and retaliation is the whole of it (Table 6). The U.S. tariffs alone leave aggregate consumption unchanged, the finding of the static trade literature that the 2018 tariffs, net of their revenue, cost U.S. real income close to nothing; retaliation alone costs 0.38% and returns nothing. The gains and losses from the U.S. tariffs roughly offset; those from retaliation do not.

Hand-to-mouth households lose almost twice as much as unconstrained households, 0.54 against 0.31% (Table 7). The difference is hours, 0.56 against 0.29: their skill is rationed rather than repriced and it is concentrated where retaliation landed. The rebate offsets a third of the unconstrained household's loss and less of the hand-to-mouth household's, since it receives less of it; profits play no role, being zero at every steady state. The rebate is what makes own tariffs bearable, and who receives it is what makes them regressive. Redirecting it is the one instrument in the model that changes incidence without changing aggregates.

Across countries the incidence follows the terms of trade. Taken alone, China's tariffs raise its consumption slightly, as the optimal-tariff argument predicts; in the joint war China loses 0.13%, because the U.S. tariffs remove the demand for its manufactures with nothing to replace it. The rest of the world is unaffected, its losses as a customer offset by its gains as the substitute supplier in both markets. The world loss, 0.11% of consumption, is the deadweight cost of an exchange of tariffs between two countries that together account for a third of world output.

### 7.2 A social planner

The actual war is one of many possible policy combinations: what to tax, at what rate, how to spend the revenue, and how China answers. The model can ask what a planner who weighs both households would have done on each margin. In the optimal-tariff literature a tariff moves relative prices and the planner is a representative household (Ossa, 2014; Costinot and Rodríguez-Clare, 2014); with input–output linkages the optimal tariff falls on final goods rather than inputs (Beshkar and Lashkaripour, 2020); New Keynesian models add the demand channel with one household (Bergin and Corsetti, 2023) or two households without a network (Auclert et al., 2025), and who should receive the revenue is asked with a government that does not also set the tariff (Lyon and Waugh, 2018). Here a tariff is a cost shock through the network and a demand shock through

sticky wages, the planner weighs two households, retaliation is in the model, and the war arrives on its calendar.

The planner takes the private equilibrium conditions, the tariff calendar, the retaliation schedule and the information structure as given, and chooses either the terminal increments on the U.S. legs or the rule by which the revenue $T_t = \mu T_t^L + (1-\mu)T_t^H$ is paid to the two households. It is inequality-averse, with the Atkinson objective

$$\mathcal{W}_\gamma = (1-\mu)\, u_\gamma\big(\bar{C}^H(1+\zeta^H)\big) + \mu\, u_\gamma\big(\bar{C}^L(1+\zeta^L)\big), \qquad u_\gamma(c) = \frac{c^{1-\gamma}}{1-\gamma}, \tag{43}$$

where $\zeta^h$ is the consumption equivalent of Section 7.1 on the realised path; at $\gamma = 2$ a dollar to the hand-to-mouth household is worth 1.6 dollars to the unconstrained one. I report the planner's valuation as the percent change in equally-distributed-equivalent consumption (Atkinson, 1970). The first-order condition adds to the terms-of-trade and pass-through terms of the static optimal-tariff problem a labour-income term, first order only because wages are sticky, and a revenue term weighted by who receives it; appendix I derives it and describes the solution method.

The revenue is the planner's margin, and Table 8 compares the observed rule, a fixed share $\omega_T$ of the revenue paid to hand-to-mouth households, with the one the planner would choose: a benefit indexed to the hours they lose,

$$T_t^L = \bar{T}^L + \kappa\, \bar{W}^L(\bar{N}^L - N_t^L), \qquad T_t^H = \frac{T_t - \mu T_t^L}{1-\mu}, \tag{44}$$

where $\bar{T}^L$ is the household's share of the pre-war revenue, $\bar{W}^L(\bar{N}^L - N_t^L)$ its lost earnings at the pre-war wage, and $\kappa$ is set so that the benefit exhausts the war's additional revenue over the window, which gives $\kappa = 2.06$ (appendix I.9); the unconstrained household receives the residual, so that the budget holds period by period. The rule does not change the aggregate path, since both households spend the revenue, the unconstrained as permanent income and the hand-to-mouth as it arrives; it decides who consumes it. Under the benefit the hand-to-mouth household gains from the war instead of losing half a percent, the unconstrained household loses twice as much as it did, and the planner's cost falls from 0.45 to 0.14 percent of equally-distributed consumption over the lifetime, by about two thirds.

Table 8: **Who receives the revenue.** Consumption-equivalent cost of the war, percent, for unconstrained (H) and hand-to-mouth (L) households and the U.S. aggregate over the first twenty quarters; the planner's equally-distributed equivalent (EDE, $\gamma = 2$) over twenty quarters and the lifetime; GDP at its trough, percent.

| | H | L | US | EDE, 20q | EDE, life | GDP trough |
|---|---|---|---|---|---|---|
| Observed rule (share 0.23 to hand-to-mouth) | −0.31 | −0.54 | −0.39 | −0.43 | −0.45 | −0.50 |
| Benefit on lost hours ($\kappa = 2.06$) | −0.63 | +0.33 | −0.31 | −0.12 | −0.14 | −0.46 |

Appendix I puts the same planner to the remaining questions: whether a tariff could have raised manufacturing employment without a recession, which tariff structure costs least, the planner's own

schedule, China's retaliation portfolio and the planner's reaction to it.

# 8 Conclusion

Tariffs are sold on a substitution argument: taxing imports makes buyers switch to domestic producers, who hire. This paper asks whether that happened in the 2017–2019 trade war, once the production network and the retaliation that followed are taken into account, and who paid when it did not.

The empirical answer rests on a recentered network shift-share design. The design carries a tariff on one product to every industry it reaches, through input costs on the way down and through gained or lost sales on the way up. It also isolates the variation in exposure the schedules produced from the exposure an industry's position in the network would have given it under any schedule. Tariffs passed into prices and lowered real consumption of the affected goods, and created no jobs, in the industries they were meant to help or elsewhere. Retaliation cost jobs: employment in the exposed industries fell by about 20%, with wages that did not move, and the loss fell on the hours of the lowest-paid workers, who are disproportionately hand-to-mouth. The incidence of the war is regressive, through earnings.

The model recovers what the cross-sectional estimates cannot: the aggregate cost. The model is a three-country, three-sector New Keynesian economy with production networks, two household types and skill-specific wage rigidity, disciplined by the estimates and fed the calendar of the war. It lowers U.S. GDP by 0.4% permanently and puts the loss where the estimates put it: in the retaliated sectors and on hand-to-mouth households, who lose almost twice as much consumption as unconstrained households. Retaliation accounts for the whole of the aggregate cost; the U.S. tariffs, net of their revenue, cost close to nothing and add close to nothing to manufacturing employment, because the input-tariff cascade and the retaliation on manufactures take back what the consumer tariff gives. Who receives the revenue is what decides how regressive the war is.

A planner who weighs both households would have spent the revenue differently: paying it to hand-to-mouth households cuts the planner's cost by two thirds. The prescription departs from the optimal-tariff benchmark through the labour-income term that sticky wages make first order, the term the empirical sections found to be the whole labour-market cost of the war.

One question is left for future work. The same network that carries a tariff carries a subsidy, a procurement rule or a reshoring incentive, and the same incidence calculus applies. Which sectors an industrial policy should target, and whether the jobs it creates reach the workers it is meant for, can be asked in this setting, with the production network, the household distribution and the planner in place.

## References


Acemoglu, Daron, Ufuk Akcigit, and William Kerr. 2016. "Networks and the Macroeconomy: An Empirical Exploration." *NBER Macroeconomics Annual* 30(1): 273–335.

Acemoglu, Daron, Vasco M. Carvalho, Asuman Ozdaglar, and Alireza Tahbaz-Salehi. 2012. "The Network Origins of Aggregate Fluctuations." *Econometrica* 80 (5): 1977–2016.

Adão, Rodrigo, Michal Kolesár, and Eduardo Morales. 2019. "Shift-Share Designs: Theory and Inference." *Quarterly Journal of Economics* 134(4): 1949–2010.

Adjemian, Stéphane, Michał Bacchetta, Houtan Bastani, Frédéric Karamé, Junior Maih, Ferhat Mihoubi, Willi Mutschler, Johannes Pfeifer, Marco Ratto, Normann Rion, and Sébastien Villemot. 2024. "Dynare: Reference Manual, Version 7." *Dynare Working Papers* 80, CEPREMAP.

Amiti, Mary, Stephen J. Redding, and David E. Weinstein. 2019. "The Impact of the 2018 Tariffs on Prices and Welfare." *Journal of Economic Perspectives* 33(4): 187–210.

Andreolli, Michele, Natalie Rickard, and Paolo Surico. 2025. "Non-Essential Business-Cycles." Working paper, London Business School and Boston College.

Andrews, Isaiah, Matthew Gentzkow, and Jesse M. Shapiro. 2017. "Measuring the Sensitivity of Parameter Estimates to Estimation Moments." *Quarterly Journal of Economics* 132 (4): 1553–1592.

Antràs, Pol, and Davin Chor. 2021. "Global Value Chains." *Handbook of International Economics* 5: 297–376.

Atalay, Enghin. 2017. "How Important Are Sectoral Shocks?" *American Economic Journal: Macroeconomics* 9(4): 254–280.

Atkinson, Anthony B. 1970. "On the Measurement of Inequality." *Journal of Economic Theory* 2 (3): 244–263.

Auclert, Adrien. 2019. "Monetary Policy and the Redistribution Channel." *American Economic Review* 109(6): 2333–2367.

Auclert, Adrien, Matthew Rognlie, and Ludwig Straub. 2025. "The Macroeconomics of Tariff Shocks." Working paper, Stanford University.

Autor, David, Anne Beck, David Dorn, and Gordon H. Hanson. 2024. "Help for the Heartland? The Employment and Electoral Effects of the Trump Tariffs in the United States." NBER Working Paper 32082.

Autor, David H., David Dorn, and Gordon H. Hanson. 2013. "The China Syndrome: Local Labor Market Effects of Import Competition in the United States." *American Economic Review* 103(6): 2121–2168.

Baqaee, David Rezza, and Emmanuel Farhi. 2018. "Macroeconomics with Heterogeneous Agents and Input-Output Networks." NBER Working Paper 24684.

Baqaee, David Rezza, and Emmanuel Farhi. 2019. "The Macroeconomic Impact of Microeconomic Shocks: Beyond Hulten's Theorem." *Econometrica* 87 (4): 1155–1203.

Baqaee, David, and Emmanuel Farhi. 2024. "Networks, Barriers, and Trade." *Econometrica* 92(2): 505–541.

Barrot, Jean-Noël, and Julien Sauvagnat. 2016. "Input Specificity and the Propagation of Idiosyncratic Shocks in Production Networks." *Quarterly Journal of Economics* 131 (3): 1543–1592.

Benguria, Felipe, and Felipe Saffie. 2020. "The Impact of U.S. Tariffs on Wages and Employment." Working paper.

Bergin, Paul R., and Giancarlo Corsetti. 2023. "The Macroeconomic Stabilization of Tariff Shocks: What Is the Optimal Monetary Response?" *Journal of International Economics* 143: 103758.

Beshkar, Mostafa, and Ahmad Lashkaripour. 2020. "The Cost of Dissolving the WTO: The Role of Global Value Chains." Working paper, Indiana University.

Bilbiie, Florin O. 2008. "Limited Asset Markets Participation, Monetary Policy and (Inverted) Aggregate Demand Logic." *Journal of Economic Theory* 140(1): 162–196.

Bilbiie, Florin O. 2020. "The New Keynesian Cross." *Journal of Monetary Economics* 114: 90–108.

Boehm, Christoph E., Aaron Flaaen, and Nitya Pandalai-Nayar. 2019. "Input Linkages and the Transmission of Shocks: Firm-Level Evidence from the 2011 Tōhoku Earthquake." *Review of Economics and Statistics* 101(1): 60–75.

Boehm, Christoph E., Andrei A. Levchenko, and Nitya Pandalai-Nayar. 2023. "The Long and Short (Run) of Trade Elasticities." *American Economic Review* 113(4): 861–905.

Borusyak, Kirill, and Peter Hull. 2023. "Nonrandom Exposure to Exogenous Shocks." *Econometrica* 91(6): 2155–2185.

Borusyak, Kirill, Peter Hull, and Xavier Jaravel. 2022. "Quasi-Experimental Shift-Share Research Designs." *Review of Economic Studies* 89(1): 181–213.

Borusyak, Kirill, Peter Hull, and Xavier Jaravel. 2025. "A Practical Guide to Shift-Share Instruments." *Journal of Economic Perspectives* 39(1): 181–204.

Bown, Chad P., and Melina Kolb. 2021. "Trump's Trade War Timeline: An Up-to-Date Guide." Peterson Institute for International Economics, Washington, DC.

Carvalho, Vasco M., Makoto Nirei, Yukiko U. Saito, and Alireza Tahbaz-Salehi. 2021. "Supply Chain Disruptions: Evidence from the Great East Japan Earthquake." *Quarterly Journal of Economics* 136 (2): 1255–1321.

Carvalho, Vasco M., and Alireza Tahbaz-Salehi. 2019. "Production Networks: A Primer." *Annual Review of Economics* 11: 635–663.

Cavallo, Alberto, Gita Gopinath, Brent Neiman, and Jenny Tang. 2021. "Tariff Pass-Through at the Border and at the Store: Evidence from US Trade Policy." *American Economic Review: Insights* 3(1): 19–34.

Chodorow-Reich, Gabriel. 2019. "Geographic Cross-Sectional Fiscal Spending Multipliers: What Have We Learned?" *American Economic Journal: Economic Policy* 11(2): 1–34.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113 (1): 1–45.

Clarida, Richard, Jordi Galí, and Mark Gertler. 2000. "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory." *Quarterly Journal of Economics* 115 (1): 147–180.

Corden, W. Max. 1966. "The Structure of a Tariff System and the Effective Protective Rate." *Journal of Political Economy* 74(3): 221–237.

Corden, W. Max. 1974. *Trade Policy and Economic Welfare*. Oxford: Clarendon Press.

Costinot, Arnaud, and Andrés Rodríguez-Clare. 2014. "Trade Theory with Numbers: Quantifying the Consequences of Globalization." In *Handbook of International Economics*, vol. 4, 197–261. Elsevier.

de Chaisemartin, Clément, and Xavier D'Haultfœuille. 2020. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects." *American Economic Review* 110(9): 2964–2996.

Debortoli, Davide, and Jordi Galí. 2017. "Monetary Policy with Heterogeneous Agents: Insights from TANK Models." Working paper, CREI and Universitat Pompeu Fabra.

Dhyne, Emmanuel, Ayumu Ken Kikkawa, Toshiaki Komatsu, Magne Mogstad, and Felix Tintelnot. 2022. "Foreign Demand Shocks to Production Networks: Firm Responses and Worker Impacts." NBER Working Paper 30447.

Fajgelbaum, Pablo D., Pinelopi Koujianou Goldberg, Patrick J. Kennedy, and Amit K. Khandelwal. 2020. "The Return to Protectionism." *Quarterly Journal of Economics* 135(1): 1–55.

Fajgelbaum, Pablo D., and Amit K. Khandelwal. 2016. "Measuring the Unequal Gains from Trade." *Quarterly Journal of Economics* 131 (3): 1113–1180.

Fajgelbaum, Pablo D., and Amit K. Khandelwal. 2022. "The Economic Impacts of the US–China Trade War." *Annual Review of Economics* 14: 205–228.

Ferrari, Alessandro. 2023. "Inventories, Demand Shocks Propagation and Amplification in Supply Chains." Working paper, arXiv:2205.03862.

Fetzer, Thiemo, and Carlo Schwarz. 2021. "Tariffs and Politics: Evidence from Trump's Trade Wars." *Economic Journal* 131(636): 1717–1741.

Flaaen, Aaron, Ali Hortaçsu, and Felix Tintelnot. 2020. "The Production Relocation and Price Effects of US Trade Policy: The Case of Washing Machines." *American Economic Review* 110(7): 2103–2127.

Flaaen, Aaron, and Justin Pierce. 2024. "Disentangling the Effects of the 2018–2019 Tariffs on a Globally Connected U.S. Manufacturing Sector." *Review of Economics and Statistics*, forthcoming.

Flood, Sarah, Miriam King, Renae Rodgers, Steven Ruggles, and J. Robert Warren. 2024. "Integrated Public Use Microdata Series, Current Population Survey: Version 12.0." IPUMS.

Galí, Jordi, J. David López-Salido, and Javier Vallés. 2007. "Understanding the Effects of Government Spending on Consumption." *Journal of the European Economic Association* 5(1): 227–270.

Galí, Jordi, and Tommaso Monacelli. 2005. "Monetary Policy and Exchange Rate Volatility in a Small Open Economy." *Review of Economic Studies* 72(3): 707–734.

Gnocato, Nicolò, Carlos Montes-Galdón, and Giovanni Stamato. 2025. "Tariffs across the Supply Chain." ECB Working Paper 3081.

Greenwood, Jeremy, Zvi Hercowitz, and Gregory W. Huffman. 1988. "Investment, Capacity Utilization, and the Real Business Cycle." *American Economic Review* 78(3): 402–417.

Grigsby, John, Erik Hurst, and Ahu Yildirmaz. 2021. "Aggregate Nominal Wage Adjustments: New Evidence from Administrative Payroll Data." *American Economic Review* 111(2): 428–471.

Guren, Adam M., Alisdair McKay, Emi Nakamura, and Jón Steinsson. 2021. "Housing Wealth Effects: The Long View." *Review of Economic Studies* 88(2): 669–707.

Handley, Kyle, Fariha Kamal, and Ryan Monarch. 2020. "Rising Import Tariffs, Falling Export Growth: When Modern Supply Chains Meet Old-Style Protectionism." NBER Working Paper 26611.

Huang, Yi, Chen Lin, Sibo Liu, and Heiwai Tang. 2023. "Trade Networks and Firm Value: Evidence from the U.S.–China Trade War." *Journal of International Economics* 145: 103811.

Jeanne, Olivier, and Jeongwon Son. 2024. "To What Extent Are Tariffs Offset by Exchange Rates?" *Journal of International Money and Finance* 142: 103015.

Johnson, Robert C., and Guillermo Noguera. 2012. "Accounting for Intermediates: Production Sharing and Trade in Value Added." *Journal of International Economics* 86(2): 224–236.

Jordà, Òscar. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1): 161–182.

Kalemli-Özcan, Şebnem, Can Soylu, and Muhammed A. Yıldırım. 2026. "Production Networks, Trade, and the International Transmission of Shocks." Working paper.

Kaplan, Greg, Giovanni L. Violante, and Justin Weidner. 2014. "The Wealthy Hand-to-Mouth." *Brookings Papers on Economic Activity* 45(1): 77–153.

Kekre, Rohan. 2023. "Unemployment Insurance in Macroeconomic Stabilization." *Review of Economic Studies* 90 (5): 2439–2480.

Korovkin, Vasily, and Alexey Makarin. 2023. "Production Networks and War: Evidence from Ukraine." CEPR Discussion Paper 16759.

Leontief, Wassily. 1936. "Quantitative Input and Output Relations in the Economic System of the United States." *Review of Economics and Statistics* 18 (3): 105–125.

Lucas, Robert E., Jr. 1987. *Models of Business Cycles*. Oxford: Basil Blackwell.

Lyon, Spencer G., and Michael E. Waugh. 2018. "Redistributing the Gains from Trade through Progressive Taxation." *Journal of International Economics* 115: 185–202.

Ma, Hong, Luca Macedoni, Jingxin Ning, and Mingzhi Xu. 2025. "Tariffs Tax the Poor More: Evidence from Household Consumption During the US–China Trade War." CESifo Working Paper 11610.

Nakamura, Emi, and Jón Steinsson. 2008. "Five Facts about Prices: A Reevaluation of Menu Cost Models." *Quarterly Journal of Economics* 123(4): 1415–1464.

Nakamura, Emi, and Jón Steinsson. 2014. "Fiscal Stimulus in a Monetary Union: Evidence from US Regions." *American Economic Review* 104(3): 753–792.

Obstfeld, Maurice, and Kenneth Rogoff. 2002. "Global Implications of Self-Oriented National Monetary Rules." *Quarterly Journal of Economics* 117(2): 503–535.

OECD. 2022. "OECD Inter-Country Input-Output Database." OECD, Paris. `http://oe.cd/icio`.

Ossa, Ralph. 2014. "Trade Wars and Trade Talks with Data." *American Economic Review* 104 (12): 4104–4146.

Patterson, Christina. 2023. "The Matching Multiplier and the Amplification of Recessions." *American Economic Review* 113 (4): 982–1012.

Pierce, Justin R., and Peter K. Schott. 2016. "The Surprisingly Swift Decline of U.S. Manufacturing Employment." *American Economic Review* 106(7): 1632–1662.

Schaab, Andreas, and Stacy Yingqi Tan. 2023. "Monetary and Fiscal Policy According to HANK-IO." Working paper, Toulouse School of Economics.

Schmitt-Grohé, Stephanie, and Martín Uribe. 2003. "Closing Small Open Economy Models." *Journal of International Economics* 61(1): 163–185.

Schmitt-Grohé, Stephanie, and Martín Uribe. 2016. "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment." *Journal of Political Economy* 124(5): 1466–1514.

Taylor, John B. 1993. "Discretion versus Policy Rules in Practice." *Carnegie-Rochester Conference Series on Public Policy* 39: 195–214.

Waugh, Michael E. 2019. "The Consumption Response to Trade Shocks: Evidence from the U.S.-China Trade War." Working paper.

Wolf, Christian K. 2023. "The Missing Intercept: A Demand Equivalence Approach." *American Economic Review* 113(8): 2232–2269.

# A Recentering of the Network Shift-Share Instrument

This appendix gives the formal motivation for the recentering of Section 3.5, following Borusyak, Hull, and Jaravel (2022) (BHJ) and Borusyak and Hull (2023) (BH), the permutation algorithm that computes the recentering means, how they enter the local projection, and the balance diagnostic.

## A.1 The Shift-Share Instrument

For each outcome unit $i$ and month $t$, the three network exposures of Section 3.3 are share-weighted sums of sector-level shocks,

$$Z^T_{i,t} \;=\; \sum_{k\in\mathcal{K}} W^T_{i,k}\,\bar\tau_{k,t}, \qquad Z^P_{i,t} \;=\; \sum_{k\in\mathcal{K}} \left[W^P(I - L^D S^T)\right]_{i,k}\bar\tau_{k,t}, \qquad Z^{RT}_{i,t} \;=\; \sum_{k\in\mathcal{K}} W^{RT}_{i,k}\,\bar\tau^*_{k,t}, \tag{45}$$

where $\mathcal{K}$ indexes the 403 BEA detail sectors, $\bar\tau_{k,t}$ and $\bar\tau^*_{k,t}$ are the sector-month tariff and retaliation rates of equations (11) and (16), and $W^T = L^D S^T$, $W^P_{ik} = L^D_{ki}(Y_{nk} - E_k)IS_k/Y_{ni}$ and $W^{RT}_{ik} = L^D_{ki}E_k/Y_{ni}$ are the share matrices of equations (14), (15) and (18), carried from BEA sectors to Census industries or PCE categories through the concordances. The labour-market regressions use $Z^{T+P} = Z^T + Z^P$ as the tariff exposure, a shift-share in the same rates with share matrix $W^T + W^P(I - L^D S^T)$. The shares are built from the 2017 input–output table and 2017 trade values and are constant over $t$; the exposure is linear in the shocks given the shares, as in the linear shift-share framework of BHJ.

## A.2 The Identification Challenge

BHJ (Theorem 1) show that OLS in the $\{i,t\}$ panel recovers the coefficient on $Z$ consistently when the shocks are uncorrelated with the share-weighted average of the residuals. Equivalently (Borusyak and Hull, 2023, Proposition 1), if the shocks are as good as randomly assigned conditional on a vector of observables $w_{i,t}$,

$$\mathbb{E}\big[\varepsilon_{i,t} \mid \{W_{i,k}\}_k,\, w_{i,t}\big] \;=\; 0 \qquad\Longleftrightarrow\qquad \mathbb{E}\big[Z_{i,t}\,\varepsilon_{i,t} \mid w_{i,t}\big] = \underbrace{\mathbb{E}\big[Z_{i,t} \mid w_{i,t}\big]}_{\mu_{i,t}} \cdot \mathbb{E}\big[\varepsilon_{i,t} \mid w_{i,t}\big]. \tag{46}$$

The first equality is the BHJ assumption; the second decomposes the bias in $\mathrm{Cov}(Z,\varepsilon)$ into a shock-driven part and a share-driven part that runs through the conditional mean $\mu_{i,t}$. If $\mu_{i,t}$ is left uncontrolled, the coefficient on $Z$ confounds the effect of the shock with the omitted variation that moves with the shares. The concern is concrete: an industry with a large total tariff share $\bar s_i^{T+P}$ is more exposed to any schedule, and also tends to be on a different trajectory in employment, wages and prices for reasons unrelated to the war. The balance test of Section A.5 shows that this is the case in the data.

## A.3 The Recentering Procedure

BH solve the problem by constructing counterfactual shock realisations and subtracting their share-weighted average from $Z_{i,t}$. The implementation has three steps.

**Step 1: The shock-assignment model.** The model holds the timing and the size of each wave fixed and treats the choice of products as random. A wave is a policy regime, the Section 301 lists on China, the Section 232 measures on steel and aluminium, or the remaining measures, together with an effective month on the tariff side, and a retaliating partner together with an effective month on the retaliation side. The products a wave could have targeted are the HS6 codes with positive 2017 U.S. imports from the wave's partner, or positive 2017 U.S. exports to it, that map to a BEA sector; the map covers 7,941 HS6 codes, the tariffed and retaliated lines keeping the sector they carry in the schedules and the remaining codes assigned through the Pierce and Schott (2016) and BEA concordances. The institutional content of the model is that, within a wave, every product the partner traded was equally likely to be hit, and which products were in fact chosen is unrelated to the trajectories of the sectors that use or produce them.

**Step 2: Counterfactual schedules.** I draw $S = 500$ counterfactual schedules. In each draw and for each wave, the wave's distinct HS6 lines are replaced one for one by lines drawn uniformly without replacement from the wave's pool. The drawn line keeps the wave's partner, effective date and rate path, so that the shock keeps its timing and size, and brings its own sector, its own 2017 partner shares and its own trade weight, so that only the product receiving the shock changes. The sector rates $\bar{\tau}_{k,t}^{(s)}$ and $\bar{\tau}_{k,t}^{*(s)}$ are rebuilt from each counterfactual schedule with the 2017 weights of equations (11) and (16).

**Step 3: The recentering mean.** For each $(i, t)$ cell the counterfactual exposure applies the same share matrix to the counterfactual rates,

$$Z_{i,t}^{(s)} \;=\; \sum_{k \in \mathcal{K}} W_{i,k}\, \bar{\tau}_{k,t}^{(s)}, \tag{47}$$

and the recentering mean is the average over the draws and the actual realisation, equation (20) of the main text, following BH equation (2.8). Including the actual realisation makes the demeaned exposure $\tilde{Z}_{i,t} \equiv Z_{i,t} - \mu_{i,t}$ exactly mean-zero over the permutation distribution. The means are computed for each of the three exposures, and $\mu_{i,t}^{T+P} = \mu_{i,t}^{T} + \mu_{i,t}^{P}$.

## A.4 Implementation in the Local Projection

The local projection of the main text, equation (21), includes $\mu_{i,t}^{T+P}$ and $\mu_{i,t}^{RT}$ as regressors alongside $Z_{i,t}^{T+P}$ and $Z_{i,t}^{RT}$, together with the total shares $\bar{s}_i^{T+P}$ and $\bar{s}_i^{RT}$ interacted with the month-year effects, the incomplete-shares control of Borusyak, Hull, and Jaravel (2025, Appendix A.1). By Frisch–Waugh–Lovell, the coefficient on $Z_{i,t}^{T+P}$ equals the coefficient on $\tilde{Z}_{i,t}^{T+P}$ in a regression on

the demeaned exposure alone with the same fixed effects and controls. Entering $\mu$ as a regressor rather than subtracting it leaves its coefficient to the data, so that an imperfect assignment model is not imposed with a unit coefficient, and the coefficient on $\mu$ is a specification check in the sense of Borusyak and Hull (2023, §3.3).

### A.5 Diagnostics for the Recentering

Borusyak and Hull (2023, §3.4) propose a balance test: the recentered exposure should be unrelated to predetermined characteristics of the units, while the raw exposure need not be. Table 12 in Appendix B reports it. The raw exposures are strongly related to pre-war industry size and wages: industries with higher tariff exposure were smaller and had lower wage growth in 2012–2014, and the joint test rejects at any level for both shocks ($p < 0.001$). The recentered exposures are not: the coefficients shrink by one to two orders of magnitude and the joint tests do not reject ($p = 0.17$ for the tariff exposure, $p = 0.54$ for retaliation). The recentering removes the share-driven relation between exposure and pre-war characteristics, which is what it is designed to do.

## B Validation of the Network Shift-Share Instrument

This appendix looks for the patterns that would appear if the identifying conditions of Section 3.5 failed, all on the baseline specification of equation (21) with the same exposures, recentering means and controls as the main estimates. A *placebo policy-date test* (Section B.1) replays the war in a pre-war window and asks whether the design fabricates effects where no tariffs were imposed. A *cross-sectional pre-trend test* (Section B.2) asks whether the exposure an industry would later carry predicts its pre-war growth. The *balance tests* of Borusyak and Hull (2023) ask whether the recentered exposure (Section B.3) and the recentered shifts (Section B.4) are unrelated to predetermined characteristics. Section B.5 examines the 2019 floods, Section B.6 re-estimates the retaliation effect without the most exposed sectors, and Section B.7 reports the shift-share inference of Adão et al. (2019). Throughout, coefficients on exposure are reported in the units of the main estimates, log points per unit of exposure; stars use the same month-clustered (placebo) or heteroskedasticity-robust (cross-sections) standard errors as the corresponding estimates.

### B.1 Placebo Policy-Date Test

To assess whether the network shift-share design itself produces spurious estimates in periods unaffected by tariffs, I shift the entire trade-war schedule, exposures and recentering means alike, backward by 36 months, so that the January 2018 to March 2020 war is replayed on January 2015 to March 2017, and I re-estimate equation (21) on outcomes between January 2015 and October 2017. The window ends in the last month before any tariff in the data (the first non-zero line is Canadian softwood lumber in November 2017; the trade-war waves begin in January 2018), so no lead of the outcome reaches the actual war. The specification matches the main LP one for one. Under the null of valid identification, the placebo coefficients should be near zero at every horizon.

Table 9: Placebo Policy-Date Test (Schedule Shifted Backward 36 Months, Outcomes January 2015 to October 2017)

| | Tariff ($Z^{T+P}$) | | | Retaliation ($Z^{RT}$) | | |
|---|---|---|---|---|---|---|
| Outcome | $h$=6 | $h$=10 | $h$=12 | $h$=6 | $h$=10 | $h$=12 |
| Employment | +2.26 | +2.47 | +2.46 | +41.04* | +15.39 | +15.10 |
| | (2.80) | (2.54) | (2.54) | (23.35) | (15.47) | (17.32) |
| Real wage | −2.40 | −7.58** | −6.68** | −46.12*** | −36.89** | −17.90 |
| | (2.57) | (3.62) | (2.67) | (14.92) | (16.38) | (19.39) |
| PCE real | +0.85 | +1.36* | +0.73 | −2.36 | −3.93 | −0.41 |
| | (0.83) | (0.73) | (0.70) | (2.98) | (2.57) | (2.30) |
| PCE price | +0.31 | +0.30 | +0.76 | +2.96** | +3.15* | +3.60* |
| | (0.91) | (0.73) | (0.83) | (1.25) | (1.78) | (1.88) |

*Notes:* Each cell reports the placebo coefficient at the indicated horizon, in log points per unit of exposure as in the main estimates, with month-clustered standard errors in parentheses. The full specification of equation (21) is re-estimated with exposures and recentering means shifted backward 36 months, industry (or PCE category) and month fixed effects, both recentering means and both total shares interacted with month. Stars: $*p < 0.10$, $**$ $p < 0.05$, $***p < 0.01$.

**Discussion.** Table 9 reports the placebo coefficients at horizons 6, 10 and 12. The employment placebo is clean on both sides: between +2.3 and +2.5 and insignificant on the tariff side, and on the retaliation side positive and marginal at $h = 6$ and at zero at $h = 10$ and $h = 12$; where the main estimate is a loss of about 18 log points from retaliation at $h = 10$, the placebo finds nothing of the kind. The real-wage placebo fails on both sides: negative and significant on the retaliation side at $h = 6$ and $h = 10$ (−46.1 and −36.9), the horizons at which the main estimate shows a short-lived movement, and on the tariff side at $h = 10$ and $h = 12$ (−7.6 and −6.7). The wage results pass the pre-trend and the balance tests, so the main text reads them as flat, the absence of a measurable adjustment; the short-lived movements at these horizons are not interpreted. The PCE price placebo is zero on the tariff side and positive on the retaliation side, the opposite sign to the main estimate, so the placebo cannot be generating either price result. The real-consumption placebo is zero in every cell but one, a marginal positive on the tariff side at $h = 10$, again of the opposite sign to the main estimate.

## B.2 Cross-Sectional Pre-Trend Test

The second test asks whether industries that the war would later expose were already growing differently before it. I compute each unit's mean exposure over the war, $\bar{Z}_i = \text{mean}_t Z_{i,t}$ for $t \in [2018\text{m}1, 2020\text{m}3]$, and regress pre-war growth of the outcome over 12 and 24 months ending in October 2017, the last month before any tariff, on it:

$$\log y_{i,2017\text{m}10} - \log y_{i,2017\text{m}10-W} = \beta_T \bar{Z}_i^T + \beta_{RT} \bar{Z}_i^{RT} + \boldsymbol{\gamma}^\top \bar{\mu}_i + \boldsymbol{\delta}^\top \bar{s}_i + u_i, \qquad W \in \{12, 24\}, \quad (48)$$

with heteroskedasticity-robust standard errors. Here $\bar{\mu}_i = (\bar{\mu}_i^T, \bar{\mu}_i^{RT})$ are the mean recentering means and $\bar{s}_i = (\bar{s}_i^T, \bar{s}_i^{RT})$ the total-share controls, matching the main specification. The null is

$\beta = 0$. A second cutoff in March 2017, before the Section 232 and 301 investigations were opened, gives the same picture. Table 11 repeats the test over the six months before each side of the war began: for the tariffs the six months to December 2017, for retaliation the six months to March and to June 2018, with the tariff exposure already in force entered as a control.

Table 10: Cross-Sectional Pre-Trend Test: Pre-War Growth to October 2017 on Later Exposure

| | Future Tariff ($Z^{T+P}$) | | Future Retaliation ($Z^{RT}$) | |
|---|---|---|---|---|
| Outcome | 12 months | 24 months | 12 months | 24 months |
| Employment | +5.34 | −8.39 | +5.31 | −79.32 |
| | (5.61) | (8.21) | (54.11) | (62.37) |
| Real wage | −1.15 | −2.89 | −39.26 | +77.32 |
| | (13.67) | (12.97) | (68.63) | (57.55) |
| PCE nominal | −2.44 | −4.65 | +8.50* | +10.27 |
| | (3.74) | (8.15) | (4.50) | (6.89) |
| PCE real | +2.71 | +10.73 | −0.47 | −11.27 |
| | (5.60) | (11.96) | (5.12) | (11.79) |
| PCE price | −5.15 | −15.38* | +8.96*** | +21.54** |
| | (3.75) | (8.59) | (2.39) | (10.72) |

*Notes:* Each cell reports $\beta_T$ or $\beta_{RT}$ from equation (48), in log points per unit of mean 2018–2020 exposure, with robust standard errors in parentheses; one observation per Census industry (employment, real wage) or PCE category. Both exposures, the mean recentering means and the total shares enter jointly. Stars: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 11: Pre-Trend Test over the Six Months before Each Side of the War Began

| | Tariff ($Z^{T+P}$) | Retaliation ($Z^{RT}$), tariffs in force | |
|---|---|---|---|
| Outcome | to Dec 2017 | to Mar 2018 | to Jun 2018 |
| Employment | −2.07 | +50.88 | −51.21 |
| | (11.08) | (55.42) | (34.92) |
| Real wage | +15.81 | −58.36 | +105.20 |
| | (10.34) | (73.08) | (95.52) |
| PCE real | +3.76 | −20.07*** | −17.86*** |
| | (3.97) | (6.61) | (5.67) |
| PCE price | −6.62** | +12.62** | +9.59*** |
| | (2.86) | (5.44) | (2.20) |

*Notes:* Each cell reports the coefficient on the unit's mean 2018m1–2020m3 exposure in a cross-sectional regression of the growth of the outcome over the six months ending in the month shown, in log points per unit of exposure, robust standard errors in parentheses; one observation per Census industry or PCE category. Both exposures, their mean recentering means and both total shares enter jointly. The tariff column ends in December 2017, the month before the first tariffs; the retaliation columns end in March 2018, the month before the first Chinese measures, and in June 2018, the month before the Section 301 duties and the main retaliation, so each retaliation pre-trend is conditional on the tariff exposure already in force. Stars: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

**Discussion.** Table 10 shows no pre-trend for the labour-market outcomes: neither future tariff nor future retaliation exposure predicts pre-war employment or wage growth over either window,

and the point estimates change sign across windows. The same holds for real consumption. The cells that reject are on prices. The price of categories later exposed to retaliation had been rising before the war (+9.0 over 12 months, +21.5 over 24); the main estimate for that cell is a price *fall* after retaliation, the opposite sign, so the pre-trend works against the result rather than for it. The price of categories later exposed to tariffs had been falling over the 24-month window (−15.4, marginal), again the opposite sign to the main estimate of a price rise. I nonetheless treat the retaliation price response as the least clean of the price results. Table 11 shows the same picture over the six months before each side began: no pre-trend for employment or earnings on either exposure, and the retaliation price pre-trend, of the opposite sign to the estimate, in both retaliation windows.

### B.3 Balance Test of the Recentered Exposure

Borusyak and Hull (2023, §3.4) propose testing the recentering directly: the recentered exposure $\tilde{Z}_i = Z_i - \mu_i$ should be unrelated to predetermined unit characteristics, while the raw exposure $Z_i$ need not be. I regress the mean war-period exposure, raw and recentered, on four pre-war characteristics of each Census industry, log employment and log real weekly wage in December 2014 and their growth from December 2012 to December 2014, with robust standard errors and a joint $F$-test.

Table 12: Balance Test: Raw and Recentered Exposure on Pre-War Industry Characteristics

| | Tariff ($Z^{T+P}$) | | Retaliation ($Z^{RT}$) | |
|---|---|---|---|---|
| Pre-war characteristic | raw $Z$ | recentered $Z-\mu$ | raw $Z$ | recentered $Z-\mu$ |
| Log employment, 2014 | −1.579*** | +0.338** | −0.335*** | +0.004 |
| | (0.288) | (0.166) | (0.073) | (0.015) |
| Employment growth, 2012–14 | −1.016 | +0.739 | +0.305 | +0.004 |
| | (1.988) | (1.254) | (0.402) | (0.073) |
| Log real wage, 2014 | +2.431** | +1.273** | +0.594** | −0.004 |
| | (1.140) | (0.516) | (0.278) | (0.051) |
| Wage growth, 2012–14 | −4.650*** | −0.161 | −0.927*** | −0.209 |
| | (1.421) | (0.658) | (0.266) | (0.131) |
| Joint $p$-value | 0.000 | 0.172 | 0.000 | 0.535 |

*Notes:* Coefficients (×1000) from regressions of the mean 2018m1–2020m3 exposure of each Census industry, raw ($Z$) or recentered ($Z-\mu$), on the four pre-war characteristics, robust standard errors in parentheses; the last row is the $p$-value of the joint test that all four are zero. Stars: $*p<0.10$, $**p<0.05$, $***p<0.01$.

**Discussion.** The raw exposures are far from balanced: the industries the war exposed were smaller in 2014 and had seen lower wage growth, and the joint test rejects at any conventional level on both sides. The recentered exposures are balanced for retaliation ($p = 0.54$, every coefficient within one standard error of zero) and nearly so for tariffs ($p = 0.17$), where positive associations with the 2014 wage and employment levels remain. The recentering removes the share-driven relation between exposure and pre-war industry characteristics, which is what it is designed to do.

## B.4 Balance Test of the Shifts

The balance test of Table 12 is at the level of the exposure. Table 13 repeats it at the level of the shifts, one observation per BEA sector, regressing the sector's war-average tariff and retaliation rates, raw and net of their recentering means, on the pre-war characteristics of the Census industries linked to the sector. The raw rates are not balanced on either side: the tariffed sectors were smaller, faster-growing in 2012–14, more import-penetrated and less export-oriented, and the retaliated sectors smaller and lower-paid, which is what the choice of the lists implies. The recentered rates are close to balanced, with coefficients an order of magnitude smaller: the retaliation rates are balanced at conventional levels, and on the tariff side the joint test rejects unweighted but not when the sectors are weighted by their contribution to the exposure of all industries ($p = 0.07$), the residual association running through 2012–14 wage growth and the 2017 export share. The pattern is the one the design implies: targeting was selective, and what the recentering leaves is close to orthogonal to the pre-war characteristics of the sectors.

Table 13: Shift-level balance: sector rates on pre-war sector characteristics.

| | Tariff rate | | Retaliation rate | |
|---|---|---|---|---|
| | War average | Recentered | War average | Recentered |
| Log employment 2014 | −0.0032 | −0.0001 | −0.0020 | −0.0002 |
| | (0.0005) | (0.0001) | (0.0004) | (0.0001) |
| Employment growth 2012–14 | 0.0263 | 0.0032 | 0.0072 | 0.0023 |
| | (0.0058) | (0.0019) | (0.0040) | (0.0011) |
| Log real wage 2014 | −0.0030 | 0.0008 | −0.0056 | −0.0012 |
| | (0.0027) | (0.0009) | (0.0029) | (0.0008) |
| Wage growth 2012–14 | −0.0054 | −0.0132 | −0.0016 | −0.0017 |
| | (0.0177) | (0.0077) | (0.0147) | (0.0045) |
| Import penetration 2017 | 0.0615 | −0.0042 | −0.0006 | −0.0021 |
| | (0.0087) | (0.0042) | (0.0043) | (0.0012) |
| Export share 2017 | −0.0389 | 0.0073 | 0.0088 | 0.0021 |
| | (0.0105) | (0.0041) | (0.0075) | (0.0020) |
| Joint $p$-value | 0.000 | 0.005 | 0.000 | 0.078 |
| Joint $p$-value, importance-weighted | | 0.07 | | 0.41 |
| Sectors | 378 | 378 | 378 | 378 |

Notes: one observation per BEA sector, unweighted unless stated. War average: the sector's mean rate over 2018m1–2020m3, in decimals. Recentered: the mean over the same months of the rate minus its recentering mean, the variation the local projections use. Characteristics are means over the Census industries linked to the sector through the BEA–NAICS–Census concordance; import penetration and export share from the 2017 input–output accounts. Robust standard errors in parentheses. The importance-weighted joint test weights sectors by their contribution to the network exposure of all industries, as in Table 3.

## B.5 The 2019 Floods

The spring 2019 floods delayed planting across the corn and soybean belt eight to eleven months after the July 2018 retaliation on soybeans, so that an independent fall in agricultural employ-

ment at those horizons could load on the retaliation exposure. Table 14 re-estimates the retaliation coefficient in the employment and real-wage regressions under four variants: dropping every industry-month whose outcome month falls in March–June 2019; adding an indicator for agriculture, forestry and fishing interacted with the outcome month falling in that window; dropping crop production; and dropping crop and livestock production. The coefficients at $h = 3$ and $h = 6$ are unchanged under every variant, and at $h = 10$ the point estimate is unchanged under three of the four and loses precision only when the four flood months are removed from the outcomes, which mechanically thins that horizon. The response predates the floods: it is at $-20$ log points by the fourth month after retaliation, in late 2018.

Table 14: Retaliation coefficient and the 2019 floods.

| Outcome | Specification | $h = 3$ | $h = 6$ | $h = 10$ |
|---|---|---|---|---|
| Employment | Baseline | -19.10 | -12.63 | -18.35 |
| | | ( 7.33) | ( 7.85) | ( 5.87) |
| Employment | Drop outcome months 2019m3–2019m6 | -21.53 | -17.61 | -16.95 |
| | | ( 7.41) | ( 9.59) | ( 13.00) |
| Employment | Agriculture × flood window | -19.19 | -12.40 | -20.16 |
| | | ( 7.30) | ( 7.89) | ( 5.89) |
| Employment | Drop crop production | -19.04 | -11.90 | -18.46 |
| | | ( 7.58) | ( 8.08) | ( 6.20) |
| Employment | Drop crop and livestock production | -19.06 | -11.93 | -18.35 |
| | | ( 7.61) | ( 8.07) | ( 6.15) |
| Real weekly wage | Baseline | 15.73 | 37.54 | -15.84 |
| | | ( 13.62) | ( 15.14) | ( 10.68) |
| Real weekly wage | Drop outcome months 2019m3–2019m6 | 13.94 | 30.27 | 9.21 |
| | | ( 14.03) | ( 13.64) | ( 15.78) |
| Real weekly wage | Agriculture × flood window | 15.53 | 37.33 | -16.66 |
| | | ( 13.59) | ( 14.96) | ( 11.38) |
| Real weekly wage | Drop crop production | 17.17 | 39.14 | -14.97 |
| | | ( 13.69) | ( 15.29) | ( 11.23) |
| Real weekly wage | Drop crop and livestock production | 17.06 | 39.07 | -15.12 |
| | | ( 13.67) | ( 15.28) | ( 11.18) |

Notes: coefficient on the network retaliation exposure $Z^{RT}$, log points per unit of exposure, from equation (21) with the total shares interacted with month-year effects, standard errors clustered by month in parentheses. The flood window is March–June 2019. Agriculture is Census 1990 industry codes below 040; crop production is Census industry 010 and livestock 011.

### B.6 Retaliation Estimates without the Most Exposed Sectors

Retaliation fell on fewer sectors than the tariffs, and the retaliation estimates draw on a correspondingly smaller set of shifts. Table 15 re-estimates the employment response with the largest shifts removed: removing a shift sets the sector's retaliation rate and its recentering mean to zero and recomputes every industry's exposure through the fixed shares, so that the industries the sec-

tor reaches keep their other exposure. Without the fishing shift the ten-month loss is larger, at −33 log points, and the effective number of shifts rises to about ten; the early response, at three months, is not there without it, so that the loss builds up over the year rather than arriving within a quarter. Table 16 removes each of the five largest shifts in turn: none of the other four moves the coefficients, and dropping the fishing industry from the sample as an observation, rather than its shift from the exposures, gives the same numbers as removing its shift. With the five largest shifts removed together the ten-month coefficient is −28, with a sector-clustered $t$ of −1.0. The loss is not the product of one sector, but its precision rests on a small number of shifts, and the sector-clustered standard errors of Table 17 are the appropriate measure of it.

Table 15: Retaliation coefficient on employment with the largest shifts removed.

| Sample | Horizon | $\hat{\delta}_h$ | $t$, month clusters | $t$, sector clusters | Effective shifts |
|---|---|---|---|---|---|
| All shifts | $h = 3$ | −19.1 | −2.6 | −2.4 | 2.3 |
| | $h = 6$ | −12.6 | −1.6 | −3.2 | 1.7 |
| | $h = 10$ | −18.3 | −3.1 | −2.7 | 1.9 |
| Fishing removed | $h = 3$ | 0.9 | 0.1 | 0.1 | 9.3 |
| | $h = 6$ | −14.5 | −0.8 | −0.9 | 9.5 |
| | $h = 10$ | −33.4 | −2.5 | −1.9 | 9.8 |
| Five largest removed | $h = 3$ | 15.5 | 0.6 | 0.8 | 9.7 |
| | $h = 6$ | −10.2 | −0.5 | −0.3 | 10.0 |
| | $h = 10$ | −28.0 | −1.8 | −1.0 | 9.7 |

Notes: coefficient on $Z^{RT}$ in the employment regression, log points per unit of exposure. Removing a shift sets the sector's retaliation rate and its recentering mean to zero and recomputes every industry's exposure through the fixed shares. The five largest shifts are fishing, glass products, motorcycles and bicycles, clay products and oilseed farming. Effective shifts: inverse Herfindahl index of the sector shares of the residualised variation in exposure (Adão et al., 2019). Sector clusters: standard errors with the sector shifts as the random units.

## B.7 Shift-Share Inference

The standard errors in the figures are clustered by calendar month. Adão et al. (2019) show that in a shift-share design this can overstate precision: two industries with similar input–output positions load on the same sector shocks whatever their month, so their residuals are correlated across clusters, and the appropriate asymptotics run over the number of sectors that carry a shock. Their estimator treats the shares as fixed and the sector shocks as random: for each sector $k$ the score is the recentered shock path times the share-weighted sum of the regression residuals of every unit the sector reaches, summed over months, and the variance is the sandwich of the sector scores. I compute it for both coefficients jointly, with the two share matrices of (19) and the recentered shocks $\bar{\tau} - \mu_{\bar{\tau}}$, and verify it against the equivalent shock-level instrumental-variables regression of Borusyak, Hull, and Jaravel (2022) stacked over the two shocks, which reproduces the coefficients and standard errors to eight digits. I also report the null-imposed confidence sets (AKM0), obtained by inverting the score test, which remain valid when few sectors carry the identifying variation,

Table 16: Retaliation coefficient on employment, leaving out one shift at a time.

| Shift removed | $h = 3$ | $h = 6$ | $h = 10$ |
|---|---|---|---|
| None (baseline) | -19.10 | -12.63 | -18.35 |
| | ( 7.33) | ( 7.85) | ( 5.87) |
| Fishing, hunting and trapping (114000) | 0.91 | -14.46 | -33.41 |
| | ( 17.15) | ( 18.80) | ( 13.39) |
| Glass and glass products (327200) | -20.49 | -13.33 | -18.36 |
| | ( 7.44) | ( 8.53) | ( 5.59) |
| Motorcycles, bicycles and parts (336991) | -21.79 | -13.87 | -17.71 |
| | ( 7.97) | ( 6.99) | ( 4.41) |
| Clay products and refractories (327100) | -17.75 | -10.13 | -14.24 |
| | ( 7.59) | ( 7.27) | ( 5.80) |
| Oilseed farming (1111A0) | -18.58 | -12.28 | -19.65 |
| | ( 7.65) | ( 7.65) | ( 6.38) |
| All five | 15.51 | -10.23 | -28.00 |
| | ( 27.03) | ( 19.94) | ( 15.98) |
| Fishing industry dropped as an observation | 0.79 | -14.40 | -33.26 |
| | ( 17.08) | ( 18.80) | ( 13.36) |

Notes: coefficient on $Z^{RT}$ in the employment regression of equation (21), log points per unit of exposure, standard errors clustered by month in parentheses. Removing a shift sets the sector's retaliation rate and its recentering mean to zero and recomputes every industry's network exposure through the fixed shares; the five sectors are those with the largest shares of the residualised variation in exposure. The last row keeps all shifts and drops the fishing Census industry from the sample instead.

and a summary of that concentration: the share of the residualised regressor's sum of squares attributable to each sector, whose inverse Herfindahl is an effective number of sectors.

Table 17: Shift-Share Inference at $h = 10$: Month-Clustered and Sector-Level Standard Errors

| Outcome | Shock | Coef. | $t$ (month) | $t$ (AKM, sector) | $t$ (AKM, 3-digit) | AKM0 90% set | Eff. sectors |
|---|---|---|---|---|---|---|---|
| Employment | Tariff | −2.27 | −0.9 | −1.1 | −0.9 | [−6.43, 2.54] | 6.1 |
| Employment | Retaliation | −18.35 | −3.1 | −2.7 | −2.7 | unbounded | 1.9 |
| Real wage | Tariff | −1.86 | −0.5 | −0.3 | −0.3 | [−13.16, 9.84] | 6.6 |
| Real wage | Retaliation | −15.84 | −1.5 | −1.5 | −1.5 | unbounded | 2.0 |
| PCE price | Tariff | +1.63 | 2.0 | 1.0 | 1.8 | [−0.51, 26.64] | 3.1 |
| PCE price | Retaliation | −4.58 | −3.1 | −3.2 | −5.7 | [−9.09, 3.25] | 3.2 |
| PCE real | Tariff | −3.77 | −4.7 | −3.4 | −3.6 | [−14.13, −1.31] | 3.1 |
| PCE real | Retaliation | −1.45 | −0.6 | −0.5 | −1.2 | [−31.24, 2.75] | 3.2 |

*Notes:* Coefficients of equation (21) at horizon $h = 10$ under the baseline recentering, in log units per unit of exposure. $t$ (month): standard errors clustered by calendar month, as in the figures. $t$ (AKM, sector): Adão et al. (2019) standard errors with the 403 BEA sectors as the shock units, each sector's monthly shock path treated as one draw. $t$ (AKM, 3-digit): the same with sectors grouped by three-digit code (27 groups carry a shock). AKM0 90% set: the null-imposed confidence set; "unbounded" means the quadratic inequality has no finite solution at the 90% level. Eff. sectors: inverse Herfindahl of the sector shares of the residualised regressor's sum of squares; the AKM0 set is bounded at 90% only when the Herfindahl is below 0.37.

**Discussion.** Table 17 reports the comparison at the headline horizon. For the main results the sector-level standard errors are of the same order as the month-clustered ones: the retaliation

employment coefficient keeps $t = -2.7$ with sector clustering and with three-digit groups, and is stronger at $h = 6$ ($-3.2$ against $-1.6$); the real-consumption response to tariffs keeps $t = -3.4$, and its null-imposed set excludes zero; the retaliation price response is unchanged. The two places where the sector-level inference bites are the tariff price response, whose $t$-statistic falls from 2.0 to 1.0 with sector clustering at $h = 10$ and from 2.6 to 1.3 at $h = 12$, and the retaliation coefficients on the labour-market outcomes, for which the AKM0 sets are unbounded. The last column explains why: the identifying variation for retaliation on the labour side comes from few sectors, so the null-imposed test cannot bound the coefficient at conventional levels. The tariff side draws on six to seven effective sectors on the labour side, led by leather tanning, apparel and toys, and on three on the consumption side, led by fabric mills and communications equipment. The retaliation employment effect is identified by the contrast between the sectors retaliation targeted and the rest, and the sector-clustered interval is the more reliable measure of its precision. Appendix B.6 shows that the loss does not depend on any one of them.

### B.8 Implications for Inference

1. The **employment** results pass the pre-trend and balance tests and are not reproduced by the placebo; the retaliation effect survives sector-level clustering but rests on a small number of targeted sectors, and the month-clustered interval reported in the text is of the same order as the sector-clustered one.

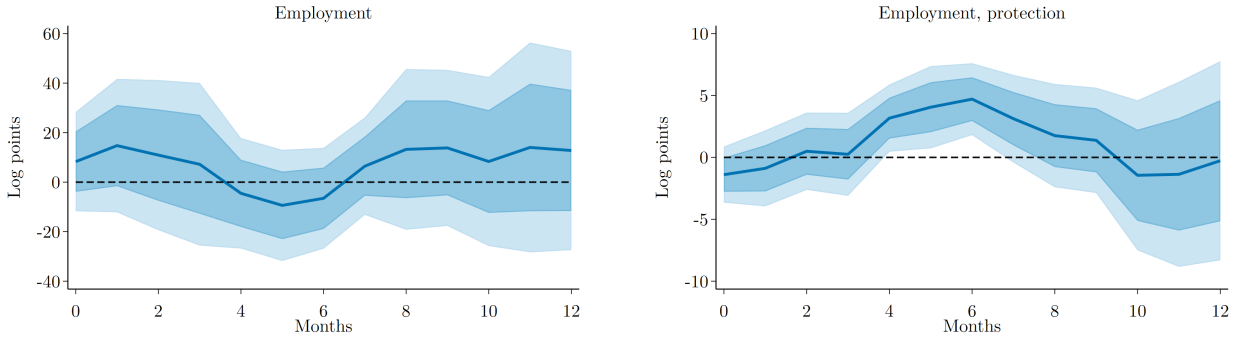
2. The **wage** results are flat at every horizon but one and pass the pre-trend and balance tests; the placebo produces significant movements of its own, at $h = 6$ on the retaliation side, of the opposite sign to the main estimate, and at $h = 10$ and $h = 12$ on the tariff side, so the flat response is read as the absence of a measurable adjustment and the short-lived movements are not interpreted.

3. The **real consumption** response to tariffs passes every test and keeps its precision under sector-level inference, where the null-imposed set excludes zero.

4. The **PCE price** response to tariffs passes the balance test, its placebo is zero and its pre-trend has the opposite sign; its precision depends on the clustering choice. The price response to retaliation has a pre-trend of the opposite sign to the estimate and is treated as the least clean of the price results.

## C Decomposing the Tariff Exposure: Cost and Protection

The labour-market regressions of the main text use the sum of the cost exposure $Z^T$ of (14) and the protection exposure $Z^P$ of (15) as one regressor. This appendix enters the two separately, with the retaliation exposure, the three recentering means and the three total shares interacted with month effects, and reports what each coefficient looks like on its own. Figure 13 shows the employment response to each component.




(a) Cost exposure $Z^T$

(b) Protection exposure $Z^P$

Figure 13: **Employment response to the cost and the protection exposure, entered separately.** Coefficients on $Z^T$ of (14) and on $Z^P$ of (15) from the employment regression of equation (21) with the two entered as separate regressors, with the retaliation exposure, the three recentering means and the three total shares interacted with month effects; in log units per unit of exposure, horizons 0 to 12 months. Shaded areas are 68 and 90% confidence bands, standard errors clustered by month.

Three things stand out. First, retaliation is unaffected by the split. Second, the two tariff components are not separately identified. They are built from the same product rates, the cost chain has a quarter of the cross-sectional spread of $Z^P$, and the two are correlated 0.6 after recentering; the separated coefficients are accordingly large, of opposite sign and unstable across samples, including the placebo window of Section B.1, which is the signature of collinearity rather than of two effects. The sum is the paper's regressor because both components are the same tariff reaching the industry, through its input bill and through its sales, and because only their sum is identified. Third, what the split does show on protection is a short-lived employment gain at months four to six that does not survive sector-level inference, and a negative earnings coefficient of similar robustness; neither is interpreted. The finer split of $Z^P$ into nominal protection and the cost exposure of the protected customers, which would test the effective-rate restriction, cannot be estimated for the same reason: the second term is collinear with $Z^T$ and its coefficient is of the order of $\pm 100$ with $t$ below one.

# D The Stacked Input–Output System

Let $U_{ji}$ be the 2017 Use-table flow of product $j$ into sector $i$ in dollars, split by the BEA import matrix into a domestic part $U^D_{ji}$ and an imported part $U^M_{ji}$, and let $Y_i$ be sector $i$'s gross output. The technical coefficients of Section 3.1 are $a^D_{ij} = U^D_{ji}/Y_i$ and $s^T_{ij} = U^M_{ji}/Y_i$, and the $J \times J$ matrices $A^D = [a^D_{ij}]$ and $S^T = [s^T_{ij}]$ have buyers in rows and sellers in columns, the transpose of the Use table's layout. Row $i$ of $A^D$ is sector $i$'s domestic input mix per dollar of its output; column $j$ is the set of sectors that buy domestic $j$, in dollars per dollar of their own output.

Market clearing for domestic product $j$ states that its output is sold to final users or used as an input, $Y_j = F_j + \sum_i a^D_{ij} Y_i$, which in matrix form is $Y = F + (A^D)^\top Y$ and has the solution $Y = (L^D)^\top F$ with $L^D = (I - A^D)^{-1}$. Unit costs satisfy $d\log c_i = \sum_j a^D_{ij}\, d\log c_j + z^T_i$, or $d\log c = A^D\, d\log c + z^T$, with solution $d\log c = L^D z^T$. The tariff exposure is therefore $Z^T = L^D z^T =$

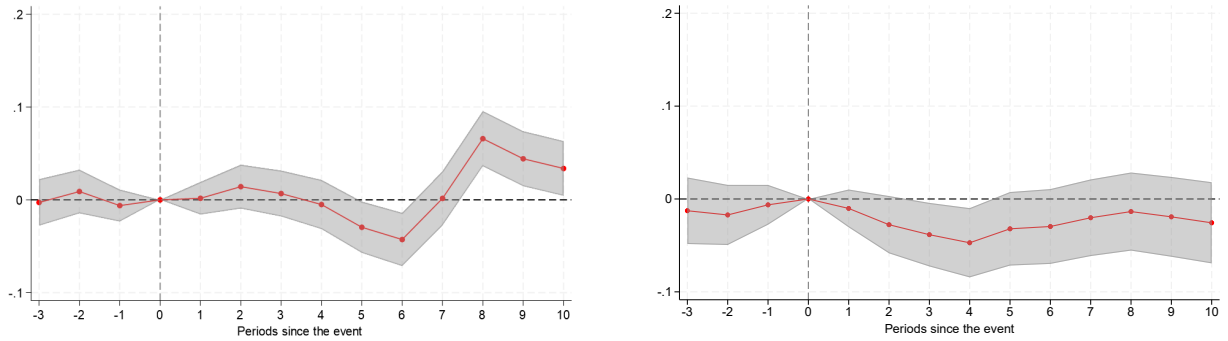
$L^D S^T \bar{\tau}$, a row operation that collects the costs of a sector's suppliers, and the retaliation exposure is $Z^{RT} = \text{diag}(Y)^{-1}(L^D)^\top \text{diag}(E)\,\bar{\tau}^*$, a column operation that collects the lost sales of a sector's customers. In the 2017 table the largest column sum of $A^D$ is below one, the diagonal of $L^D$ lies between 1.00 and 1.61, and the Neumann series converges.

# E Trade Diversion: Non-Tariffed Sources and Non-Retaliating Destinations

This appendix complements the headline product-level estimates in Section 4.5 by asking whether the trade contractions documented there reflect a true reduction in U.S. trade with the world, or whether the same products are simply being sourced from, or sold to, partners that were not part of the tariff or retaliation lists. The exercise re-estimates the product-level event study in equation (23),

$$\log y_{pm,t+h} - \log y_{pm,t-1} \;=\; \alpha_{pm} \;+\; \delta_t \;+\; \sum_{\ell \neq -1} \beta_{h\ell}\, \mathbf{1}\{t - g_{pm} = \ell\} \;+\; \varepsilon_{pm,t+h},$$

on two alternative samples. For each tariffed HS6 line, I track imports of the same product from countries *not* subject to the U.S. tariff; for each retaliated HS6 line, I track U.S. exports of the same product to destinations *not* subject to the retaliation. In both cases, $g_{pm}$ is the implementation month of the policy on the originally tariffed (or retaliated) partner, not on the partner being studied: the construction isolates whether trade that left the tariffed (retaliated) channel reappeared elsewhere in U.S. trade with the world. Following recent recommendations on staggered-adoption event-study designs, I report the heterogeneity-robust estimator of de Chaisemartin and D'Haultfœuille (2020).




(a) Imports from non-tariffed sources

(b) Exports to non-retaliating destinations

Figure 14: **Trade diversion.** Estimates of $\beta_{h\ell}$ from equation (23) at the HS6-by-country-by-month level. Panel (a): imports of tariffed products from countries *not* subject to the U.S. tariff. Panel (b): U.S. exports of retaliated products to destinations *not* subject to the retaliation. Coefficients computed with the heterogeneity-robust estimator of de Chaisemartin and D'Haultfœuille (2020). Horizon in months relative to the implementation date $g_{pm}$ of the policy on the originally treated partner. Shaded areas are 90% confidence intervals. Standard errors clustered at the policy-date level.

The estimates appear in Figure 14. On the import side (Panel 14a), the pre-trend is flat and

the short-run responses ($h \leq 4$) are indistinguishable from zero. There is a mild negative dip around $h = 5$–6 and a positive bump at longer horizons, with the point estimate peaking near +6 to +7% at $h = 8$ and settling at about +3% at $h = 10$. So imports from non-tariffed sources do rise late in the window, but at a magnitude that recoups only a small fraction of the roughly −40% contraction in imports from tariffed sources documented in Panel (a) of Figure 7. On the export side (Panel 14b), the response is qualitatively flatter and centred below zero throughout: a mild downward drift to about −5% around $h = 3$–4, recovering to roughly −2 to −3% by $h = 10$, with confidence intervals that comfortably bracket zero at every horizon. U.S. exports of retaliated products are therefore not redirected towards non-retaliating destinations; if anything, the negative point estimates suggest a small spillover of the retaliation shock onto sales in unaffected markets.

Taken together, the two panels support the interpretation in the main text. The bulk of the import contraction in Figure 7(a) is a net reduction in U.S. trade rather than a redirection towards alternative sources, and the export contraction in Figure 7(b) is not the byproduct of U.S. producers redirecting sales towards markets that did not retaliate.

# F Model: Full Specification

This appendix states the primitives, derivations and equilibrium conditions summarised in section 5, in the same order: environment, preferences, firms, nominal rigidities, the foreign economies, government and policy, and the equilibrium with its solution method. Price- and wage-adjustment costs throughout are payments that discipline price and wage setting but do not use up resources: each is returned within the period as a lump-sum transfer to the agents who paid it, so that they appear in no budget constraint and in no market-clearing condition.

## F.1 Environment and the network

Countries are $n, m \in \{1, 2, 3\}$ for the United States, the rest of the world and China, sectors $i, j \in \{1, 2, 3\}$ for manufacturing, services and agriculture. The exchange rate $E_{n,t}$ is in units of country $n$'s currency per dollar, $E_{1,t} \equiv 1$, and the buyer prices $\tilde{p}^{C}_{n,m,i,t}$ and $\tilde{p}^{X}_{n,m,i,t}$ are those of (24), with $\tau^{C}_{n,n,i,t} = \tau^{X}_{n,n,i,t} = 0$.

The four weight sets of section 5.1 are

$$\begin{aligned}
\Gamma^{\text{sec}}_{n,i} &= \text{share of country-}n\text{ household expenditure on sector } i, \\
\Gamma^{\text{src}}_{n,i,m} &= \text{share of country-}n\text{ sector-}i\text{ consumption sourced from country } m, \\
\Omega^{\text{sec}}_{n,i,j} &= \text{share of the intermediate spending of sector } (n,i) \text{ on sector-}j\text{ goods}, \\
\Omega^{\text{src}}_{n,i,j,m} &= \text{share of that sector-}j\text{ input spending sourced from country } m,
\end{aligned}$$

each summing to one over its last index. They are computed from the OECD Inter-Country Input–Output tables for 2015 (OECD, 2022): the consumption weights from household and non-profit final consumption by sector and origin, the production weights from the intermediate-use block by

purchasing sector, input sector and origin, each aggregated to three countries and three sectors. The mapping from ISIC codes to the model sectors follows Kalemli-Özcan et al. (2026): manufacturing is ISIC C13–C33, agriculture is ISIC A together with C10–C12 (food, beverages and tobacco), and services is the residual. The labour weights $\alpha_{n,i}$ of the production function are the value-added shares of gross output in the same tables.

### F.2 Preferences

**Utility and bundles.** Households of type $h \in \{H, L\}$ have the preferences (25). The division by $\Gamma^{\text{sec}}_{1,i}$ inside the Cobb–Douglas aggregate is a normalisation that makes the associated price index the weight-free geometric average in (27) and leaves demands unaffected. Within each sector, the origin bundle is (26), and expenditure minimisation gives the price indices and origin demands in (27) together with the sectoral allocation

$$P^{C}_{1,i,t} C^{h}_{i,t} = \Gamma^{\text{sec}}_{1,i} P^{C}_{1,t} C^{h}_{t}. \tag{49}$$

The Cobb–Douglas aggregate is the unit-elastic limit of the non-homothetic specification of Andreolli et al. (2025), under which sectoral expenditure shares are constant and equal to the network weights. It aligns the steady-state expenditure structure of the household block with the empirical shares without free parameters along the transition, and isolates the network and incidence channels from the income-elasticity channel that operates only when sectoral elasticities differ. The Greenwood–Hercowitz–Huffman form (Greenwood et al., 1988) places hours inside the composite $\tilde{C}^h$, so that the marginal rate of substitution between hours and consumption is $\chi^h (N^h_t)^{\eta_h}$, independent of the marginal utility of wealth. This keeps the desired hours of hand-to-mouth households from responding mechanically to the contemporaneous bite of their budget constraint, a response that would generate a correlation between their consumption and hours with no counterpart in the evidence on earnings, and confines the incidence of the war on them to the real wage, hours and the consumption basket.

**Unconstrained households** choose $\{C^H_{i,t}, N^H_t, a_t\}$ to maximise (25) subject to (28), where $a_t$ is end-of-period per-capita holdings of the international bond and

$$\Pi_t \equiv \sum_i \left( P_{1,i,t} Y_{1,i,t} - W^{\text{sec}}_{1,i,t} L_{1,i,t} - P^{X}_{1,i,t} X_{1,i,t} \right) \tag{50}$$

is the operating surplus of U.S. firms. With $\lambda^h_t$ the multiplier on the date-$t$ budget constraint, the first-order conditions for consumption, hours and bonds are

$$\lambda^h_t \, \tilde{C}^h_t \, P^{C}_{1,t} = 1, \qquad \chi^h \big(N^h_t\big)^{\eta_h} = \frac{W^h_t}{P^{C}_{1,t}}, \qquad h \in \{H, L\}, \tag{51}$$

$$\lambda^H_t = \beta \, \lambda^H_{t+1} (1 + i_{1,t}). \tag{52}$$

The marginal utility of wealth drops out of the labour-supply condition, so hours depend on the real wage alone; under sticky wages this condition holds only in the long run and becomes the target around which wages adjust. Combining the two conditions for $h = H$ gives the Euler equation of section 5.2.

**Hand-to-mouth households** hold no assets and own no firms, so their budget constraint is (29). They allocate consumption across sectors and origins as in (49) and (27) and satisfy the labour-supply condition in (51) with their own $\chi^L$ and $\eta_L$.

**Profit and rebate allocation.** Firm profits accrue entirely to unconstrained households and tariff revenue is split by $\omega_T$. Routing profits to the unconstrained block is the convention of the two-agent New Keynesian literature (Bilbiie, 2020; Auclert, 2019), and is appropriate here because customs duties are collected at the federal border and reach households through income-tax adjustment and corporate profit pass-through, both concentrated at the top of the income distribution. The equal-per-capita rebate, $\omega_T = \mu$, and the fully regressive rebate, $\omega_T = 0$, are reported as robustness, and the role of the rebate rule is examined separately in section 7.

### F.3 Firms

**Technology.** Each firm in sector $(n, i)$ produces with (30), where the intermediate bundle is the two-tier aggregate

$$X_{n,i,t} = \Big[ \textstyle\sum_j \left(\Omega^{\text{sec}}_{n,i,j}\right)^{1/\theta_{Xh}} X_{n,i,j,t}^{(\theta_{Xh}-1)/\theta_{Xh}} \Big]^{\theta_{Xh}/(\theta_{Xh}-1)}, \tag{53}$$

$$X_{n,i,j,t} = \Big[ \textstyle\sum_m \left(\Omega^{\text{src}}_{n,i,j,m}\right)^{1/\theta_{X\ell,n}} x_{n,i,j,m,t}^{(\theta_{X\ell,n}-1)/\theta_{X\ell,n}} \Big]^{\theta_{X\ell,n}/(\theta_{X\ell,n}-1)}, \tag{54}$$

with $x_{n,i,j,m,t}$ the purchases of sector-$j$ goods from country $m$ by sector $(n, i)$. Cost minimisation yields the price indices (31), the input demands

$$x_{n,i,j,m,t} = \Omega^{\text{src}}_{n,i,j,m} \left(\frac{\tilde{p}^X_{n,m,j,t}}{P^X_{n,i,j,t}}\right)^{-\theta_{X\ell,n}} \Omega^{\text{sec}}_{n,i,j} \left(\frac{P^X_{n,i,j,t}}{P^X_{n,i,t}}\right)^{-\theta_{Xh}} X_{n,i,t}, \tag{55}$$

the input–labour ratio and the real marginal cost $mc_{n,i,t} \equiv MC_{n,i,t}/P_{n,i,t}$ of (32),

$$\frac{X_{n,i,t}}{L_{n,i,t}} = \frac{1-\alpha_{n,i}}{\alpha_{n,i}} \left(\frac{W^{\text{sec}}_{n,i,t}}{P^X_{n,i,t}}\right)^{\theta_X}. \tag{56}$$

Labour is freely reallocated across sectors, so these conditions hold period by period; the only frictions are the nominal ones of appendix F.4.

**The network limit.** Log-differentiating (32) and (31) at the steady state and letting $\theta_X, \theta_{Xh}, \theta_{X\ell,n} \to 0$ gives

$$d\log mc_{n,i} = \alpha_{n,i}\, d\log W^{\text{sec}}_{n,i} + (1-\alpha_{n,i}) \sum_j \Omega^{\text{sec}}_{n,i,j} \sum_m \Omega^{\text{src}}_{n,i,j,m}\, d\log \tilde{p}^X_{n,m,j},$$

whose coefficients $(1-\alpha_{n,i})\Omega^{\text{sec}}_{n,i,j}\Omega^{\text{src}}_{n,i,j,m}$ are the technical coefficients $a_{ni,mj}$ of equation (5). Imposing $d\log P_{n,j} = d\log mc_{n,j}$ for domestic sellers and holding wages and foreign prices fixed, the solution across sectors is the Leontief propagation of equation (14) with the tariffs as the forcing term, so that the exposure of section 3 is the first-order marginal-cost response of the model in its no-substitution limit.

**Skill aggregation.** In the United States the labour input is the skill aggregate (33), with $L^h_{i,t}$ sector $i$'s use of skill $h$. Cost minimisation gives the sectoral wage index in (33) and the skill demands

$$L^h_{i,t} = \alpha^h_i \left( \frac{W^h_t}{W^{\text{sec}}_{1,i,t}} \right)^{-\theta_{HL}} L_{1,i,t}, \qquad h \in \{H, L\}. \tag{57}$$

With $\theta_{HL} \neq 1$ the weights $\alpha^L_i$ differ from the steady-state employment shares of the two skills, and recovering them from the PSID requires an inversion. Taking the ratio of the two conditions in (57) at the steady state, the sector-$i$ low-skill employment share $s_i \equiv L^L_i / L_{1,i}$ satisfies

$$\frac{s_i}{1-s_i} = \frac{\alpha^L_i}{\alpha^H_i} \left( \frac{W^H}{W^L} \right)^{\theta_{HL}}, \tag{58}$$

which inverts to (66) in appendix F.8. The skill premium is endogenous, so the inversion defines a fixed point: weights are set at a trial premium, the steady state is solved, the realised premium read off, and the weights re-inverted; convergence takes three to four passes. Two properties of the mapping matter. Feeding the PSID shares in as weights, as a Cobb–Douglas version would, overstates hand-to-mouth employment by three to five percentage points in every sector at a premium of 1.5. And the ratio that governs the distributional result, the share of low-skill hours in the retaliated sectors relative to the same share for high-skill hours, is invariant to the realised premium: at premia of 1.3, 1.5 and 1.8 the calibrated weights deliver the same ratio of 2.04. The fixed point matters for matching $\mu$ and is immaterial for the mechanism.

## F.4 Nominal rigidities

**Prices.** Varieties within sector $(n, i)$ are aggregated with elasticity $\theta_R > 1$ and supplied by monopolistically competitive firms, which pay a quadratic cost $\frac{\delta_{n,i}}{2}(\pi_{n,i,t} - 1)^2$ of changing their nominal price, in units of sectoral revenue. A constant subsidy on marginal cost at rate $1/\theta_R$, financed lump sum, offsets the flexible-price markup, so that the steady state is efficient, price equals marginal cost and pure profits are zero. In the symmetric equilibrium prices satisfy (35). The slope $(\theta_R - 1)/\delta_{n,i}$ is the Rotemberg counterpart of the Calvo slope $(1-\vartheta_{n,i})(1-\beta\vartheta_{n,i})/\vartheta_{n,i}$, where $\vartheta_{n,i}$ is the probability of not adjusting, so that sectoral price durations map into $\delta_{n,i}$ through

$\delta_{n,i} = (\theta_R - 1)\vartheta_{n,i}/[(1 - \vartheta_{n,i})(1 - \beta\vartheta_{n,i})]$.

**Wages.** Each U.S. skill is supplied as a continuum of labour varieties aggregated with elasticity $\theta_{R,W} > 1$; the union setting the wage of a variety pays a quadratic cost $\frac{\delta_W^h}{2}(\pi_t^{W,h} - 1)^2$ of changing it, and a subsidy at rate $1/\theta_{R,W}$ on the marginal disutility of labour offsets the wage markup. The wage of skill $h$ then satisfies (36); with $\delta_W^h = 0$ it collapses to the labour-supply condition in (51). At the zero-inflation steady state the wage Phillips curve pins the static condition $\chi^h(\bar{N}^h)^{\eta_h} = \bar{W}^h/\bar{P}_1^C$, which is what allows $\chi^H$ and $\chi^L$ to be recovered from the steady state.

### F.5 The foreign economies

The representative household in country $n \in \{2, 3\}$ ranks sequences according to

$$\mathcal{U}_{n,0} = \sum_{t=0}^{\infty} \beta^t \left[ \frac{C_{n,t}^{1-\sigma}}{1-\sigma} - \chi_n \frac{L_{n,t}^{1+\eta}}{1+\eta} \right], \tag{59}$$

with consumption aggregated across sectors as in (25) at the weights $\Gamma_{n,i}^{\text{sec}}$ and across origins as in (26) with its own $\theta_{C\ell,n}$. Its optimality conditions are

$$\frac{W_{n,t}}{P_{n,t}^C} = \chi_n L_{n,t}^{\eta} C_{n,t}^{\sigma}, \qquad 1 = \beta \left( \frac{C_{n,t+1}}{C_{n,t}} \right)^{-\sigma} \frac{P_{n,t}^C}{P_{n,t+1}^C}(1 + i_{n,t}), \tag{60}$$

together with $P_{n,i,t}^C C_{n,i,t} = \Gamma_{n,i}^{\text{sec}} P_{n,t}^C C_{n,t}$ and the origin allocation in (27). The household holds the dollar bond, receives the profits of its firms and the tariff revenue of its government. Two differences from the U.S. block are deliberate: foreign preferences are separable, so the term $C_{n,t}^{\sigma}$ reintroduces the wealth effect on labour supply that (25) removes, and foreign wages are flexible, so the first condition in (60) holds period by period. Foreign firms are otherwise identical to U.S. firms and satisfy (31)–(32) and (35) with $W_{n,i,t}^{\text{sec}} = W_{n,t}$.

### F.6 Government and policy

**Tariff revenue.** U.S. revenue is (39), with the analogous expression $T_{n,t}$ for each foreign country. Each government rebates its revenue in full within the period; budgets balance and no debt is issued. In the United States the share rebated to hand-to-mouth households is the product of the Market Facilitation Program payments over customs duties and the low-skill share of agricultural labour income,

$$\omega_T = 0.35 \times 0.664 = 0.232. \tag{61}$$

**Monetary policy.** The policy rule is (40), with $\pi_{n,t}^C \equiv P_{n,t}^C/P_{n,t-1}^C$, $Y_{n,t}$ real value added and $\bar{Y}_{n,t}$ the steady-state output associated with the tariff vector agents currently believe permanent. The intercept $1/\beta$ centres the rule at the steady-state real rate and the exponent $1 - \rho_n$ makes $\phi_{\pi,n}$ the long-run response to inflation. The price-level term $\phi_{p,n} > 0$ is required for determinacy: under

perfect foresight with permanent shocks it pins down the long-run price level, and for China it also removes the near-unit root in the nominal exchange rate that a weak inflation response would otherwise induce.

**International finance.** The only asset traded internationally is a one-period nominal bond in dollars, in zero net supply; no state-contingent claims are traded and hand-to-mouth households participate in no asset market. With $\mathcal{B}_{n,t}$ the net foreign asset position of country $n$ and $\mathcal{B}_{1,t} = (1-\mu)a_t$, positions are subject to the cost in (41), and each foreign position evolves according to its balance of payments,

$$\mathcal{B}_{n,t} = (1+i_{1,t-1})\mathcal{B}_{n,t-1} + \sum_i P_{n,i,t}Y_{n,i,t} + T_{n,t} - \Big[\sum_{m,i} \tilde{p}^C_{n,m,i,t}c_{n,m,i,t} + \sum_{m,i,j} \tilde{p}^X_{n,m,j,t}x_{n,i,j,m,t}\Big], \qquad n \neq 1, \tag{62}$$

with bond-market clearing

$$\sum_n \mathcal{B}_{n,t} = 0. \tag{63}$$

The cost $\psi$ in (41) is a stationarity device rather than a calibrated risk price: with a common discount factor nothing else pins down the steady-state distribution of net foreign assets, and $\psi > 0$ selects the one in which $\mathcal{B}_n = 0$ for every country.

**The tariff path.** Tariffs are legislated at daily frequency and the model is quarterly: each quarter carries, on every bilateral sectoral leg, the day-weighted average of the statutory rates in force during that quarter, and the last quarter of the sequence carries the September 2019 schedule. The announcement vectors $\boldsymbol{\tau}^{(s)}$, $s = 1, \ldots, S$, are the quarterly paths so constructed, so that no parameter of the shock process is free; section 6 gives the calendar. Before the war every cross-border goods leg carries the most-favoured-nation rate of section 6 in both instruments; own-country legs and all services legs carry no duty in any period.

### F.7 Equilibrium, information structure and solution

**Equilibrium under a given tariff vector.** Given initial conditions $\{a_{-1}, \mathcal{B}_{n,-1}, P_{n,i,-1}, W^h_{-1}, W_{n,-1}, i_{n,-1}\}$ and a constant tariff vector, an equilibrium is a collection of prices $\{P_{n,i,t}, P^C_{n,i,t}, P^C_{n,t}, P^X_{n,i,j,t}, P^X_{n,i,t}, W^H_t, W^L_t, W^{\text{sec}}_{1,i,t}, W_{n,t}, E_{n,t}, i_{n,t}\}$ and quantities $\{C^h_{i,t}, N^h_t, a_t, C_{n,i,t}, c_{n,m,i,t}, L_{n,t}, Y_{n,i,t}, L_{n,i,t}, L^h_{i,t}, X_{n,i,t}, x_{n,i,j,m,t}, \mathcal{B}_{n,t}\}$ such that, at every date:

(i) U.S. households satisfy (27), (49) and (51); type $H$ satisfies (52) and (28); type $L$ satisfies (29);

(ii) foreign households satisfy (60) and their budget constraints;

(iii) firms in every $(n, i)$ satisfy (31)–(32), (55)–(56) and the Phillips curve (35);

(iv) U.S. wages satisfy (33), (57) and (36); foreign wages satisfy the intratemporal condition in (60);

Table 18: Quarterly implementation calendar: fraction of the peak increment in force

| | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| Leg | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| US from China, Manuf (Sec. 301) | 0 | 0 | 0.12 | 0.43 | 0.43 | 0.59 | 0.89 | 1.00 |
| US from RoW, Manuf (Sec. 232) | 0.09 | 0.90 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| China from US, Agriculture | 0 | 0.10 | 0.70 | 0.75 | 0.75 | 0.85 | 0.95 | 1.00 |
| China from US, Manufacturing | 0 | 0 | 0.38 | 0.70 | 0.70 | 0.85 | 0.97 | 1.00 |
| RoW from US, Manufacturing | 0 | 0.30 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| RoW from US, Agriculture | 0 | 0.30 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

*Notes.* Each entry is the within-quarter time average of the applied increment, as a fraction of the peak in table 5. Section 232 is announced 1 March and effective 23 March 2018, with partner exemptions to 1 June, giving 0.09 in Q1 and 0.90 in Q2. List 1 is effective 6 July and List 2 on 23 August 2018; List 3 at 10% on 24 September 2018; the increase to 25% on 10 May 2019; List 4A on 1 September 2019. Chinese and other-partner retaliation is mirrored on its own announced dates. The $\tau^C$ and $\tau^X$ channels of a given leg share the same calendar. Agents observe each column when it arrives and treat it as permanent thereafter.

(v) goods markets clear, for all $(n, i)$,

$$Y_{n,i,t} = \sum_m c_{m,n,i,t} + \sum_m \sum_j x_{m,j,i,n,t}, \tag{64}$$

where $c_{1,n,i,t} = (1-\mu)c^H_{1,n,i,t} + \mu\, c^L_{1,n,i,t}$ aggregates the two U.S. types;

(vi) labour markets clear, skill by skill in the United States,

$$\sum_i L^H_{i,t} = (1-\mu)N^H_t, \qquad \sum_i L^L_{i,t} = \mu N^L_t, \tag{65}$$

and $\sum_i L_{n,i,t} = L_{n,t}$ abroad;

(vii) government budgets balance, with revenue (39) rebated as in appendix F.6;

(viii) the bond market clears, (63); the parity condition (41) holds for $n \neq 1$; and each foreign position evolves according to (62);

(ix) monetary policy follows (40) in every country, and $E_{1,t} \equiv 1$.

By Walras' law the budget constraint of the unconstrained households is implied by the remaining conditions; it is retained as a residual and verified along every solved path.

**Information structure.** Fix announcement dates $1 = q_1 < q_2 < \cdots < q_S$ and tariff vectors $\{\boldsymbol{\tau}^{(s)}\}_{s=1}^S$. At each $q_s$ agents observe $\boldsymbol{\tau}^{(s)}$ and believe with certainty that $\boldsymbol{\tau}_t = \boldsymbol{\tau}^{(s)}$ for all $t \geq q_s$; beliefs are revised only at the dates $q_s$. Each tranche of the war was contested up to the day it took effect and none was preannounced as part of a committed schedule, which is why the currently implemented configuration is taken as the belief. Beliefs are wrong $S-1$ times, at every $q_s$ with $s \geq 2$, and these expectation errors are the only source of surprise in an otherwise deterministic model.

**Definition 1** (Equilibrium with expectation errors)**.** *Given the announcement dates and tariff vectors, an equilibrium is a sequence of plans* $\{\mathcal{E}^{(s)}\}_{s=1}^{S}$ *and a realised path* $\{\mathcal{X}_t\}_{t\geq 1}$ *such that each* $\mathcal{E}^{(s)}$ *is an equilibrium in the sense above for the constant tariff vector* $\boldsymbol{\tau}^{(s)}$*, with initial conditions given by the realised state at* $q_s - 1$ *and terminal condition the steady state associated with* $\boldsymbol{\tau}^{(s)}$*; the realised path satisfies* $\mathcal{X}_t = \mathcal{E}_t^{(s)}$ *for* $q_s \leq t < q_{s+1}$ *and* $\mathcal{X}_t = \mathcal{E}_t^{(S)}$ *for* $t \geq q_S$*; and the reference level of output in* (40) *is the steady-state output associated with the prevailing* $\boldsymbol{\tau}^{(s)}$*.*

The realised path is not the solution to any single optimisation problem: the optimality conditions hold within plans and not across them, so that (52) is satisfied for each date's believed continuation rather than for the realised one. Since beliefs at $q_S$ are never falsified, the realised long run is the steady state associated with $\boldsymbol{\tau}^{(S)}$; the case $S = 1$ is the single perfect-foresight experiment.

**Steady states.** A steady state is an equilibrium in which tariffs and all endogenous variables are constant, with the normalisations $P_n^C = 1$ in local currency for every $n$ and $E_1 = 1$. Gross inflation equals one and $i_n = \beta^{-1} - 1$; real marginal cost equals one, so price equals marginal cost and profits (50) are zero; the labour-supply condition in (51) holds exactly; net foreign assets are zero and trade is balanced, since (41) with constant exchange rates and $i_n = i_1$ requires $\mathcal{B}_n = 0$; and each nominal exchange rate is the reciprocal of that country's consumption price index in dollars, which the price-level term of the policy rule anchors. The algorithm requires $S + 1$ steady states, the pre-war one and the terminal one associated with each announcement. The pre-war steady state, at the most-favoured-nation tariffs, is the calibration point: the preference constants $\chi^h$ and $\chi_n$ and the skill weights $\alpha_i^h$ are recovered there from the per-capita budgets of the two U.S. types and the sectoral expenditure shares, and are held fixed across the war steady states, so that any difference between allocations is the tariff and not a refitted preference. Each with-tariff steady state is solved in dollar prices, from which exchange rates cancel and are recovered afterwards from the price-level anchors, over the sectoral producer prices and the consumption and hours of each household; because the retaliation legs reach 30% and the Armington nests are strongly curved at those rates, the system is solved by continuation in the tariff scale, at 25%, 50%, 75% and 100% of the announced vector, each solution seeding the next.

**Solution algorithm.** Let $\mathcal{S}_t$ collect the predetermined variables, $\mathcal{S}_t = \{P_{n,i,t}, W_t^H, W_t^L, W_{n,t}, \mathcal{B}_{n,t}, i_{n,t}, \boldsymbol{\tau}_t\}$, and let $H$ be a truncation horizon long enough that the terminal condition does not bind on the reported window.

**Step 1.** *Initialise.* Compute the pre-war steady state $\bar{x}^{(0)}$ and set $\mathcal{S}_{q_1-1} = \bar{x}^{(0)}$.

**Step 2.** *Believed terminal state.* For announcement $s$, solve the steady state $\bar{x}^{(s)}$ at $\boldsymbol{\tau}^{(s)}$, a full nonlinear solve repeated for every $s$, and set the reference output in (40) to $\bar{Y}_n^{(s)} = Y_n(\bar{x}^{(s)})$.

**Step 3.** *Solve the plan.* Solve the equilibrium over $t = q_s, \ldots, q_s + H$ holding $\boldsymbol{\tau}_t = \boldsymbol{\tau}^{(s)}$, with $\mathcal{S}_{q_s-1}$ given and $x_{q_s+H} = \bar{x}^{(s)}$, initialised by linear interpolation between the inherited state and

the terminal steady state.

**Step 4.** *Splice.* If $s < S$, retain $\mathcal{E}_t^{(s)}$ for $t = q_s, \ldots, q_{s+1} - 1$, discard the remainder, and pass $\mathcal{S}_{q_{s+1}-1}$ to Step 2 for announcement $s + 1$. If $s = S$, retain the entire plan.

The plans tile the calendar without gaps or overlaps, and expectation errors occur only at the dates $q_2, \ldots, q_S$. The decomposition exercises that feed the U.S. legs alone or the foreign legs alone apply the same algorithm to a masked tariff vector, so that each has its own sequence of believed terminal states; the difference between the joint path and the sum of the two is a general-equilibrium interaction. The implementation is the perfect-foresight-with-expectation-errors routine of Adjemian et al. (2024).

### F.8 Calibration details

**Hand-to-mouth shares and skill weights.** In the PSID, 2003 to 2021, a household is hand-to-mouth when its liquid assets, checking and savings accounts, certificates of deposit, bonds and directly held equity net of liquid debt, are below one month of family income, the definition of Kaplan et al. (2014); the population share is $\mu = 1/3$. Each household is assigned to the Census industry of its primary earner, the industry is mapped to the three model sectors through the crosswalk used for the exposures, manufacturing being ISIC C13–C33, agriculture ISIC A with C10–C12, and services the rest, and the hand-to-mouth share of each sector's hours is $s_i^{\text{PSID}} = (0.30, 0.20, 0.45)$ for manufacturing, services and agriculture. Because U.S. employment is concentrated in services, the employment-weighted mean of these shares is 0.21, below $\mu$; since the PSID identifies the cross-sector pattern more credibly than the level, the vector is scaled up, giving the target hours shares $s_i = (0.422, 0.273, 0.664)$ of table 4 with the ordering and spacing preserved. Their employment-weighted mean is 0.30; the remaining gap to $\mu$ is closed by hours per worker, unconstrained households working about fifteen percent more hours than hand-to-mouth households at the steady state, which is the hours difference the relative wage is set against. With $\theta_{HL} \neq 1$ the CES weights are not the shares: from the skill demands (57) at the steady state, the target share $s_i$ requires

$$\frac{\alpha_i^L}{\alpha_i^H} = \frac{s_i}{1 - s_i} \left( \frac{W^L}{W^H} \right)^{\theta_{HL}}, \qquad \alpha_i^L = \frac{r_i}{1 + r_i}, \quad r_i \equiv \frac{\alpha_i^L}{\alpha_i^H}, \tag{66}$$

evaluated at the equilibrium skill premium. The premium is endogenous, so the weights are set at a trial premium, the steady state is solved, the realised premium is read off and the weights re-inverted; three to four passes converge, and the result is $\alpha_i^L = (0.412, 0.265, 0.655)$, which reproduces the target hours shares exactly at the calibration steady state.

**The relative wage.** The premium is pinned by the income ratio between the two types rather than estimated: in the PSID the per-capita income of non-hand-to-mouth households is about 1.25 times that of hand-to-mouth households, and unconstrained households in the model work about fifteen percent more hours, so a wage ratio $W^H/W^L = 1.086$ reproduces the income ratio at the

calibration steady state. The ratio that governs the distributional result, the share of low-skill hours in the retaliated sectors relative to the same share for high-skill hours, is invariant to the premium across the range 1.3 to 1.8, premia used only in that sensitivity check; the baseline premium is 1.086.

**Price and wage durations.** The adjustment costs are set from durations through the Calvo equivalence of appendix F.4: with $\theta_R = 10$, $\delta_{n,i} = (33, 150, 37.5)$ gives Phillips-curve slopes of 0.27, 0.06 and 0.24, which correspond to mean price durations of about two and a half quarters in manufacturing, five in services and two and a half in agriculture, the manufacturing value, seven and a half months, at the lower end of the eight-to-eleven-month range that Nakamura and Steinsson (2008) report for regular price changes excluding sales. The wage costs $\delta_W^H = 75$ and $\delta_W^L = 130$ at $\theta_{R,W} = 10$ imply durations of about one year for high-skill and two years for low-skill wages, the ordering that Grigsby et al. (2021) document between salaried and hourly workers.

**The rebate share and the pre-war tariff.** The rebate share is (61): the Market Facilitation Program returned to farm households about 35 percent of the duties collected under the July 2018 and May 2019 authorisations, and the low-skill share of agricultural labour income, $\alpha^L_{\text{Agri}} = 0.664$, is the fraction of those payments that reaches hand-to-mouth households in the model. The pre-war steady state carries a 2% duty on every cross-border goods leg in both instruments, the U.S. trade-weighted applied most-favoured-nation rate, and none on services; at that steady state customs revenue is 0.19% of GDP against 0.2% in the data, and the escalation is measured from the rates firms and households actually faced, so that an 18-point tranche raises the applied rate from 2 to 20 percent rather than from zero.

### F.9 Welfare: household incidence by income source

Table 19: U.S. household welfare: consumption-equivalent variation by income source (%)

| | Total | Wage income | (rate) | (hours) | Rebate | Profits | Saving, prices |
|---|---|---|---|---|---|---|---|
| *Joint war: cumulative 20-quarter CEV (%)* | | | | | | | |
| Unconstrained ($H$) | −0.31 | −0.54 | −0.26 | −0.29 | +0.34 | 0.00 | −0.11 |
| Hand-to-mouth ($L$) | −0.54 | −0.70 | −0.14 | −0.56 | +0.26 | 0 | −0.10 |
| $H - L$ gap (pp) | +0.23 | +0.16 | −0.12 | +0.27 | +0.08 | 0.00 | −0.01 |
| Ratio $L/H$ | 1.75 | | | | | | |
| *By shock: 20-quarter CEV (%)* | | | | | | | |
| US tariffs only, $H$ | +0.02 | −0.28 | −0.14 | −0.14 | +0.35 | 0.00 | −0.05 |
| US tariffs only, $L$ | −0.08 | −0.30 | −0.06 | −0.24 | +0.27 | 0 | −0.05 |
| Retaliation only, $H$ | −0.33 | −0.27 | −0.12 | −0.15 | 0.00 | +0.01 | −0.07 |
| Retaliation only, $L$ | −0.48 | −0.42 | −0.08 | −0.34 | 0.00 | 0 | −0.06 |
| *Long run: permanent consumption loss (%)* | | | | | | | |
| Unconstrained ($H$) | −0.30 | | | | | | |
| Hand-to-mouth ($L$) | −0.60 | | | | | | |
| Ratio $L/H$ | 2.02 | | | | | | |

*Note*: two distributional statistics. The upper blocks give the cumulative consumption-equivalent variation over the twenty quarters of the war window, in percent of each agent's steady-state consumption, discounted at $\beta$ and normalised by the discounted weight of the window; the measure is the consumption part of lifetime utility, so a fall in rationed hours is not credited as leisure. The income-source columns follow the attribution of section 7.1; wage income is the sum of the rate and hours columns, and the last column collects net saving and the price level, so that the columns sum to the total up to rounding. Profits are zero at every steady state and their transitional fluctuations are worth at most a hundredth of a percent. The lower block is the deviation of the terminal with-tariff steady state from the pre-war steady state: a comparison of two steady states, with no discounting and no transition, identical across the one-shot and sequential-surprise designs. Read: −0.54 for the hand-to-mouth household means it would surrender 0.54% of its own consumption over the war window to avoid the shock.

## G Additional Model Results

This appendix reports the responses not shown in section 6.1: the full set of U.S. responses, the U.S. external account, the foreign economies, and the comparison of the model with the evidence.

**The full set of responses.** Figure 15 reports every U.S. variable under the joint shock.

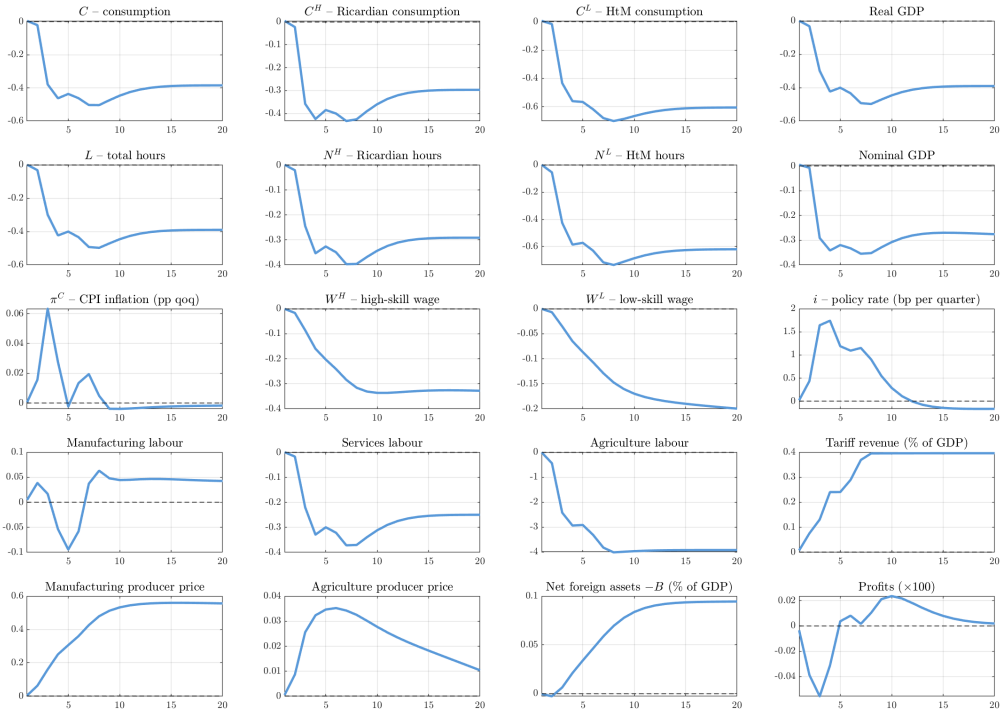



Figure 15: **The United States: full set of responses.** Aggregate and household-level consumption and hours, inflation, wages by skill, the policy rate, sectoral employment, tariff revenue, sectoral producer prices, net foreign assets and profits, in percent deviation from the pre-war steady state. Joint shock.

**The external account.** Figure 16 shows U.S. imports, exports, the trade balance and the dollar. Imports from China fall by a quarter and the bilateral balance with China improves by 0.16% of GDP, the observed thirty billion dollars. Two features are limits of the structure rather than predictions. Total exports fall by as much as total imports and the aggregate trade balance does not move, because with every wave believed permanent there is no motive to borrow, and the tariff that cuts imports taxes exports one for one through the exchange rate, whereas the deficit widened in the data. And imports from third countries stay flat where they rose, because a single Armington nest sends the substitution away from China to domestic producers rather than to Vietnam or Mexico. The dollar depreciates on the early waves, when the retaliation legs land, and ends 0.77% stronger against the renminbi and 0.27% stronger against the rest of the world. The two legs are individually large and of opposite sign: the U.S. tariff alone appreciates the dollar by about 3.3% against the renminbi and retaliation alone depreciates it by about 2.4%, so the small net movement in the data is the sum of two large offsetting forces rather than a weak exchange-rate channel.

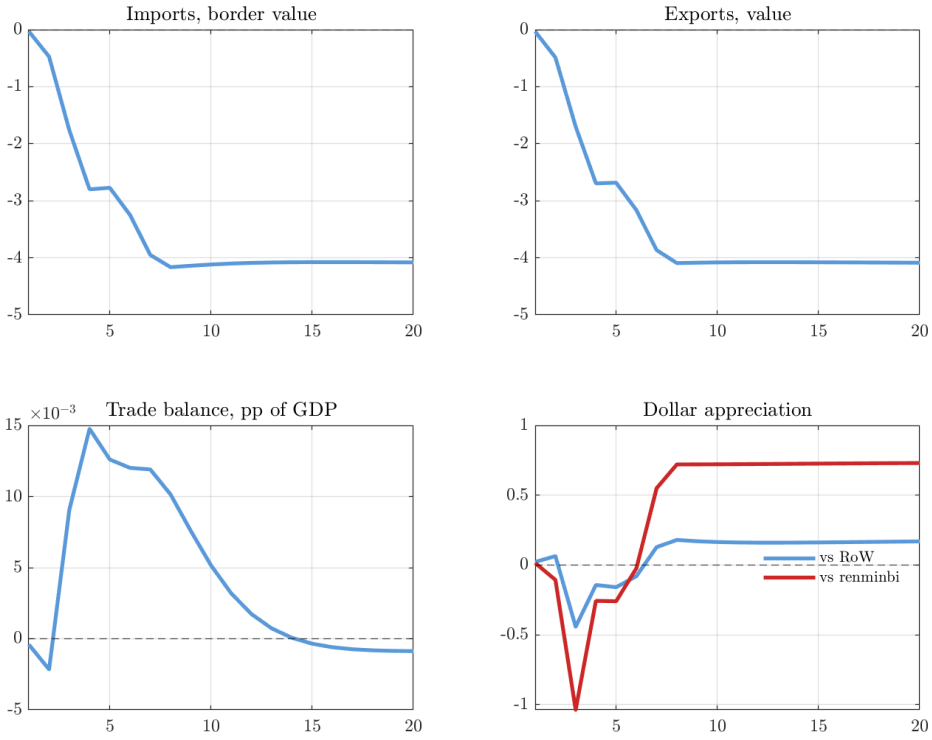



Figure 16: **The U.S. external account.** Imports at border values and exports in percent deviation from the pre-war steady state; the trade balance in percentage points of pre-war GDP; the dollar against the rest of the world and against the renminbi, a rise being an appreciation. Joint shock.

**The foreign economies.** China bears the mirror image of the U.S. adjustment (Figure 17). Its manufacturing employment falls by 0.65% as the U.S. tariff removes demand for its exports, its agricultural employment rises by 0.6% as it replaces U.S. soybeans with its own and with Brazilian supply, its real wage falls by a third of a percent and its trade shrinks by four and a half percent on both sides. Its consumption falls by less than its earnings, because it receives its own tariff revenue as a rebate and borrows abroad. The rest of the world is nearly untouched: its losses from lower U.S. and Chinese demand and its gains as the substitute for tariffed varieties in both markets cancel to one decimal.

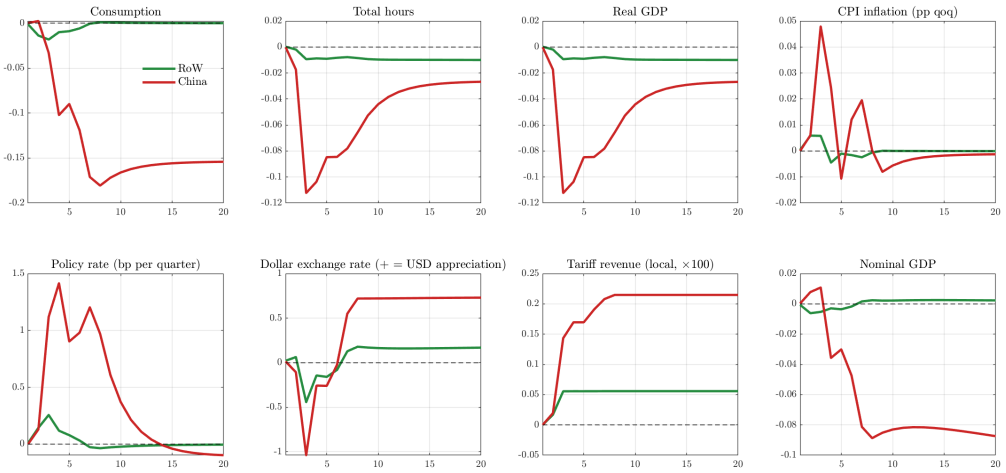



Figure 17: **The foreign economies.** China and the rest of the world under the joint shock: consumption, hours, real GDP, inflation, the policy rate, the bilateral dollar exchange rate, tariff revenue and nominal GDP, in percent deviation from the pre-war steady state or levels where indicated.

**The model against the evidence.** Table 20 collects the comparisons. The relative responses inside the model match the estimated ones, and the aggregate responses, which are untargeted, land where the external evidence puts them, with the dollar the one aggregate the model understates.

Table 20: Model against the evidence. Model entries are the joint war, long run unless stated.

| Object | Evidence | Model |
|---|---|---|
| *Paper's estimates* | | |
| Retaliation-exposed employment, 12m, per unit exposure | −20 | −19 |
| Tariff-exposed employment, 12m, per unit exposure | 0 (n.s.) | +4 |
| Earnings, 12m, per unit exposure | 0 (n.s.) | +0.2 |
| Hours, hand-to-mouth over unconstrained | 1.3–1.5 (Patterson, 2023) | 1.8 |
| *Trade* | | |
| Targeted import varieties | −32% (Fajgelbaum et al., 2020) | −30% |
| Exports to China | −18% (customs) | −17% |
| U.S.–China bilateral balance | +0.15% of GDP | +0.16% |
| Tariff revenue, pre-war | 0.2% of GDP | 0.19% |
| Dollar, tariff-attributable | +0.9 to 1.1 effective (Jeanne and Son, 2024) | +0.4 effective |
| Imports from other partners | rose | flat |
| Aggregate trade balance | worsened | unchanged |

# H Model Extensions

This appendix uses the baseline model for three experiments. Each keeps every parameter of section 6 and changes one thing: the Federal Reserve's rule, the tariff schedule, or the path of productivity. Welfare is measured by the twenty-quarter consumption equivalent of section 7, for the two households and their aggregate.

**A monetary counterfactual.** I re-solve the 2018–19 war under an *output-focused* rule that ignores inflation and responds to the output gap with a coefficient of one ($\phi_\pi = 0$, $\phi_y = 1$), holding the smoothing parameter, the price-level anchor and the foreign rules fixed, and compare it with the estimated rule of the baseline. Figure 18 shows the results. The counterfactual produces a milder recession, a trough of $-0.41\%$ against $-0.50$ under the estimated rule, and the two paths converge to the same long run. Welfare follows, at $-0.34$ against $-0.39\%$ of consumption for the U.S. aggregate, with the same two-to-one ratio between hand-to-mouth and unconstrained households under both rules. The mechanism runs through the expected real rate within each information set. A tariff wave lifts the price level once; given the anchor in the rule, every believed plan then contains a slow expected deflation back to target, which raises expected real rates and makes households defer consumption. A rule that cuts along the persistent output gap keeps expected real rates low and offsets part of the demand shortfall. The inflation arm of the rule is nearly inert, because tariff inflation is a sequence of one-quarter level shifts that the smoothing term filters out; the realised policy rate never moves by more than seven basis points under either rule.

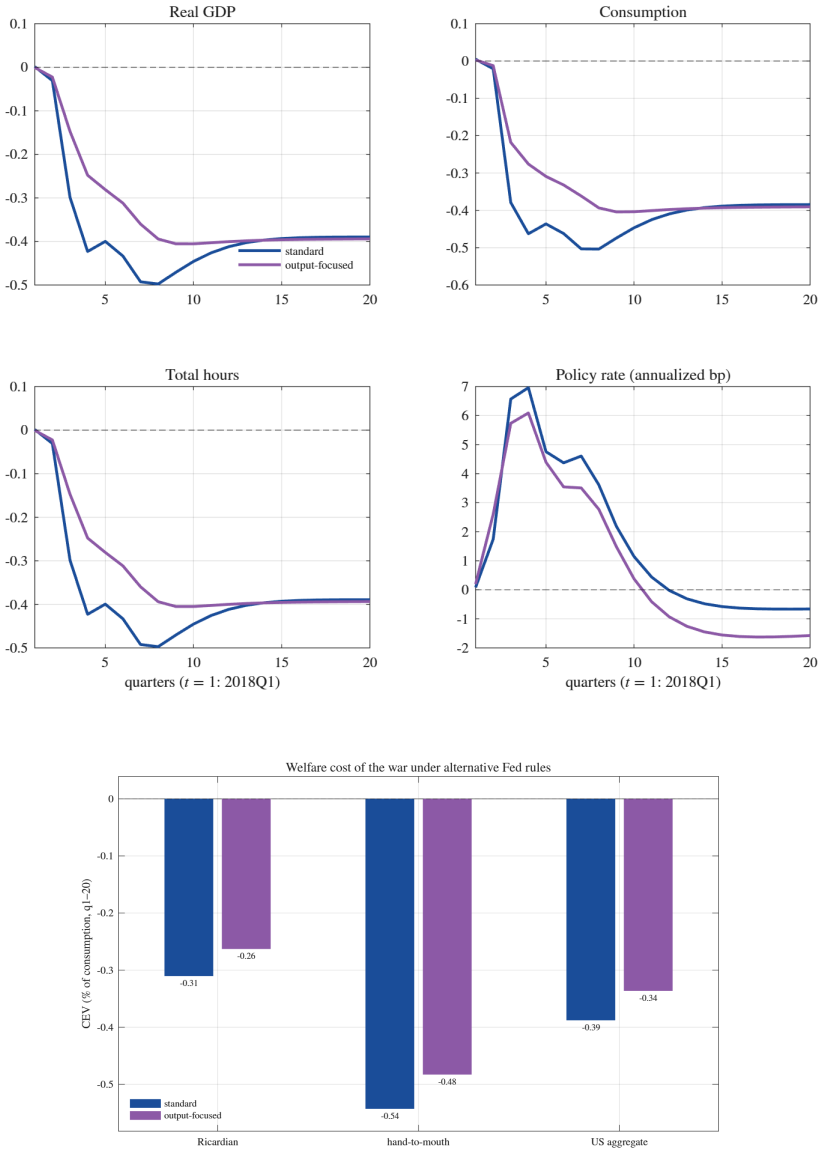



Figure 18: **The 2018–19 war under the estimated and the output-focused rule.** Top: real GDP, consumption, hours and the policy rate. Bottom: welfare cost of the first twenty quarters by household.

**The 2025 war.** I run the 2025 schedule as a second war starting from the terminal steady state of the first, with the calibration constants unchanged, so that the two episodes are two shocks to one and the same economy. The settled increments over the 2018 rates are 30 points on Chinese manufactures and agriculture, 10 on rest-of-world manufactures and 6 on its farm goods, 12 points of Chinese retaliation on U.S. agriculture and 10 on U.S. manufactures, and 2 from the rest of the world; they arrive as four quarterly waves from 2025Q1, with the April 2025 spike, a 93 percent rate on Chinese goods for part of one quarter, entering as a day-weighted overshoot in the second wave. Figure 19 compares the two wars. The 2025 war is a spike where the 2018 war was a staircase.

Output falls by 1.4% in the spike quarter and recovers to −0.5 within two years, where it remains; the price level peaks at +0.36%, two and a half times the 2018 peak, because the tariff base now covers every trading partner; and the dollar appreciates by 3.8% against the renminbi, five times the 2018 response. Yet the welfare cost is smaller: −0.31% of consumption for the U.S. aggregate against −0.39 for the first war, −0.24 against −0.31 for unconstrained households and −0.46 against −0.54 for hand-to-mouth households. The reason lies in the balance of the two halves. U.S. tariffs alone are now a net gain, +0.05% and +0.09 for unconstrained households, because a larger and broader tariff raises more revenue and moves the terms of trade further, the optimal-tariff logic at work; retaliation is of the same size as in 2018 and costs the same, −0.37. The incidence is as regressive as before: hand-to-mouth households lose under U.S. tariffs alone, −0.04, and bear the larger share of the retaliation loss, so the ratio of their loss to that of unconstrained households rises from about 1.7 to 1.9. One caveat applies. The model predicts a dollar appreciation for this episode, whereas the dollar depreciated sharply over the first half of 2025, through channels the model does not contain, tariff-related uncertainty, doubts about fiscal sustainability and the independence of the central bank, and portfolio rebalancing away from dollar assets. The smaller cost of the 2025 war rests on the terms-of-trade gain that the appreciation delivers; a depreciation would remove it, raise the price level by more, and shift the burden towards unconstrained households. The lower welfare cost of the 2025 war should therefore be read as an upper bound on how favourable the second war was, conditional on an exchange-rate response that did not materialise.

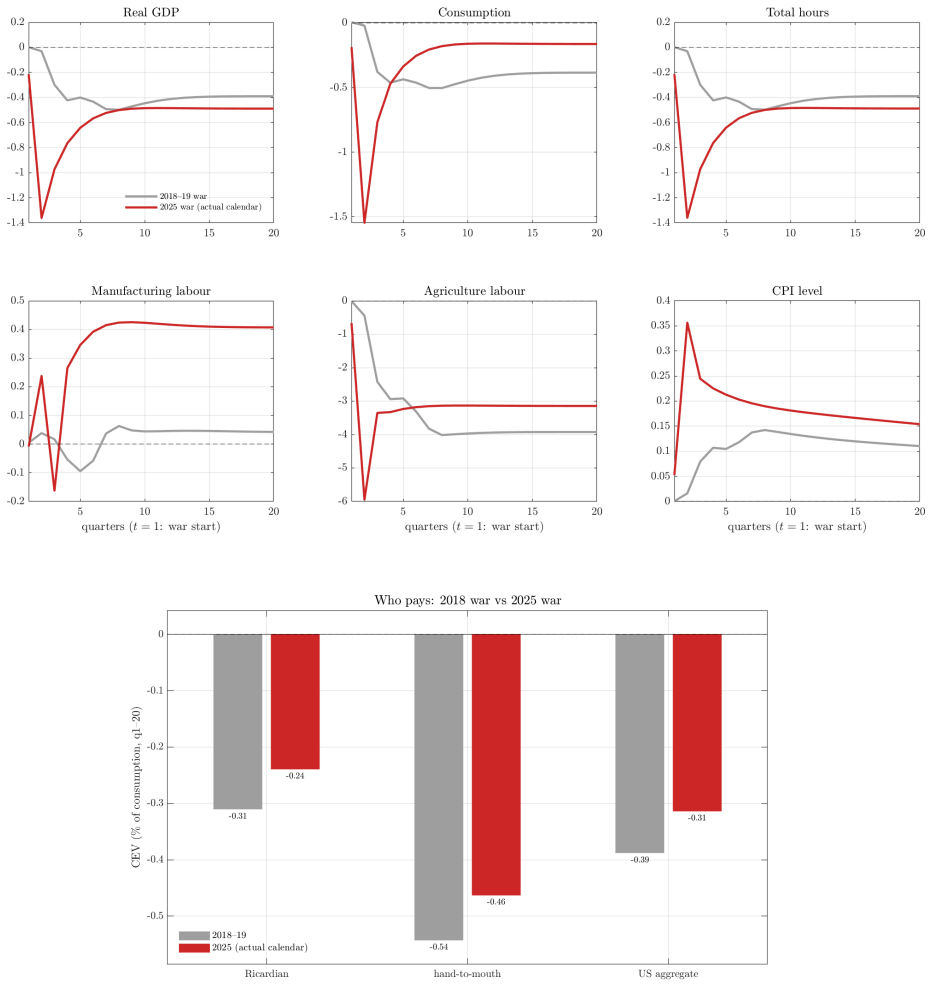



Figure 19: **The 2018–19 war and the 2025 war**, each relative to its own starting steady state. Top: output, consumption, hours, sectoral employment and the price level. Bottom: welfare cost of the first twenty quarters by household.

**The 2025 war with a productivity boom.** The third experiment adds to the 2025 war a one-percent Hicks-neutral productivity gain in U.S. services, arriving with the first wave and decaying at 0.95 per quarter, the model's reading of a services-biased technology shock. Figure 20 shows the war with and without it. The boom does not cushion the war on impact; it deepens the contraction and then reverses it. Output falls by 2.8% in the first quarter, and hours by more than four, before output turns positive in the fourth quarter and peaks at +0.9%. This is the response of a sticky-price economy to a positive supply shock: higher productivity lowers marginal costs, prices fall only slowly, and demand does not rise enough to absorb the additional capacity, so firms produce the demanded quantity with fewer hours; the expected deflation that follows raises real rates against a slowly moving nominal rate and holds consumption down until prices have adjusted. Once they have, the productivity gain is consumed and the economy is richer. Over twenty quarters the aggregate turns from a loss of 0.31% to a gain of 0.12, but the gain belongs entirely to unconstrained

households, +0.37: hand-to-mouth households, who cannot borrow against the coming boom and whose income consists of the hours that the initial contraction removes, end at −0.38 against −0.46 under the war alone: they recover about a fifth of their loss while unconstrained households gain 0.61. A productivity boom that arrives through a nominal contraction therefore does not substitute for the rebate.

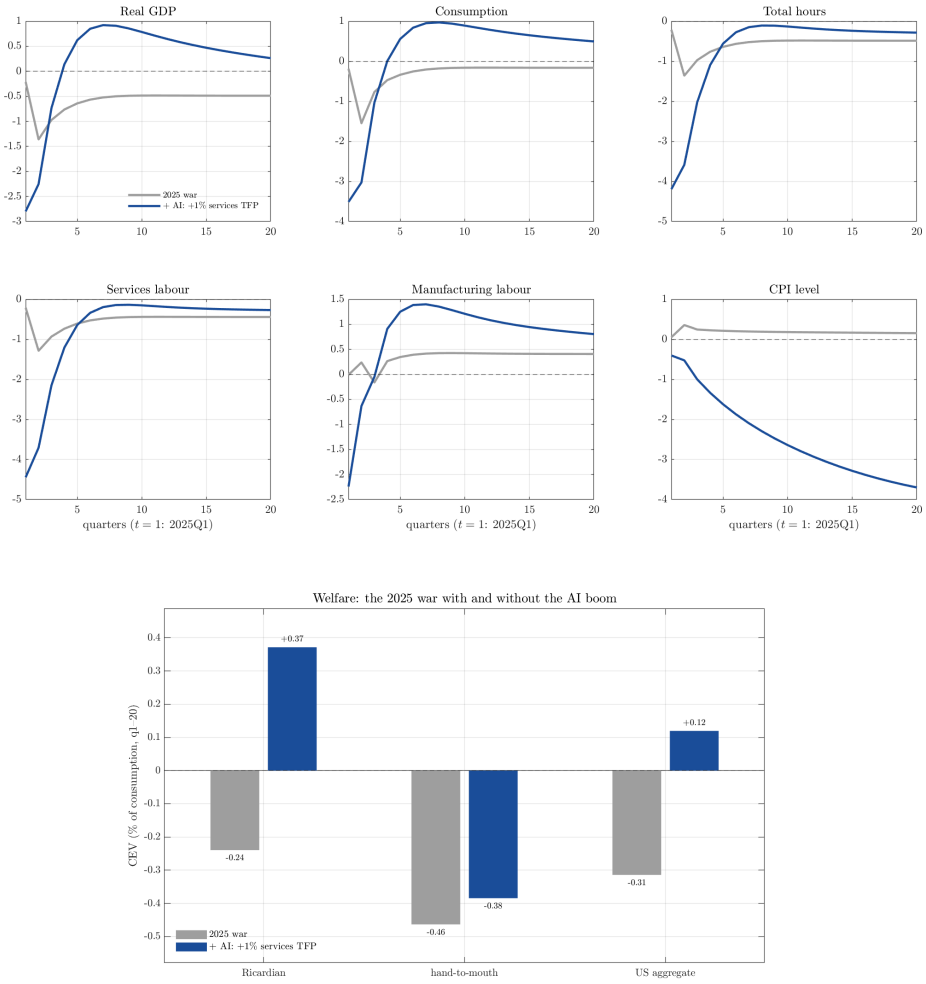



Figure 20: **The 2025 war with and without a one-percent U.S. services productivity boom.** Top: output, consumption, hours, sectoral employment and the price level. Bottom: welfare cost of the first twenty quarters by household.

# I The Planner: Derivation, Method and Further Results

## I.1 The constraint set

The planner takes as given the private block, the equilibrium conditions of appendix F.7 that do not involve the transfer rule,

$$\Phi(\mathcal{X}_{t-1}, \mathcal{X}_t, \mathcal{X}_{t+1}; \boldsymbol{\tau}_t) = 0, \tag{67}$$

where $\mathcal{X}_t$ collects the endogenous variables at date $t$ and $\boldsymbol{\tau}_t = (\boldsymbol{\tau}_{\mathrm{US},t}, \boldsymbol{\tau}_{R,t})$ the U.S. and retaliation legs; the government block, the revenue identity (39) and the budget

$$T_t = \mu\, T_t^L + (1-\mu)\, T_t^H, \tag{68}$$

with $T_t^L$ and $T_t^H$ the per-capita transfers under the rule in force; the tariff path on the historical calendar, $\boldsymbol{\tau}_{\mathrm{US}}^{(s)} = \bar{\boldsymbol{\tau}}_{\mathrm{US}} + \mathbf{f}_s \odot \boldsymbol{\theta}$ with the observed wave fractions $\mathbf{f}_s$, and the retaliation schedule; and the information structure of appendix F.7. The problem is $\max_{\boldsymbol{\theta}\in\Theta} \mathcal{W}_\gamma(\boldsymbol{\theta})$ subject to these, the schedule chosen once and implemented on the historical calendar. The private block collects, at every date of every plan: (i) the U.S. households' demand allocations, labour-supply conditions and the unconstrained Euler equation; (ii) the foreign households' optimality conditions; (iii) the input price indices, input demands, input–labour ratios and marginal costs of every sector, and the price Phillips curves; (iv) the sectoral wage indices, skill demands and the two wage Phillips curves; (v) goods-market clearing for every sector; (vi) labour-market clearing, skill by skill in the United States and nationally abroad; (vii) the balance of payments of each foreign country, the parity condition with the intermediation cost, and bond-market clearing; (viii) the monetary rule of each country with its believed potential output; and (ix) the hand-to-mouth budget. The government block is the revenue identity (39) and the budget (68), where the transfers enter the two budgets in place of $\omega_T T_t/\mu$ and $(1-\omega_T)T_t/(1-\mu)$; the baseline rule is $T_t^L = \omega_T T_t/\mu$. The tariff path is $\boldsymbol{\tau}_{\mathrm{US}}^{(s)} = \bar{\boldsymbol{\tau}}_{\mathrm{US}} + \mathbf{f}_s \odot \boldsymbol{\theta}$ with $\boldsymbol{\tau}_R^{(s)}$ given, $s = 1, \ldots, S$. The information structure is that of appendix F.7: at each announcement date agents observe $\boldsymbol{\tau}^{(s)}$ and believe it permanent, each plan solves $\Phi = 0$ with the government block from the realised state to the steady state at $\boldsymbol{\tau}^{(s)}$, and the realised path is the splice. The welfare of household $h$ is $\zeta^h(\boldsymbol{\theta})$ defined by

$$\sum_{t=1}^{\infty} \beta^{t-1} u^h\big((1+\zeta^h)\bar{C}^h\big) = \sum_{t=1}^{T} \beta^{t-1} u^h\big(C_t^h(\boldsymbol{\theta})\big) + \frac{\beta^T}{1-\beta} u^h\big(C_\infty^h(\boldsymbol{\theta})\big), \qquad u^h(C) = \log(C - \bar{D}^h), \tag{69}$$

the consumption-only convention of section 7.1.

The experiments modify one element of this set at a time. The structure comparison imposes, for each tariff family, one scalar chosen so that long-run revenue equals that of the observed schedule, $T_\infty(\mathcal{X}(\boldsymbol{\theta}_F)) = T_\infty(\mathcal{X}(\boldsymbol{\theta}^{\mathrm{obs}}))$, with the baseline rebate and observed retaliation. The planner's schedule maximises (43) over the four U.S.–China increments in $[0, 60]$ points with revenue free. The retaliation portfolio holds the U.S. legs observed and reshuffles China's legs at the observed trade-weighted average rate; the reaction function replaces the fixed retaliation by $\boldsymbol{\tau}_R^{(s)} = \bar{\boldsymbol{\tau}}_R + \mathbf{f}_s \odot (\lambda_R M \boldsymbol{\theta})$. The revenue experiments keep the observed schedules and change the transfer rule: the share $\omega_T$, or the benefit $T_t^L = \bar{T}^L + \kappa \bar{W}^L(\bar{N}^L - N_t^L)$ with the residual on the unconstrained household, $\kappa$ set so that the benefit exhausts the war's additional revenue over the window. In every run the unconstrained budget is retained as a residual, so that any error in the transfer accounting would appear as a nonzero residual.

## I.2 Derivation of the first-order condition

Let $\lambda_t^h$ be the planner's value of a dollar to household $h$ at date $t$, the population share times the planner's marginal valuation of the household's consumption equivalent, times the discounted marginal utility of consumption divided by the price level. Differentiating (43) along the realised path through the two budget constraints gives, for the tariff on leg $k$,

$$\frac{\partial \mathcal{W}_\gamma}{\partial \theta_k} = \sum_{t\geq 1}\sum_{h\in\{H,L\}} \lambda_t^h \Big[ W_t^h \frac{dN_t^h}{d\theta_k} + N_t^h \frac{dW_t^h}{d\theta_k} + \varpi^h \frac{dT_t}{d\theta_k} + \mathbf{1}\{h=H\}\frac{1}{1-\mu}\frac{d\Pi_t}{d\theta_k} - C_t^h \frac{dP_t^C}{d\theta_k}\Big], \tag{70}$$

with $\varpi^L = \omega_T/\mu$ and $\varpi^H = (1-\omega_T)/(1-\mu)$ the rebate shares. Collecting the terms by their source, the condition at an interior optimum reads

$$\underbrace{\text{terms of trade}_k}_{(+)} - \underbrace{\text{price level}_k}_{(-)} - \underbrace{\text{hours and wages}_k}_{(-)} + \underbrace{\text{revenue}_k}_{(+)} + \underbrace{\text{distribution}_k}_{(\pm)} = 0, \tag{71}$$

the first two the terms-of-trade gain and the pass-through loss of the static optimal-tariff condition, the third the change in labour income, first order only because prices and wages are sticky, the fourth the rebated revenue weighted by who receives it, and the fifth the covariance between the planner's household weights and the household-specific gains. The condition has no closed form, because the realised path is spliced from eight plans with different beliefs; it is the decomposition of the numerical gradient that the optimisation drives to zero. The derivation follows.

Since $\zeta^h$ is a monotone transformation of the lifetime value $V_C^h = \sum_t \beta^{t-1} u^h(C_t^h)$ on the realised path, the derivative of (43) with respect to the tariff on leg $k$ is

$$\frac{\partial \mathcal{W}_\gamma}{\partial \theta_k} = \sum_{h\in\{H,L\}} \mu_h \frac{\partial \mathcal{W}_\gamma}{\partial \zeta^h}\frac{d\zeta^h}{dV_C^h}\sum_{t\geq 1}\beta^{t-1}u^{h\prime}(C_t^h)\frac{dC_t^h}{d\theta_k}, \qquad \mu_H = 1-\mu,\ \mu_L = \mu, \tag{72}$$

where $\partial \mathcal{W}_\gamma/\partial \zeta^h = \bar{C}^h u'_\gamma(\bar{C}^h(1+\zeta^h))$, larger for the hand-to-mouth household and the more so the larger $\gamma$, and $d\zeta^h/dV_C^h = (1-\beta)\big[(1+\zeta^h)\bar{C}^h - \bar{D}^h\big]/\bar{C}^h$ is the conversion from utils to consumption units, positive, so it never changes the sign of a term; for the twenty-quarter measure $1-\beta$ is replaced by $(1-\beta)/(1-\beta^{20})$. The derivative differentiates the consumption part of utility only, the convention of section 7.1. The consumption response of each household follows from its budget. For the hand-to-mouth household, $P_t^C C_t^L = W_t^L N_t^L + \omega_T T_t/\mu$, so

$$\frac{dC_t^L}{d\theta_k} = \frac{1}{P_t^C}\Big[W_t^L\frac{dN_t^L}{d\theta_k} + N_t^L\frac{dW_t^L}{d\theta_k} + \frac{\omega_T}{\mu}\frac{dT_t}{d\theta_k} - C_t^L\frac{dP_t^C}{d\theta_k}\Big], \tag{73}$$

where the last term is the loss of purchasing power on the old bundle. For the unconstrained

household the per-capita budget adds profits, its rebate share and net saving,

$$\frac{dC_t^H}{d\theta_k} = \frac{1}{P_t^C}\Big[W_t^H \frac{dN_t^H}{d\theta_k} + N_t^H \frac{dW_t^H}{d\theta_k} + \frac{1}{1-\mu}\frac{d\Pi_t}{d\theta_k} + \frac{1-\omega_T}{1-\mu}\frac{dT_t}{d\theta_k} + \frac{d\big[(1+i_{t-1})a_{t-1} - a_t\big]}{d\theta_k} - C_t^H \frac{dP_t^C}{d\theta_k}\Big]. \tag{74}$$

The net-saving term drops out of the lifetime sum: by the household's Euler equation a dollar borrowed at $t$ and repaid at $t+1$ has zero present value at its own marginal utilities, so with initial wealth given and the no-Ponzi condition the bond terms telescope to zero once weighted by $\beta^{t-1}u^{H\prime}(C_t^H)/P_t^C$ and summed. Defining $\lambda_t^h \equiv \mu_h(\partial \mathcal{W}_\gamma/\partial \zeta^h)(d\zeta^h/dV_C^h)\beta^{t-1}u^{h\prime}(C_t^h)/P_t^C$ and substituting (73) and (74) into (72) gives (70).

The grouping into the five terms of (71) follows from the consumer price index. With $P_t^C = \prod_i (P_{1,i,t}^C)^{\Gamma^{\text{sec}}_{1,i}}$ and $\tilde{p}_{1,m,i,t}^C = (1+\tau_{1,m,i,t}^C)P_{m,i,t}/E_{m,t}$,

$$\frac{d\log P_t^C}{d\theta_k} = \sum_i \Gamma^{\text{sec}}_{1,i} \sum_m s_{1,i,m,t}\Big[\underbrace{\frac{\mathbf{1}\{(m,i)=k\}}{1+\tau_k}}_{\text{pass-through}} + \underbrace{\frac{d\log P_{m,i,t}}{d\theta_k} - \frac{d\log E_{m,t}}{d\theta_k}}_{\text{terms of trade, } m\neq 1}\Big], \tag{75}$$

where $s_{1,i,m,t}$ is the expenditure share of origin $m$ in sector $i$, and for the domestic origin the bracket is the rise in domestic producer prices as tariffed inputs raise marginal cost through the Phillips curve. The pass-through and domestic-price pieces, weighted by $\lambda_t^h C_t^h$, are the price-level term; the foreign-price and exchange-rate pieces, with the part of profits that moves with them, are the terms-of-trade term; the hours and wage derivatives, with the part of profits that moves with domestic demand and costs, are the hours-and-wages term; the revenue derivative weighted by $\varpi^h$ is the revenue term; and writing $\lambda_t^h = \bar{\lambda}_t + (\lambda_t^h - \bar{\lambda}_t)$ with $\bar{\lambda}_t$ the population-weighted average, the four terms at $\bar{\lambda}_t$ are the aggregate effect and the remainder is the distribution term. With flexible prices, one household and hours chosen optimally, the hours-and-wages and distribution terms vanish by the envelope theorem and (71) is the terms-of-trade condition of the optimal-tariff literature. Under sticky prices and wages hours are off the labour-supply schedule, so the term is first order; for the input instrument it has a second route, through marginal cost and the Phillips curve. At a corner, $\theta_k = 0$, the condition holds as $\partial \mathcal{W}_\gamma/\partial\theta_k \leq 0$.

### I.3 Solution method

The derivatives in (70) are total derivatives of equilibrium objects along the realised path, after every adjustment in the model, and have no closed form because the path is a splice of plans with expectation errors. The problem is therefore solved by direct optimisation over $\boldsymbol{\theta}$. The planner knows the calendar, eight waves at the observed fractions of the terminal rates, and chooses the terminal rates once; households discover them wave by wave. It is a commitment planner evaluated on the realised path. Each candidate policy is a full solution of the nonlinear model with the algorithm of appendix F.7, about ten seconds. For the four U.S.–China legs the search is a grid of $3^4$ points at 5, 18 and 35 percent plus the observed schedule, then a Nelder–Mead search in logs from the best grid point, bounded in $[0, 60]$ points; the bound never binds except on the agricultural

final-goods leg, where the objective is flat. The structure comparisons solve one scalar per family by root-finding on long-run revenue; the benefit parameter by root-finding on the window revenue. A gate run with every policy switch off reproduces the baseline on all common variables to $2 \times 10^{-12}$, and the unconstrained budget is retained as a residual in every run so that an error in the transfer accounting under a new rule would appear as a nonzero residual. A Ramsey formulation would double the model's equations with multipliers and is available only by perturbation, which does not apply to a nonlinear path with large permanent shocks.

### I.4 A tariff for manufacturing

Could a tariff have raised manufacturing activity without a recession? Table 21 takes the planner's structure, a final-goods tariff with inputs exempt (appendix I.6), imposed at once at the start and believed permanent, and varies its rate and base, with and without the observed retaliation. Manufacturing hours rise for good, in proportion to the rate. Without retaliation long-run GDP does not fall and the planner gains. No tariff avoids a contraction in the first quarter: the dollar appreciates on announcement, exports fall at once, and the switch to domestic goods takes two quarters to offset it. The dip is a fraction of a percent for one quarter, against the eight-quarter decline of the actual war. With retaliation, long-run GDP falls under every rate, and the planner loses at rates below 13 points on the broad legs and at every rate on the China legs.

Table 21: **Final-goods tariffs with inputs exempt, imposed at once.** Rate in points; GDP trough over twenty quarters, long-run GDP and manufacturing hours in percent; U.S. consumption-equivalent cost over twenty quarters and the planner's EDE.

| Legs | Retaliation | Rate | GDP trough | GDP | Manuf. hours | US | EDE, 20q |
|---|---|---|---|---|---|---|---|
| All partners | none | 5 | −0.40 | +0.04 | +0.67 | +0.23 | +0.22 |
| All partners | none | 10 | −0.77 | +0.07 | +1.36 | +0.41 | +0.38 |
| All partners | none | 20 | −1.41 | +0.12 | +2.73 | +0.65 | +0.61 |
| All partners | observed | 5 | −0.74 | −0.16 | +0.54 | −0.21 | −0.26 |
| All partners | observed | 13.2 | −1.30 | −0.11 | +1.66 | +0.06 | +0.00 |
| All partners | observed | 20 | −1.71 | −0.07 | +2.58 | +0.21 | +0.15 |
| China only | none | 10 | −0.21 | 0.00 | +0.37 | +0.07 | +0.06 |
| China only | observed | 10 | −0.54 | −0.20 | +0.23 | −0.37 | −0.41 |

### I.5 The planner's schedule on the U.S.–China legs

Table 22 reports the planner's choice of the four terminal increments on the U.S.–China legs, consumption and input instruments for manufactures and agriculture, with retaliation and the other legs observed and revenue free. The planner sets the input tariff to zero, keeps a final-goods manufacturing tariff near the observed rate, and taxes Chinese agricultural final goods at the bound, a small base that China does not retaliate against; the objective is flat in that rate above 33 points. The optimum raises a third less revenue and cuts the long-run GDP loss from 0.39 to 0.24%. On the China legs alone, final goods cannot raise the observed revenue at any rate: with a consumption

elasticity of 4, revenue peaks below 0.35% of GDP, a prohibitive 100-point tariff costs 0.45, and inputs alone need 37.5 points and cost 0.51.

Table 22: **The planner's schedule.** Terminal increments on the four U.S.–China legs, points, on manufacturing (Mnf.) and agricultural (Agr.) final goods (C) and inputs (X); revenue in percent of GDP and GDP in percent, long run; consumption-equivalent cost over twenty quarters for unconstrained (H) and hand-to-mouth (L) households and the U.S. aggregate, and the planner's EDE.

| | Mnf. C | Mnf. X | Agr. C | Agr. X | Rev. | GDP | H | L | US | EDE, 20q | EDE, life |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Observed schedule | 18.0 | 24.0 | 0.0 | 0.0 | 0.59 | −0.39 | −0.31 | −0.54 | −0.39 | −0.43 | −0.45 |
| Planner ($\gamma = 2$) | 19.7 | 0.0 | 60.0 | 0.0 | 0.38 | −0.24 | −0.24 | −0.46 | −0.31 | −0.36 | −0.34 |

## I.6 The least costly tariff structure

The observed schedule raised 0.585% of GDP in the long run, with its highest rate, 24 points, on Chinese inputs and 18 points on Chinese final manufactures. Table 23 holds the revenue fixed and changes the structure, with retaliation at its observed schedule. Taxing inputs is the worst structure: it is a cost shock that the network passes to every user, with no gain for any domestic producer, and manufacturing hours fall by 1%. Taxing final goods is the best: demand shifts to domestic producers and part of the burden goes abroad through the terms of trade, manufacturing hours rise by 1.7%, and the war is no longer a loss for the planner. The observed schedule falls mostly on inputs and is close to the most costly structure. Two qualifications. The hand-to-mouth household gains under no structure, because the price effect falls on it while the gains from the shift towards domestic producers accrue to profits and high-skill hours, which is why the planner's gain from the best structure is a hundredth where the unconstrained household's is 0.15. And the final-goods structure taxes the rest of the world with its retaliation fixed; on the China legs alone, final goods cannot raise the observed revenue at any rate. A planner free to set the four U.S.–China legs reaches the same conclusion, twenty points on final manufactures and nothing on inputs, at a cost of 0.36 instead of 0.43 (appendix I.5).

Table 23: **Tariff structure at fixed revenue** (0.585% of GDP in the long run). Rates in points; long-run GDP and manufacturing hours in percent; consumption-equivalent cost over twenty quarters for unconstrained (H) and hand-to-mouth (L) households and the U.S. aggregate, and the planner's EDE.

| | Rate | GDP | Manuf. hours | H | L | US | EDE, 20q | EDE, life |
|---|---|---|---|---|---|---|---|---|
| Observed | 18 / 24 | −0.39 | +0.04 | −0.31 | −0.54 | −0.39 | −0.43 | −0.45 |
| Final goods only | 13.2 | −0.11 | +1.66 | +0.15 | −0.11 | +0.07 | +0.01 | +0.11 |
| Inputs only | 8.3 | −0.47 | −0.95 | −0.44 | −0.62 | −0.50 | −0.53 | −0.59 |
| Uniform, all legs | 4.6 | −0.31 | +0.03 | −0.17 | −0.40 | −0.25 | −0.29 | −0.29 |

## I.7 China's retaliation portfolio

China's retaliation was agriculture-heavy: 12 and 30 points on U.S. agricultural final goods and inputs, 13 on both manufacturing legs. Table 24 reshuffles the four legs at the same trade-weighted

average rate of 13.7%, with the U.S. schedule observed. China chose the portfolio that hurt the United States most and cost China least. Had it put the same average rate entirely on U.S. manufactures, the planner's cost would have fallen from 0.43 to 0.28 percent of equally-distributed consumption, a third lower, and China's own cost would have risen from 0.13 to 0.15. The reason is who bears each portfolio. Agriculture is the low-skill sector, so retaliation on it falls on hand-to-mouth households, whose loss is 0.61 under the agriculture-only portfolio against 0.31 under manufactures only; retaliation on manufactures falls on high-skill hours and profits, which the planner weights less. And U.S. farm goods are the imports China can most easily buy elsewhere, so taxing them costs China least. The result also bounds what the planner can gain. If China answers the U.S. schedule in proportion, every point the United States adds brings an agriculture-heavy response whose cost exceeds the gain, and the planner's best tariff on the China legs is zero (appendix I.8).

Table 24: **China's retaliation at equal average rate.** Rates in points on agricultural and manufacturing final goods (C) and inputs (X); consumption-equivalent cost over twenty quarters for unconstrained (H) and hand-to-mouth (L) households and the U.S. aggregate, the planner's EDE, and China's consumption-equivalent cost.

| Portfolio | Agr. C / X | Mnf. C / X | H | L | US | EDE, 20q | China |
|---|---|---|---|---|---|---|---|
| Observed | 12 / 30 | 13 / 13 | −0.31 | −0.54 | −0.39 | −0.43 | −0.13 |
| All on agriculture | 20 / 20 | 0 / 0 | −0.30 | −0.61 | −0.40 | −0.46 | −0.13 |
| All on manufactures | 0 / 0 | 43 / 43 | −0.24 | −0.31 | −0.26 | −0.28 | −0.15 |
| Balanced | 14 / 14 | 14 / 14 | −0.32 | −0.55 | −0.40 | −0.44 | −0.13 |

## I.8 The reaction function

In place of a fixed retaliation schedule, China's four legs keep their observed proportions and scale with the average U.S. tariff on China, $\boldsymbol{\tau}_R^{(s)} = \bar{\boldsymbol{\tau}}_R + \mathbf{f}_s \odot (\lambda_R M \boldsymbol{\theta})$, where $M$ maps each U.S. leg to the matched Chinese leg and $\lambda_R$ is the observed ratio of Chinese to U.S. coverage-weighted rates: the observed U.S. schedule reproduces the observed retaliation, twice the schedule doubles it, zero removes it. The believed terminal state of each plan is solved at the reacted schedule. Re-solving the planner under this rule gives zero on all four legs. The remaining cost, 0.07 for both households and for the planner, is the rest-of-world legs, which the planner does not control. A uniform 5 points on the four legs costs the U.S. aggregate 0.21, the observed schedule 0.39, 18 points 0.54 and 35 points 0.90.

## I.9 The timing of the transfer

The benefit of Table 8 pays the hand-to-mouth household $T_t^L = \bar{T}^L + \kappa \bar{W}^L(\bar{N}^L - N_t^L)$ per capita, with $\bar{T}^L$ its share of the pre-war revenue, and the unconstrained household receives the residual $T_t^H = (T_t - \mu T_t^L)/(1-\mu)$, negative in any quarter in which the benefit exceeds revenue, so that the government budget holds period by period. Setting $\kappa$ so that the benefit exhausts the war's additional revenue over twenty quarters gives $\kappa = 2.06$: the revenue is about twice the lost earnings.

Hours stay 0.6% below their pre-war level under a permanent tariff, so the benefit is permanent, 16 percent of its present value falls in the window, and in the long run it absorbs 92 percent of the additional revenue. It is, to a close approximation, the rule that hands the hand-to-mouth household the revenue for good, which is why its welfare is within hundredths of the all-to-hand-to-mouth share, and its only advantage is the calendar. A constant stream of equal present value paid to hand-to-mouth households over the window gives the same welfare to two decimals. Maximising (43) over $\kappa$ without the self-financing condition runs to the bound of the search, because transfers are costless and hours do not respond to them; only the self-financed value is informative. Three changes would make the benefit a stabiliser: beliefs under which the revenue is temporary, so that the unconstrained household saves its rebate while the hand-to-mouth household spends the benefit; a passive monetary rule during the war; or an employment margin, under which the benefit insures separations and carries the incentive cost studied by Kekre (2023).