Tariffs and Trade Deficits*

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Abstract

We develop a dynamic multi-country Ricardian trade model with aggregate uncertainty, where trade imbalances emerge as countries exchange goods and assets. We introduce a method for computing counterfactuals in this setting, which does not require specifying the stochastic process of shocks or solving for asset prices. Applying the model to tariff shocks, we quantify their effects on prices, income, spending, and trade imbalances. We find that higher U.S. tariffs reduce the U.S. trade deficit through general equilibrium adjustments, but raise domestic prices and lower real consumption. Our findings highlight that movements in trade imbalances are shaped by the structure of global trade and finance, and that attempts to influence external balances through changes in trade barriers carry significant implications for real economic outcomes.

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1 Introduction

Countries are exposed to myriad unexpected shocks in their economic environment. As a result, economic agents engage in international asset trade to insure against such risks. Globalization of asset markets has reshaped how consumption aligns with both current and uncertain future income. Taking this force into account is essential in order to evaluate the quantitative impact of recent turmoil in the global economy.

This paper develops a dynamic multi-country quantitative trade model that jointly determines trade in goods and holdings of state-contingent assets. The model incorporates aggregate uncertainty, with countries facing stochastic shocks to fundamentals such as productivity, trade costs, and, more recently, tariffs. In particular, we model tariff changes as exogenous aggregate shocks and study their effects on equilibrium allocations across alternative scenarios. Unlike most quantitative trade models, trade imbalances emerge endogenously as equilibrium outcomes of optimal intertemporal decisions under uncertainty.

Assessing the implications of shocks to the economic environment can be a demanding task. We propose a method that enables us to compare outcomes of a state generated by counterfactual shocks, such as tariff shocks, to outcomes from the state of the world that generated the data. This parsimonious method is feasible for dynamic stochastic models with an arbitrary number of countries and sectors.

With data for 187 countries we quantify the effects of recent and ongoing uncertain tariff changes, including the *Liberation Day tariff* schedule announced by the United States in April 2025.[1] Our results show that unilateral tariff changes can affect trade imbalances through general equilibrium effects. In particular, we find that an increase in U.S. tariffs—especially those targeted at China—narrows the U.S. trade deficit. This narrowing arises from endogenous adjustments in income, spending, and asset positions across states. Tariff-induced changes in income are partly absorbed in an economy with complete asset markets, as these markets facilitate intertemporal reallocation

[1]See Executive Order (EO) 14257 of April 2, 2025 (Federal Register published document: 2025-06063 (90 FR 15041) (2025)). Trade imbalances figure prominently in EO 14257 to justify increased tariffs: "... U.S. trading partners' economic policies that suppress domestic wages and consumption, as indicated by large and persistent annual U.S. goods trade deficits, constitute an unusual and extraordinary threat to the national security and economy of the United States." The tariff rates proposed in EO 14257 have since been modified many times, most recently in an Executive Order on July 31, 2025.

and allow countries to smooth consumption.

Despite rising U.S. income due to improved terms of trade and tariff revenue, higher domestic prices erode real consumption in the United States under a positive tariff shock. In contrast, surplus countries benefit in real terms by smoothing losses in income through increased asset-backed consumption. The gains and losses are unevenly distributed, shaped by each country's initial exposure to trade with the United States, their baseline trade imbalance, and the structure of global trade. We also show that bilateral trade imbalances adjust asymmetrically across partners. U.S. deficits with key trade partners—China, Mexico, Canada, and the European Union—shrink by between roughly one-quarter and two-thirds under the positive tariff shock. Thus, our framework highlights that tariffs can induce shifts in the global pattern of imbalances.

We depart from the existing literature on quantitative trade models that assume either balanced trade or exogenous trade imbalances. Instead, we introduce complete asset markets through trade in state-contingent claims, following Arrow (1964) and Debreu (1959).[2] Adding this asset-market structure endogenizes trade imbalances in quantitative trade models like Eaton and Kortum (2002), while also integrating multiple sectors and tariffs as in Caliendo and Parro (2015).

Our key contribution is to develop a methodology for performing counterfactuals in this multi-country complete-markets setting. By expressing the system of equilibrium conditions in an alternative state of the world relative to data from the actual state, we show how to quantify the effects of aggregate shocks on various outcomes. Importantly, we do not need to infer objects such as state-contingent security prices, the probabilities of different state histories, or the Lagrange multipliers associated with each country's budget constraint. Our methodology extends the *exact hat algebra* method (Dekle et al. (2007) and Costinot and Rodríguez-Clare (2014)) to dynamic trade settings under uncertainty.[3]

[2]In their seminal paper, Backus and Smith (1993) showed that complete asset markets are easily rejected in a 2-country model with a frictionless traded sector, leading to the famous Backus-Smith puzzle. More in line with our approach, Obstfeld and Rogoff (2001), Corsetti et al. (2008), Fitzgerald (2012), and Eaton et al. (2016a) find that trade frictions alone go a long way in resolving such international macro puzzles, even in the absence of asset-market frictions. As described in Section 2.4, we also go further here by introducing frictions, due to oligopolistic financial intermediaries, in an extension to our baseline model.

[3]Our work also relates to dynamic-hat algebra methods in spatial economics, under perfect foresight

The framework we propose connects with a growing literature on quantitative trade models featuring endogenous trade imbalances under perfect foresight (e.g., Eaton et al. (2016b) and Reyes-Heroles (2017)), as well as models that incorporate uncertainty regarding trade policies and aggregate shocks (e.g., Alessandria et al. (2024) and Alessandria and Choi (2021)).[4] We build upon this body of work by incorporating complete asset markets under uncertainty. This innovation enables us to analyze how trade imbalances and other outcomes respond to shocks to fundamentals such as productivity, trade costs, and tariffs.

Interpreting tariff changes as unanticipated events that occur in a given state of the world, rather than as deliberate government decisions, connects to the public finance literature that studies the economic effects of state-contingent taxes (e.g., Lucas and Stokey (1983) and Stockman (1988)). More related to our paper, Stockman and Dellas (1986) study an environment in which individuals trade in asset markets and select optimal portfolios of Arrow securities, facing uncertainties about tariffs stemming from random government trade policies. While we cannot claim that the complete markets setting perfectly describes reality, we argue that it provides a better benchmark for today's globally integrated world than one in which countries cannot trade securities and must consume their current domestic income. Furthermore, in an key extension to the baseline model, presented in Section 2.4, we incorporate oligopolistic financial intermediaries that introduce frictions into international asset markets.

Our research relates to recent theoretical studies on optimal trade policy and its consequences for trade imbalances, including Itskhoki and Mukhin (2025), Aguiar et al. (2025), Costinot and Werning (2025), and Dávila et al. (2025). We differ from this literature by pursuing a positive analysis and by focusing on the effect of tariff changes on impact rather than across steady states. Finally, Ignatenko et al. (2025) use a static model to quantify the welfare effects of U.S. tariff increases and how these effects are shaped by the retaliation of its trading partners, an issue we do not pursue here.

(Caliendo et al. (2019)) and under uncertainty and evolving beliefs (Fan et al. (2023)).

[4]Our work also connects to other models with endogenous trade imbalances and perfect foresight that examine the labor market adjustment to the China shock (Dix-Carneiro et al. (2023)), the impact of trade imbalances on employment in the industrial sector (Kehoe et al. (2018)), and the role of asymmetric trade barriers in shaping bilateral trade imbalances (Cuñat and Zymek (2023)). It also relates to the study of trade policy uncertainty on welfare and trade dynamics (e.g., Handley and Limao (2015), Alessandria et al. (2021), Steinberg (2019)).

The rest of the paper is structured as follows. Section 2 lays out the framework with trade in goods, complete markets, and endogenous trade imbalances. Section 3 presents the quantitative analysis, and Section 4 concludes.

2 Model

We consider a global economy consisting of N countries, indexed by n (typically the importer) and i (typically the exporter). A country n is endowed with a measure L_n of identical infinitely-lived individuals, each inelastically supplying a unit of labor. Time is discrete and indexed by $t = 0, 1, 2, ...$ At each date t the global economy faces uncertainty, represented by events in the world $s_t \in S$. We denote a history of such events, or state history, by $s^t = (s_0, s_1, \ldots, s_t) \in S^t$.

Let $\Pi(s^t) \geq 0$ denote the probability of observing history $s^t = (s_0, s_1, \ldots, s_t)$ given s_0, with $\Pi(s_0) = 1$. At each date, $\sum_{s^t \in S^t} \Pi(s^t) = 1$. We can write the conditional probability of any history of the form $s^{t+1} = (s^t, s_{t+1})$, given s^t, as $\Pi(s^{t+1}|s^t) = \Pi(s^{t+1})/\Pi(s^t)$. Summing over all s^{t+1} that are possible from s^t gives $\sum_{s^{t+1}|s^t} \Pi(s^{t+1}|s^t) = 1$.

A history s^t specifies, in each country, the fundamentals of the global economy and the resulting trade equilibrium as described in Sections 2.1 and 2.2. The key outcomes include bilateral trade, price levels $p_{n,t}(s^t)$, individual consumption $c_{n,t}(s^t)$, and individual income $y_{n,t}(s^t)$. Prices, spending, and income are measured in terms of a numéraire for s^t, which we take to be global expenditure $\sum_{n=1}^{N} L_n p_{n,t}(s^t) c_{n,t}(s^t) = \sum_n X_{n,t}(s^t) = 1$.

The underlying stochastic fundamentals include productivity levels $T_{i,t}(s^t)$, bilateral iceberg trade costs $d_{ni,t}(s^t)$, and tariffs $\tau_{ni,t}(s^t)$ (expressed as one plus the ad-valorem rate that country n applies to imports from country i). This formulation incorporates the possibility of stochastic tariff shocks. While the primary focus of the analysis in this paper is to examine how tariff shocks impact economic outcomes, we also allow for the possibility that economies may experience other events, including fluctuations in productivity and in non-tariff trade costs.

2.1 Asset Markets and the Consumption Problem

We start by assuming asset markets are complete, allowing agents to trade a full set of state-contingent claims at common international prices (we will relax this assumption below). An asset pays one unit of the numéraire in s^t, conditional on the realization of that specific state history, and pays nothing otherwise. We denote by $q_t^0(s^t)$ the price at date 0 of such an asset in terms of the numéraire in s^0, normalizing $q_0^0(s^0) = 1$.[5]

International trade in goods takes place after s^t is revealed. The initial-period trade in state-contingent assets determines subsequent expenditures, and thus trade imbalances, in each country in every potential future state history. Asset trade in these claims at date 0 is known in the literature as the *Arrow-Debreu* market structure.[6]

Consider an individual with intertemporal preferences over consumption paths, discount factor $\beta < 1$, and twice differentiable period utility function $u(c)$ that is strictly increasing and strictly concave. Prior to the realization of uncertainty, the individual chooses a state-contingent consumption plan to maximize expected lifetime utility. Formally, an individual in country n solves:

$$\max_{\{c_{n,t}(s^t)\}} U_n = \sum_{t=0}^{\infty} \sum_{s^t \in S^t} \beta^t \, \Pi(s^t) \, u\left(c_{n,t}(s^t)\right), \tag{1}$$

[5]The term $q_t^0(s^t)p_{n,t}(s^t)$ represents the price at s^0 in country n of securing a unit of consumption in history s^t. Since only relative prices matter, our normalization of $q_0^0(s^0) = 1$ resolves ambiguity in $q_t^0(s^t)$ and the numéraire for s^t resolves ambiguity in $p_{n,t}(s^t)$. This term leads to an expression for the gross one-period real riskless interest rate in country n:

$$1 + r_{n,t}(s^t) = \frac{q_t^0(s^t)p_{n,t}(s^t)}{\sum_{s^{t+1}|s^t} q_{t+1}^0(s^{t+1})p_{n,t+1}(s^{t+1})} = \frac{p_{n,t}(s^t)}{\sum_{s^{t+1}|s^t} q_{t+1}(s^{t+1}|s^t)p_{n,t+1}(s^{t+1})},$$

where $q_{t+1}(s^{t+1}|s^t) = q_{t+1}^0(s^{t+1})/q_t^0(s^t)$ is the price in s^t of an asset delivering a unit of the numéraire in s^{t+1}. Thus $1 + r_{n,t}(s^t)$ is the quantity of consumption returned with certainty in $t+1$ at the cost of a unit of consumption in s^t.

[6]See Sargent and Ljungqvist (2012) for a definitive treatment of equilibrium with complete markets in a closed pure-exchange economy. They show that a market structure in which asset trades occur sequentially delivers the same allocation as one in which all trades occur at date 0, as in the formulation we adopt. We depart from their closed pure-exchange economy by incorporating production of multiple goods, international trade, tariffs, and trade costs.

subject to the intertemporal budget constraint:

$$\sum_{t=0}^{\infty} \sum_{s^t \in S^t} q_t^0(s^t) \left(p_{n,t}(s^t)\, c_{n,t}(s^t) - y_{n,t}(s^t) \right) = 0.$$

It costs $q_t^0(s^t) p_{n,t}(s^t) c_{n,t}(s^t)$ at date 0 for an individual to finance consumption spending in s^t while they receive $q_t^0(s^t) y_{n,t}(s^t)$ at date 0 from issuing state-contingent claims against future income in s^t. The intertemporal budget constraint ensures that over time and across states these sales of securities are sufficient to finance the purchases needed to carry out the individual's consumption plan. The Lagrange multiplier on this constraint is λ_n.[7]

The first-order condition of (1) with respect to $c_{n,t}(s^t)$ is:

$$\beta^t\, \Pi(s^t) u_c \left(c_{n,t}(s^t) \right) = \lambda_n\, q_t^0(s^t)\, p_{n,t}(s^t), \tag{2}$$

where $u_c(\cdot)$ denotes the marginal utility of consumption. This condition equates discounted expected marginal utility to the opportunity cost of the securities to deliver a unit of consumption in s^t. We can invert equation (2) to solve for an individual's consumption. Country n's aggregate spending in history s^t is then:

$$X_{n,t}(s^t) = p_{n,t}(s^t) L_n\, u_c^{-1} \left(\frac{\lambda_n\, q_t^0(s^t)\, p_{n,t}(s^t)}{\beta^t\, \Pi(s^t)} \right).$$

To obtain a sharper characterization of the model, and to facilitate empirical implementation, we assume that preferences are of the constant relative risk aversion (CRRA) form:

$$u\left(c\right) \equiv \frac{c^{1-\gamma} - 1}{1-\gamma},$$

so that $u_c(c) = c^{-\gamma}$. Here $\gamma > 0$ denotes the coefficient of relative risk aversion and the

[7] The intertemporal budget constraint sets the individual's, and hence the country's, net foreign asset position to zero at date 0. This assumption is not restrictive since, starting from any history s^{t_0}, for $t_0 \geq 0$, country n's net foreign asset position will emerge as:

$$NFA_{t_0}(s^{t_0}) = L_n \sum_{t \geq t_0} \sum_{s^t | s^{t_0}} q_t(s^t | s^{t_0}) \left(p_{n,t}(s^t) c_{n,t}(s^t) - y_{n,t}(s^t) \right),$$

where $q_t(s^t|s^{t_0}) = q_t^0(s^t)/q_{t_0}^0(s^{t_0})$ is the price in s^{t_0} of an asset delivering a unit of the numéraire in s^t.

inverse of the elasticity of intertemporal substitution. This specification is widely used in both theoretical and quantitative macroeconomic models.

Exploiting CRRA and our choice of global spending as numéraire, we can express country n's aggregate spending in history s^t as:

$$X_{n,t}(s^t) = \frac{L_n \lambda_n^{-1/\gamma} \, p_{n,t}(s^t)^{1-1/\gamma}}{\sum_k L_k \lambda_k^{-1/\gamma} \, p_{k,t}(s^t)^{1-1/\gamma}}. \tag{3}$$

Components of the marginal cost of consumption that are common across countries in a given state, $q_t^0(s^t)$, β^t, and $\Pi(s^t)$, cancel out. As a result, relative spending shares are determined by country-specific terms: the Lagrange multiplier λ_n, the labor supply L_n, and the local price level $p_{n,t}(s^t)$. If the relative risk aversion parameter γ exceeds 1, as in our calibration below, countries facing a higher price level in a given state history will, all else equal, spend more.[8]

Equation (3) represents the central departure of our framework from conventional quantitative trade models that assume balanced trade or impose exogenous deficits. In those models, a country's spending is constrained to move in lockstep with its income, leaving agents fully exposed to country-specific risks, unable to smooth consumption across different economic conditions. To see how this new formulation works, we now fit it into a complete model of international trade in goods.

2.2 Prices, Trade, and Income, given a History

As shown above, the realization of s^t determines the allocation of spending across countries, $X_{n,t}(s^t)$, as a function of prices $p_{n,t}(s^t)$, Lagrange multipliers λ_n, and exogenous labor supplies L_n in each country. The supply side of the economy describes how

[8] We highlight two special cases, expressed at the individual level with $x_{n,t}(s^t) = X_{n,t}(s^t)/L_n$:
(i) with log utility, as $\gamma \to 1$, individuals' spending is constant across states:

$$x_{n,t}(s^t) = \frac{\lambda_n^{-1}}{\sum_i L_i \lambda_i^{-1}};$$

(ii) with infinite risk aversion, as $\gamma \to \infty$, individuals' consumption is synchronized across countries:

$$c_{n,t}(s^t) = \frac{x_{n,t}(s^t)}{p_{n,t}(s^t)} = \frac{1}{\sum_i L_i p_{i,t}(s^t)}.$$

these prices are determined, along with international trade and income, given a state history and the Lagrange multipliers. In the counterfactual methodology described in Section 2.3 the Lagrange multipliers cancel out, so we will condition on them here and only mention in passing how one might solve for them.

We adopt the multi-country Ricardian framework of Eaton and Kortum (2002), which features a continuum of tradable goods, $j \in [0, 1]$, with heterogeneity in production technologies. Specifically, the probability that a particular good j would be produced in country i with efficiency below z is given by:

$$F_{i,t}(z|s^t) = \exp\left(-T_{i,t}(s^t)z^{-\theta}\right),$$

the Fréchet distribution with $\theta > 1$ governing the force of comparative advantage, via the dispersion of efficiency draws, and $T_{i,t}(s^t) > 0$ a state-dependent productivity parameter governing country i's absolute advantage.

We assume that labor is the sole factor of production, supplied inelastically in quantity L_i in each country i. Since labor is perfectly mobile within a country, producers of any good in i can hire workers at wage $w_{i,t}(s^t)$. Producers operate under constant returns to scale. If in country i the efficiency of producing a good is z, then the unit cost of producing that good there is $w_{i,t}(s^t)/z$. Assuming perfect competition, this cost is the price received by a producer of that good in i. Taking account of trade costs and tariffs, this good could be delivered to country n at price $d_{ni,t}(s^t)\tau_{ni,t}(s^t)w_{i,t}(s^t)/z$.

Consumers in country n will choose to buy from the source offering the lowest price for each good. How much they buy is guided by their preferences across the unit continuum of goods. We assume CES preferences with elasticity of substitution $\sigma < \theta + 1$, common to all countries.

We now present the four equilibrium conditions that characterize the static model, conditional on a state history s^t and the Lagrange multipliers. The first condition concerns spending. Country n's spending is determined by equation (3).

The second condition concerns the price levels themselves. Applying implications of the Fréchet distribution for the distribution of the lowest price per good, the price

index in country n is given by:

$$p_{n,t}(s^t) = \tilde{\Gamma}\left(\sum_i T_{i,t}(s^t)\left(w_{i,t}(s^t)\, d_{ni,t}(s^t)\, \tau_{ni,t}(s^t)\right)^{-\theta}\right)^{-1/\theta}, \tag{4}$$

where $\tilde{\Gamma}$ is a constant that will drop out of our counterfactual analysis.[9]

The third condition concerns bilateral trade shares. Applying properties of the Fréchet distribution again, we obtain the probability that a consumer in n will find a producer in i to be the low-price source of a given good. This probability becomes the share of country n's spending allocated to goods produced in country i:

$$\pi_{ni,t}(s^t) = T_{i,t}(s^t)\left(\frac{w_{i,t}(s^t)\, d_{ni,t}(s^t)\, \tau_{ni,t}(s^t)}{p_{n,t}(s^t)/\tilde{\Gamma}}\right)^{-\theta}, \tag{5}$$

which we call the bilateral trade share.

The last condition concerns wages that clear the labor market. Total income earned by labor in country i equals the total revenue received from producing goods sold to all destinations:

$$w_{i,t}(s^t)\, L_i = \sum_n \pi_{ni,t}(s^t)\, \frac{X_{n,t}(s^t)}{\tau_{ni,t}(s^t)}. \tag{6}$$

On the right-hand side of the equation, $\pi_{ni,t}(s^t)\, X_{n,t}(s^t)/\tau_{ni,t}(s^t)$ represents payments to country i, net of tariff revenue, from spending by country n. Summing over all n yields the income flowing to country i from its goods sold globally, including goods sold in country i itself. This value must equal the total payments to labor in country i so that the labor market clears at wage $w_{i,t}(s^t)$.

The system of equations (3)-(6) corresponds to the standard one-sector Eaton and Kortum (2002) framework, but with a key departure: we do not impose trade balance at the country level. And, in contrast to Dekle et al. (2007) who allow for trade imbalances, we do not treat them as fixed or subject to exogenous manipulation in a counterfactual. Instead, trade imbalances here emerge endogenously as equilibrium outcomes, reflecting optimal intertemporal and state-contingent consumption and saving decisions. With values for all of the parameters, in principle we could solve the system

[9] In particular, $\tilde{\Gamma} = \Gamma(1-(\sigma-1)/\theta)^{1/(1-\sigma)}$ where $\Gamma(a) = \int_0^\infty x^{a-1}e^{-x}dx$ is the gamma function.

for country-level spending, prices, bilateral trade, and wages. In general there is not a closed-form solution, even conditional on the λ_n's.[10]

With a solution to this system in hand, we can readily calculate other outcomes. Central to our analysis here is a country's trade deficit:

$$D_{n,t}(s^t) = \sum_{i \neq n} \left(\pi_{ni,t}(s^t) \frac{X_{n,t}(s^t)}{\tau_{ni,t}(s^t)} - \pi_{in,t}(s^t) \frac{X_{i,t}(s^t)}{\tau_{in,t}(s^t)} \right). \tag{7}$$

It is the value of country n's imports less the value of its exports, both net of tariffs. Inspection of the formula makes clear that deficits sum to 0 across countries so that, for any given state history, international borrowing by some countries offsets international lending by others. Another key outcome is tariff revenue:

$$R_{n,t}(s^t) = \sum_i \left(\tau_{ni,t}(s^t) - 1 \right) \pi_{ni,t}(s^t) \frac{X_{n,t}(s^t)}{\tau_{ni,t}(s^t)} = X_{n,t}(s^t) - \sum_i \pi_{ni,t}(s^t) \frac{X_{n,t}(s^t)}{\tau_{ni,t}(s^t)}. \tag{8}$$

A country's aggregate income, $Y_{n,t}(s^t)$, consists of labor earnings, from (6), and tariff revenue:

$$Y_{n,t}(s^t) = w_{n,t}(s^t) L_n + R_{n,t}(s^t) = X_{n,t}(s^t) - D_{n,t}(s^t), \tag{9}$$

where the second equality comes from combining (6), (7), and (8).[11]

We will use this system to compute counterfactuals, without needing to solve for the Lagrange multipliers. The trick is to compute changes relative to baseline values

[10] Solving for the Lagrange multipliers would require knowing the probability of all future state histories. With those probabilities somehow in hand, we could then reach a solution for the Lagrange multipliers by iterating on the following steps: (i) guess values for the Lagrange multipliers (normalizing $\lambda_1 = 1$); (ii) solve (3)-(6) for each s^t; (iii) evaluate Arrow security prices by imposing CRRA preferences to rewrite (2) as:

$$q_t^0(s^t) = \frac{\beta^t \Pi(s^t)}{\lambda_n} \left(\frac{X_{n,t}(s^t)}{L_n} \right)^{-\gamma} p_{n,t}(s^t)^{\gamma - 1};$$

(iv) substitute these results into the individual's intertemporal budget constraint, increasing the guess for a Lagrange multiplier if the left-hand side of the constraint is positive and decreasing it if the left-hand side is negative; (v) return to step (i) with the updated guess. We avoid these steps (and probabilities of future states) by computing counterfactuals using the approach described in Section 2.3.

[11] Summing income across countries it follows that global income matches global spending (both equal to 1 due to our choice of numéraire). Because nominal variables like spending $X_{n,t}(s^t)$, income $Y_{n,t}(s^t)$, and deficits $D_{n,t}(s^t)$ play a prominent role in this model, it is important to clarify their interpretation given our choice of numéraire. Each has a corresponding nominal variable in data, first measured in some currency unit. We must normalize by global spending, in that same currency unit, before matching it to its model analog.

for which we have data, employing exact-hat algebra. As described next, this approach requires values for only a handful of the underlying model parameters, with the rest subsumed in the baseline data.

2.3 Counterfactuals

This framework offers a precise interpretation of a counterfactual analysis under uncertainty. Consider a particular state history $s^t = (s_0, s_1, \ldots, s_t)$ that has been realized, where s_t denotes the most recent event, at time t. This history determines the equilibrium allocations at time t, and hence the data we observe.

A natural counterfactual question then arises: how would the equilibrium allocations at time t differ if, instead of the event s_t, a different event $\tilde{s}_t$ had occurred? In this thought experiment, the two histories up to time $t-1$ are identical in both scenarios—i.e., $s^{t-1} = (s_0, s_1, \ldots, s_{t-1})$—but diverge in the last period. That is, we compare the history $s^t = (s^{t-1}, s_t)$, for which we observe the outcome in the data, with a counterfactual history $\tilde{s}^t = (s^{t-1}, \tilde{s}_t)$, that deviates only due to the event at date t.[12]

To implement such a counterfactual, we consider potential changes in fundamentals across the two histories, $s^t = (s^{t-1}, s_t)$ and $\tilde{s}^t = (s^{t-1}, \tilde{s}_t)$. We use hat notation to capture the *proportional change* in any variable x in the counterfactual state history $x(\tilde{s}^t)$ relative to its value in the realized state $x(s^t)$. Hence, for any exogenous fundamental or any endogenous outcome of the model, we define $\hat{x} = x(\tilde{s}^t)/x(s^t)$, which we will simply call the counterfactual *change* in x. In particular, to capture how the exogenous variables in the model are shocked due to a counterfactual event at date t, we define the following changes in fundamentals: $\hat{T}_{n,t} = T_{n,t}(\tilde{s}^t)/T_{n,t}(s^t)$ (productivity shocks), $\hat{d}_{ni,t} = d_{ni,t}(\tilde{s}^t)/d_{ni,t}(s^t)$ (trade costs shocks), and $\hat{\tau}_{ni,t} = \tau_{ni,t}(\tilde{s}^t)/\tau_{ni,t}(s^t)$ (tariff shocks).

The relevant data observed under the realized state s^t are:

$$\left\{ w_{i,t}(s^t) L_i, X_{n,t}(s^t), \pi_{ni,t}(s^t), \tau_{ni,t}(s^t) \right\}_{i,n=1}^{N}.$$

[12] In our setup, with complete markets and uncertain states, counterfactuals can be thought of as *stochastic comparative statics*. The distinction from *deterministic comparative statics*, as in a perfect foresight dynamic environment, is that agents in the model have anticipated the possibility of the counterfactual event under consideration. Patrick Kehoe's published discussion of Stockman (1988) in the same volume articulates the conceptual advantage of stochastic comparative statics over deterministic comparative statics.

Given these observations, our goal is to solve for changes in equilibrium outcomes under the counterfactual state $\tilde{s}^t$. The outcomes, expressed as counterfactual changes, are: $\hat{X}_{n,t} = X_{n,t}(\tilde{s}^t)/X_{n,t}(s^t)$, $\hat{p}_{n,t} = p_{n,t}(\tilde{s}^t)/p_{n,t}(s^t)$, $\hat{\pi}_{ni,t} = \pi_{ni,t}(\tilde{s}^t)/\pi_{ni,t}(s^t)$, and $\hat{w}_{i,t} = w_{i,t}(\tilde{s}^t)/w_{i,t}(s^t)$. We solve for $\{\hat{X}_{n,t}, \hat{p}_{n,t}, \hat{\pi}_{ni,t}, \hat{w}_{i,t}\}$ that satisfy the following system of equations for changes in spending, price levels, bilateral trade shares, and labor incomes:

$$\hat{X}_{n,t} = \frac{\hat{p}_{n,t}^{1-1/\gamma}}{\sum_k X_{k,t}(s^t)\hat{p}_{k,t}^{1-1/\gamma}}, \tag{10}$$

$$\hat{p}_{n,t} = \left(\sum_i \pi_{ni,t}(s^t)\hat{T}_{i,t}\left(\hat{w}_{i,t}\hat{d}_{ni,t}\hat{\tau}_{ni,t}\right)^{-\theta}\right)^{-1/\theta}, \tag{11}$$

$$\hat{\pi}_{ni,t} = \hat{T}_{i,t}\left(\frac{\hat{w}_{i,t}\hat{d}_{ni,t}\hat{\tau}_{ni,t}}{\hat{p}_{n,t}}\right)^{-\theta}, \tag{12}$$

$$w_{i,t}(s^t)L_i\hat{w}_{i,t} = \sum_n \pi_{ni,t}(s^t)\frac{X_{n,t}(s^t)}{\tau_{ni,t}(s^t)}\hat{\pi}_{ni,t}\frac{\hat{X}_{n,t}}{\hat{\tau}_{ni,t}}. \tag{13}$$

The solution yields the full set of counterfactual general equilibrium outcomes corresponding to the alternative event $\tilde{s}_t$.

The method described above is in the spirit of the exact-hat-algebra approach commonly used in quantitative trade models, extended here to accommodate economies with uncertainty. The key advantage of this methodology lies in its ability to conduct rich counterfactual analyses without requiring full identification or estimation of all structural parameters of the model. In our application here, the counterfactual system in hat variables has the tremendous advantage of not requiring that we compute the Lagrange multipliers λ_n that represent the shadow value of wealth. While fundamental in determining the equilibrium in levels, see equation (3), the multipliers drop out in changes as in equation (10). The multipliers are embedded in the observed data on spending levels, $X_{n,t}(s^t)$, that form the baseline of the counterfactual.

Having solved for $\{\hat{X}_{n,t}, \hat{p}_{n,t}, \hat{\pi}_{ni,t}, \hat{w}_{i,t}\}$, we can compute changes in other outcomes. Examples are the ratio of individual consumption in the counterfactual relative to its value in the realized state s^t, given by $\hat{c}_{n,t} = \hat{X}_{n,t}/\hat{p}_{n,t}$, and the corresponding change in the real wage, $\hat{w}_{n,t}/\hat{p}_{n,t}$.

Together with the data observed in state s^t, we can compute additional counterfactual outcomes in levels as well. Counterfactual spending in country n is $X_{n,t}(\tilde{s}^t) = X_{n,t}(s^t)\hat{X}_{n,t}$, counterfactual wages are $w_{n,t}(\tilde{s}^t) = w_{n,t}(s^t)\hat{w}_{n,t}$, and counterfactual bilateral trade shares are $\pi_{ni,t}(\tilde{s}^t) = \pi_{ni,t}(s^t)\hat{\pi}_{ni,t}$. Counterfactual tariff revenue is:

$$R_{n,t}(\tilde{s}^t) = \sum_i \left(\tau_{ni,t}(\tilde{s}^t) - 1\right) \pi_{ni,t}(\tilde{s}^t) \frac{X_{n,t}(\tilde{s}^t)}{\tau_{ni,t}(\tilde{s}^t)},$$

so that counterfactual income is $Y_{n,t}(\tilde{s}^t) = w_{n,t}(\tilde{s}^t)L_n + R_{n,t}(\tilde{s}^t)$. Country n's counterfactual deficit is:

$$D_{n,t}(\tilde{s}^t) = \sum_{i \neq n} \left(\pi_{ni,t}(\tilde{s}^t) \frac{X_{n,t}(\tilde{s}^t)}{\tau_{ni,t}(\tilde{s}^t)} - \pi_{in,t}(\tilde{s}^t) \frac{X_{i,t}(\tilde{s}^t)}{\tau_{in,t}(\tilde{s}^t)} \right) = X_{n,t}(\tilde{s}^t) - Y_{n,t}(\tilde{s}^t). \tag{14}$$

We can also compute the *bilateral* trade deficit of country n with country i under the counterfactual, $D_{ni,t}(\tilde{s}^t)$, as it is simply the i'th term in the expression for the overall deficit, (14). The framework can therefore be used to evaluate the effects of uncertain changes to trade policies—such as country-pair-specific tariffs—on the geography of trade imbalances, one goal of the quantitative section that follows.[13]

Among the various counterfactual scenarios we could consider the most extreme is autarky, an economy with no goods trade and hence no trade imbalance. This counterfactual delivers a clean expression for the change in real consumption, including the ex-post current value of intertemporal trade.[14] Formally, the autarky counterfactual considers a state history $\tilde{s}^t$ in which bilateral trade is shut down, either because ice-

[13]The numéraire, of course, also applies to the counterfactual level of spending, as can be confirmed from equation (10):

$$\sum_n X_{n,t}(\tilde{s}^t) = \sum_n X_{n,t}(s^t)\hat{X}_{n,t} = \sum_n \frac{X_{n,t}(s^t)\hat{p}_{n,t}^{1-1/\gamma}}{\sum_k X_{k,t}(s^t)\hat{p}_{k,t}^{1-1/\gamma}} = 1.$$

Thus, $X_{n,t}(\tilde{s}^t)$ is country n's counterfactual share of global spending, $Y_{n,t}(\tilde{s}^t)$ is country n's counterfactual share of global income (or global spending), and $D_{n,t}(\tilde{s}^t)$ is country n's counterfactual trade deficit relative to global spending. Similarly, $\hat{X}_{n,t}$ is the change in n's spending relative to the change in global spending, while $\hat{p}_{n,t}$ and $\hat{w}_{n,t}$ are changes in prices and wages relative to the change in global spending. These normalizations, which are governed by our choice of numéraire, are essential for interpreting data on nominal variables in light of the model.

[14]Our measure, however, does not capture the ex-ante value of intertemporal trade, since it conditions on both the initial and counterfactual state history. See Fitzgerald (2024) for a quantification of this ex-ante value.

berg trade costs or tariffs approach infinity ($d_{ni,t}(\tilde{s}^t) \to \infty$ or $\tau_{ni,t}(\tilde{s}^t) \to \infty$ for all $i \neq n$). In such a scenario, each country consumes only domestically produced goods.

Let $\hat{X}_{n,t}$ denote the change in country n's total spending in autarky relative to the observed state, and let $\hat{p}_{n,t}$ denote the corresponding change in its consumption price index. The change in real consumption in autarky relative to the current state is given by:

$$\frac{\hat{X}_{n,t}}{\hat{p}_{n,t}} = \pi_{nn,t}(s^t)^{1/\theta} \left(\frac{w_{n,t}(s^t) L_n}{X_{n,t}(s^t)} \right), \tag{15}$$

where $\pi_{nn,t}(s^t)$ is the share of country n's spending on domestically produced goods, $w_{n,t}(s^t)L_n$ is labor income, $X_{n,t}(s^t)$ is total spending, all as observed in the current state.[15] This expression reflects two distinct components. The term $\pi_{nn,t}(s^t)^{1/\theta}$ captures the static losses from moving to autarky, reflecting lost access to lower-cost imported goods (the inverse of the standard gains from trade). When a country is open to trade, its domestic spending share is less than one, which captures the loss of intratemporal gains from trade in a shift to autarky. The term $w_{n,t}(s^t)L_n/X_{n,t}(s^t)$ captures the ex-post current gains or losses from losing intertemporal trade, that had been facilitated by complete financial markets. These two components capture the effects of a move to autarky. The formula is intuitive and is readily computable from data and a single parameter.

2.4 Financial Intermediation (preliminary and incomplete)

Our baseline model assumes that individuals access the international market for state-contingent claims directly, at a common global price of $q_t^0(s^t)$. We now relax this assumption by introducing financial intermediaries that stand between individuals and the global asset market, creating an asset-market friction. The resulting wedge is not imposed; it emerges endogenously from imperfect competition in intermediation and vanishes if financial markets are competitive. By varying the number of intermediaries that compete with each other we can span the space between financial autarky (in which goods trade must balance) and frictionless complete asset markets (as in our

[15] To derive this result we invert equation (12), setting $i = n$, $\hat{T}_{n,t} = 1$, and $\hat{\pi}_{nn,t} = 1/\pi_{nn,t}(s^t)$ since $\pi_{nn,t}(\tilde{s}^t) = 1$ in a state of autarky. This inversion yields $\hat{w}_{n,t}/\hat{p}_{n,t} = \pi_{nn,t}(s^t)^{1/\theta}$. The result then follows by noting that $\hat{X}_{n,t} = \hat{w}_{n,t}(w_{n,t}(s^t)L_n)/X_{n,t}(s^t)$ since $X_{n,t}(\tilde{s}^t) = w_{n,t}(\tilde{s}^t)L_n$ in a state of autarky.

baseline model).

In each country n there is a unit continuum of identical segmented financial markets. Each segment is home to an equal portion of individuals and is served by an integer number $m_{n,t}$ of financial intermediaries. Individuals trade state-contingent claims only through the intermediaries in their segment, while intermediaries can access the global market at the common price $q_t^0(s^t)$. Intermediaries behave strategically within their segment, competing in asset quantities and taking into account the effect of their trades on the local price of claims. Each segment is measure zero in the aggregate economy, so that intermediaries take aggregate outcomes as given.

In this setting individuals face a country-specific price of claims,

$$q_{n,t}^0(s^t) = \omega_{n,t}(s^t)\, q_t^0(s^t), \tag{16}$$

where $\omega_{n,t}(s^t)$ is a financial wedge determined in equilibrium. Intermediary market power implies $\omega_{n,t}(s^t) > 1$ if individuals in country n borrow and $\omega_{n,t}(s^t) < 1$ if they lend in state history s^t. We now turn to the details of a model that delivers these results.

The individual's problem is as in Section 2.1 except that they buy and sell claims at price $q_{n,t}^0(s^t)$ rather than $q_t^0(s^t)$.[16] The first-order condition (2) becomes

$$\beta^t\, \Pi(s^t)\, u_c\left(c_{n,t}(s^t)\right) = \lambda_n\, \omega_{n,t}(s^t)\, q_t^0(s^t)\, p_{n,t}(s^t),$$

and, exploiting our assumption of CRRA preferences and our choice of numéraire,

[16] With financial intermediation the individual's intertemporal budget constraint becomes:

$$\sum_{t=0}^{\infty} \sum_{s^t \in S^t} q_t^0(s^t) \omega_{n,t}(s^t) \left(p_{n,t}(s^t)\, c_{n,t}(s^t) - y_{n,t}(s^t)\right) = 0.$$

Imagine that in period t this individual visits country i and consumes $c_{i,t}(s^t)$ there. To satisfy the intertemporal budget constraint:

$$\frac{\omega_{i,t}(s^t) p_{i,t}(s^t)}{\omega_{n,t}(s^t) p_{n,t}(s^t)} c_{i,t}(s^t) = c_{n,t}(s^t).$$

We thus formulate country n's real exchange rate as $\varepsilon_{n,t}(s^t) = 1/\left(q_{n,t}^0(s^t) p_{n,t}(s^t)\right)$, or consumption there in s^t per unit of the numéraire in s^0. Country n's bilateral real exchange rate with i is then:

$$\varepsilon_{ni,t}(s^t) = \frac{\varepsilon_{n,t}(s^t)}{\varepsilon_{i,t}(s^t)} = \frac{q_{i,t}^0(s^t) p_{i,t}(s^t)}{q_{n,t}^0(s^t) p_{n,t}(s^t)} = \frac{\omega_{i,t}(s^t) p_{i,t}(s^t)}{\omega_{n,t}(s^t) p_{n,t}(s^t)},$$

or consumption in n sacrificed per unit of consumption in i as in the intertemporal budget constraint.

country n's aggregate spending in history s^t is

$$X_{n,t}(s^t) = \frac{L_n \lambda_n^{-1/\gamma} \, \omega_{n,t}(s^t)^{-1/\gamma} \, p_{n,t}(s^t)^{1-1/\gamma}}{\sum_k L_k \lambda_k^{-1/\gamma} \, \omega_{k,t}(s^t)^{-1/\gamma} \, p_{k,t}(s^t)^{1-1/\gamma}}. \tag{17}$$

Relative to equation (3), the financial wedge acts like an inverse country-specific preference shock in a given state history: a higher $\omega_{n,t}(s^t)$ lowers spending in that state.[17]

To see how the wedge is determined, consider a segment in country n in a state history s^t. For ease of exposition, suppose the country borrows in this state history so that individuals in the segment are net purchasers of claims on the numéraire. Intermediary r in the segment chooses a quantity b_r of claims to buy on the international market, which it then sells to individuals in the local market. Total purchases in the segment are $B = \sum_{r'=1}^{m_{n,t}} b_{r'}$. Taking the purchases $b_{r'}$ of the others as given, the intermediary solves

$$b_{r,n,t}(s^t) = \arg\max_{b_r} \left[q^0_{n,t}(B) - q^0_t(s^t) \right] b_r,$$

where $q^0_{n,t}(B)$ is the inverse demand for claims in the segment. The first-order condition of this Cournot problem, after imposing symmetry so that $B_{n,t}(s^t) = m_{n,t} b_{r,n,t}(s^t)$, yields the familiar markup rule:

$$\frac{q^0_{n,t}(s^t) - q^0_t(s^t)}{q^0_{n,t}(s^t)} = \frac{1}{m_{n,t} \, \epsilon^D_{n,t}(s^t)},$$

[17] In this setting we can extend our formulation of the real interest rate in footnote 5 and connect it to our formulation of the real exchange rate in footnote 16. The price in country n at state history s^t of securing a unit of the numéraire in s^{t+1} becomes $q_{n,t+1}(s^{t+1}|s^t) = q^0_{n,t+1}(s^{t+1})/q^0_{n,t}(s^t)$, which can now vary by country. The gross one-period riskless real interest rate in state s^t in country n becomes:

$$1 + r_{n,t}(s^t) = \frac{p_{n,t}(s^t)}{\sum_{s^{t+1}|s^t} q_{n,t+1}(s^{t+1}|s^t) p_{n,t+1}(s^{t+1})}.$$

The one-period-forward real bilateral exchange rate is:

$$\varepsilon^F_{ni,t}(s^t) = \frac{\sum_{s^{t+1}|s^t} q^0_{i,t+1}(s^{t+1}) p_{i,t+1}(s^{t+1})}{\sum_{s^{t+1}|s^t} q^0_{n,t+1}(s^{t+1}) p_{n,t+1}(s^{t+1})}.$$

The forward to current exchange rate satisfies the covered real interest rate parity condition:

$$\frac{\varepsilon^F_{ni,t}(s^t)}{\varepsilon_{ni,t}(s^t)} = \frac{\sum_{s^{t+1}|s^t} q_{i,t+1}(s^{t+1}|s^t) p_{i,t+1}(s^{t+1})/p_{i,t}(s^t)}{\sum_{s^{t+1}|s^t} q_{n,t+1}(s^{t+1}|s^t) p_{n,t+1}(s^{t+1})/p_{n,t}(s^t)} = \frac{1 + r_{n,t}(s^t)}{1 + r_{i,t}(s^t)}.$$

where $\epsilon^D_{n,t}(s^t)$ is the elasticity of demand for assets.

Under our assumption of CRRA preferences, and imposing symmetry across segments so that $X_{n,t}(s^t) - Y_{n,t}(s^t) = B_{n,t}(s^t)$, the elasticity of demand for claims with respect to the local price is:

$$\epsilon^D_{n,t}(s^t) = \frac{1}{\gamma} \frac{X_{n,t}(s^t)}{X_{n,t}(s^t) - Y_{n,t}(s^t)}.$$

This expression follows from equation (17): gross spending responds to the price of claims with elasticity $1/\gamma$, while net purchases $X_{n,t}(s^t) - Y_{n,t}(s^t)$ amplify this response by the ratio of gross to net positions.

We can now solve for the wedge, $\omega_{n,t}(s^t) = q^0_{n,t}(s^t)/q^0_t(s^t)$, from the markup rule after substituting in the expression for the demand elasticity:

$$\omega_{n,t}(s^t) = \frac{X_{n,t}(s^t)}{\frac{\gamma}{m_{n,t}} Y_{n,t}(s^t) + \left(1 - \frac{\gamma}{m_{n,t}}\right) X_{n,t}(s^t)}. \tag{18}$$

While we have been assuming the country n is a borrower in state history s^t, it is easy to show that (18) also holds for $X_{n,t}(s^t) < Y_{n,t}(s^t)$. In states where spending exceeds income, $\omega_{n,t}(s^t) > 1$, intermediaries mark up the price of the claims individuals require in order to finance their spending. In states where income exceeds spending, the analogous bid-side problem delivers $\omega_{n,t}(s^t) < 1$, a markdown on the price of the claims individuals need to sell. In both cases intermediation raises the cost of reallocating spending across states. As competition intensifies, the friction disappears: $\omega_{n,t}(s^t) \to 1$ as $m_{n,t} \to \infty$, and the model converges to the complete-markets baseline of Section 2.1.

Intermediaries earn profits on the margin between local and international prices. Aggregate operating profits in country n, measured in current value, equal the wedge margin applied to the country's net position,

$$V^F_{n,t}(s^t) = \left(\omega_{n,t}(s^t) - 1\right)\left(X_{n,t}(s^t) - Y_{n,t}(s^t)\right) = \frac{\gamma \left[X_{n,t}(s^t) - Y_{n,t}(s^t)\right]^2}{\gamma\, Y_{n,t}(s^t) + (m_{n,t} - \gamma)\, X_{n,t}(s^t)}, \tag{19}$$

which is positive whenever spending and income differ, in either direction.

We assume that entry into intermediation requires regulatory and compliance la-

bor: each intermediary incurs a fixed cost $F_{n,t}(s^t)$ in units of local labor, and entry equates profits per intermediary to this cost, $V^F_{n,t}(s^t)/m_{n,t} = w_{n,t}(s^t)\, F_{n,t}(s^t)$. Profits are thus fully dissipated as payments to labor employed in intermediation. More intermediaries increase competition and reduce the wedge, but they also absorb real resources. Labor market clearing, equation (6), accordingly becomes

$$w_{i,t}(s^t)\, L_i = \sum_{n=1}^{N} \pi_{ni,t}(s^t)\, \frac{X_{n,t}(s^t)}{\tau_{ni,t}(s^t)} + V^F_{i,t}(s^t), \tag{20}$$

while income remains $Y_{n,t}(s^t) = w_{n,t}(s^t)L_n + R_{n,t}(s^t)$, with tariff revenue given by (8).

Financial intermediation alters the relationship between the trade deficit and the gap between spending and income. The deficit $D_{n,t}(s^t)$—the value of imports less the value of exports, as defined in equation (7)—now satisfies

$$D_{n,t}(s^t) = \left[X_{n,t}(s^t) - Y_{n,t}(s^t)\right] + V^F_{n,t}(s^t) = \omega_{n,t}(s^t)\left[X_{n,t}(s^t) - Y_{n,t}(s^t)\right]. \tag{21}$$

In contrast to the baseline model, the trade deficit no longer coincides with the difference between spending and income: part of national income is generated by intermediation profits rather than by sales of goods, and this income is absorbed domestically as payments to compliance labor. The two measures coincide only when trade is balanced or intermediation is perfectly competitive.

Importantly, the counterfactual methodology of Section 2.3 carries over to this economy. In taking the model to counterfactuals, a stand must be taken on how the number of intermediaries varies across the two events at date t. We can consider counterfactuals in which the government sets $m_{n,t}$ to be the same at a given date t across different states, with the fixed cost $F_{n,t}(s^t)$ adjusting across states to satisfy the entry condition; or, alternatively, counterfactuals in which the fixed cost is constant across states and $m_{n,t}$ adjusts through entry. We adopt the first, with $m_{n,t}$ predetermined relative to the event at date t: this case has the natural interpretation of a government regulating the amount of competition in the financial intermediation sector, and it is also consistent with entry taking place before the realization of the date-t event, since the two histories $s^t = (s^{t-1}, s_t)$ and $\tilde{s}^t = (s^{t-1}, \tilde{s}_t)$ coincide through $t-1$. In Appendix A.3 we work out

the hat algebra for the alternative case in which the fixed cost is held constant and the number of intermediaries changes across states.

Under predetermined $m_{n,t}$, using the notation of Section 2.3, with $\hat{x} = x(\tilde{s}^t)/x(s^t)$ denoting the counterfactual change in any variable x, the change in spending implied by equation (17) is

$$\hat{X}_{n,t} = \frac{\hat{\omega}_{n,t}^{-1/\gamma}\, \hat{p}_{n,t}^{1-1/\gamma}}{\sum_k X_{k,t}(s^t)\, \hat{\omega}_{k,t}^{-1/\gamma}\, \hat{p}_{k,t}^{1-1/\gamma}}, \tag{22}$$

where, from equation (18), the change in the wedge is

$$\hat{\omega}_{n,t} = \hat{X}_{n,t}\, \frac{\frac{\gamma}{m_{n,t}}\, Y_{n,t}(s^t) + \left(1 - \frac{\gamma}{m_{n,t}}\right) X_{n,t}(s^t)}{\frac{\gamma}{m_{n,t}}\, Y_{n,t}(s^t)\hat{Y}_{n,t} + \left(1 - \frac{\gamma}{m_{n,t}}\right) X_{n,t}(s^t)\hat{X}_{n,t}}. \tag{23}$$

As in the baseline model, the Lagrange multipliers λ_n cancel when taking ratios across states in equation (17), and equation (23) involves only observed spending and income, $X_{n,t}(s^t)$ and $Y_{n,t}(s^t)$, together with the parameters γ and $m_{n,t}$. Counterfactuals in the economy with financial intermediation therefore still require no knowledge of Arrow security prices, state probabilities, or the multipliers: the system of equations in changes is as in Section 2.3, with (22) and (23) replacing the expenditure equation and the labor market condition augmented by the change in intermediation profits implied by (19). Appendix A describes how we take this extended model to the data, including how the wedge enters the mapping from observed trade flows to spending and income.

3 Quantitative Analysis

In this section, we quantify the role of tariffs in shaping trade imbalances and other outcomes through the lens of our baseline framework with trade in goods and no frictions in asset markets. In Section 3.1, we extend the framework to incorporate a non-tradable sector and intermediate goods. Section 3.2 describes the main data sources used to recover the observed allocations necessary to take the model to the data. In Sections 3.3 and 3.4, we present the quantitative analysis and discuss our main findings.

3.1 Adding Sectors and Intermediate Goods

To help the model fit the data, we incorporate a non-tradable sector alongside the tradable sector, allowing for both final consumption and intermediate input linkages. This extension preserves the structure of the basic model for tradable goods, but introduces sectoral asymmetries in production and input use.

We assume that aggregate consumption in country n at time t, given history s^t, is a Cobb–Douglas combination of tradable and non-tradable consumption goods:

$$C_{n,t}(s^t) = \left(C^T_{n,t}(s^t)/\alpha\right)^{\alpha} \left(C^{NT}_{n,t}(s^t)/(1-\alpha)\right)^{1-\alpha}.$$

To maximize consumption, individuals allocate a share α of aggregate final spending $X_{n,t}(s^t)$ to tradables and $1-\alpha$ to non-tradables. The resulting price index for aggregate consumption is:

$$p_{n,t}(s^t) = p^T_{n,t}(s^t)^{\alpha} p^{NT}_{n,t}(s^t)^{1-\alpha}.$$

Let $Y^T_{i,t}(s^t)$ and $Y^{NT}_{i,t}(s^t)$ denote gross output of the tradable and non-tradable sectors. We assume a simple round-about production structure where tradables require tradable intermediate goods, and non-tradables require non-tradable intermediates. Let β^T and β^{NT} denote the value added shares of gross output in the tradable and non-tradable sectors, so that $1-\beta^T$ and $1-\beta^{NT}$ are the intermediate shares. Sectoral spending consists of spending on consumption and on intermediates. It follows that total spending on tradables is:

$$X^T_{i,t}(s^t) = \alpha X_{i,t}(s^t) + (1-\beta^T) Y^T_{i,t}(s^t),$$

and on non-tradables is:

$$X^{NT}_{i,t}(s^t) = (1-\alpha) X_{i,t}(s^t) + (1-\beta^{NT}) Y^{NT}_{i,t}(s^t).$$

Since a country's total spending on non-tradables equals its gross output in the non-

tradables sector, we get:

$$X_{i,t}^{NT}(s^t) = Y_{i,t}^{NT}(s^t) = \frac{1-\alpha}{\beta^{NT}} X_{i,t}(s^t). \tag{24}$$

Spending on tradables, partly driven by demand for intermediates to produce for the global market, is:

$$X_{i,t}^{T}(s^t) = \alpha X_{i,t}(s^t) + (1-\beta^T) \sum_{n=1}^{N} \pi_{ni,t}(s^t) \frac{X_{n,t}^{T}(s^t)}{\tau_{ni,t}(s^t)}.$$

Labor is perfectly mobile across sectors within each country. Spending on labor in the non-tradable sector is $\beta^{NT} Y_{i,t}^{NT}(s^t)$ and in the tradable sector is $\beta^T Y_{i,t}^{T}(s^t)$. Total labor income is thus:

$$w_{i,t}(s^t) L_i = (1-\alpha) X_{i,t}(s^t) + \frac{\beta^T}{1-\beta^T} \left(X_{i,t}^{T}(s^t) - \alpha X_{i,t}(s^t) \right).$$

We denote productivity in non-tradables by $A_{n,t}(s^t)$. Hence the price of nontradables in country n is:

$$p_{n,t}^{NT}(s^t) = \frac{1}{A_{n,t}(s^t)} w_{n,t}(s^t)^{\beta^{NT}} p_{n,t}^{NT}(s^t)^{1-\beta^{NT}} = A_{n,t}(s^t)^{-1/\beta^{NT}} w_{n,t}(s^t).$$

Productivity in the tradables sector is determined by the scale parameter of the Fréchet distribution, $T_{n,t}(s^t)$, as in the basic model. Taking into account the option to import, the price of tradables in country n is:

$$p_{n,t}^{T}(s^t) = \tilde{\Gamma} \left(\sum_{i=1}^{N} T_{i,t}(s^t) \left(w_{i,t}(s^t)^{\beta^T} p_{i,t}^{T}(s^t)^{1-\beta^T} d_{ni,t}(s^t) \tau_{ni,t}(s^t) \right)^{-\theta} \right)^{-1/\theta}.$$

Finally, following the logic of the basic model, the bilateral trade equation is:

$$\pi_{ni,t}(s^t) = T_{i,t}(s^t) \left(\frac{w_{i,t}(s^t)^{\beta^T} p_{i,t}^{T}(s^t)^{1-\beta^T} d_{ni,t}(s^t) \tau_{ni,t}(s^t)}{p_{n,t}^{T}(s^t)/\tilde{\Gamma}} \right)^{-\theta}.$$

Given a history s^t, an equilibrium consists of spending $\{X_{i,t}(s^t), X_{i,t}^{T}(s^t), X_{i,t}^{NT}(s^t)\}$, prices $\{p_{i,t}(s^t), p_{i,t}^{T}(s^t), p_{i,t}^{NT}(s^t)\}$, wages $\{w_{i,t}(s^t)\}$, and trade shares $\{\pi_{ni,t}(s^t)\}$ that jointly

satisfy the equations above, together with equation (3). This system, including the Lagrange multipliers $\{\lambda_n\}$, characterizes the equilibrium of an economy with final consumption and intermediate linkages across tradable and non-tradable sectors.

We follow the exact-hat methodology described in Section 2.3 to express the system of equilibrium conditions for counterfactual changes in spending $\{\hat{X}_{n,t}, \hat{X}^T_{n,t}\}$, prices $\{\hat{p}_{n,t}, \hat{p}^T_{n,t}\}$, bilateral trade shares $\{\hat{\pi}_{ni,t}\}$, and wages $\{\hat{w}_{i,t}\}$:

$$\hat{X}_{n,t} = \frac{\hat{p}_{n,t}^{1-1/\gamma}}{\sum_k X_{k,t}(s^t)\hat{p}_{k,t}^{1-1/\gamma}}, \tag{25}$$

$$\hat{p}^T_{n,t} = \left(\sum_i \pi_{ni,t}(s^t)\hat{T}_{i,t}\left(\left(\hat{w}_{i,t}\right)^{\beta^T}\left(\hat{p}^T_{i,t}\right)^{1-\beta^T}\hat{d}_{ni,t}\hat{\tau}_{ni,t}\right)^{-\theta}\right)^{-1/\theta}, \tag{26}$$

$$\hat{p}_{n,t} = \left(\hat{p}^T_{n,t}\right)^{\alpha}\left(\hat{w}_{n,t}\right)^{(1-\alpha)}\left(\hat{A}_{n,t}\right)^{-(1-\alpha)/\beta^{NT}}, \tag{27}$$

$$\hat{\pi}_{ni,t} = \hat{T}_{i,t}\left(\frac{\left(\hat{w}_{i,t}\right)^{\beta^T}\left(\hat{p}^T_{i,t}\right)^{1-\beta^T}\hat{d}_{ni,t}\hat{\tau}_{ni,t}}{\hat{p}^T_{n,t}}\right)^{-\theta}, \tag{28}$$

$$X^T_{i,t}(s^t)\hat{X}^T_{i,t} = \alpha X_{i,t}(s^t)\hat{X}_{i,t} + \left(1-\beta^T\right)\sum_{n=1}^{N}\pi_{ni,t}(s^t)\frac{X^T_{n,t}(s^t)}{\tau_{ni,t}(s^t)}\hat{\pi}_{ni,t}\frac{\hat{X}^T_{n,t}}{\hat{\tau}_{ni,t}}, \tag{29}$$

$$w_{i,t}(s^t)L_i\hat{w}_{i,t} = (1-\alpha)X_{i,t}(s^t)\hat{X}_{i,t} + \frac{\beta^T}{1-\beta^T}\left(X^T_{i,t}(s^t)\hat{X}^T_{i,t} - \alpha X_{i,t}(s^t)\hat{X}_{i,t}\right), \tag{30}$$

where $\hat{A}_{n,t}$ represents a productivity shock in the non-tradable sector. We condition the system on the data observed under the realized state history s^t:

$$\left\{w_{i,t}(s^t)L_i, X_{n,t}(s^t), X^T_{n,t}(s^t), \pi_{ni,t}(s^t), \tau_{ni,t}(s^t)\right\}_{i,n=1}^{N}.$$

In the next section, we describe how to take this extended model to the data, and how to use observed data in a given history s^t to compute counterfactual outcomes under an alternative history $\tilde{s}^t$.

3.2 Taking the Model to the Data

We now describe the data that we use for our quantitative analysis. Bilateral trade data comes from UN Comtrade for the year 2023, the latest available year. We compute tariff-inclusive bilateral spending on tradable goods, $X^T_{ni,t}$ for $n \neq i$, by incorporating the cost of tariffs into the Comtrade data. The tariff data needed to measure $\tau_{ni,t}$ come from the World Integrated Trade Solution (WITS). We use the most recent available effective tariff rate reported by WITS for each country, and use the MFN tariff when the effective rate is missing.

Data on production are sourced from the United Nations (UN), which reports value added for agriculture, mining, manufacturing, and utilities—grouped as the tradable sectors—and the rest of the economy, which we include in the non-tradable sector. Summing across tradable and non-tradable sectors and across countries we obtain global value added, VA_t. We obtain the share of value added in gross output for the tradable and non-tradable sectors, $\beta^T = 0.3131$ and $\beta^{NT} = 0.5715$, based on the ratio of global value added to global gross output, for each sector as reported in the World Input Output Database (WIOD). Given these value added shares, assumed to be constant across countries, we can back out gross output from value added for the tradable and non-tradable sectors. We compute domestic sales of tradables, $X^T_{nn,t}$, as the difference between gross output and country n's total exports. After data cleaning and consistency checks, we have data for $N = 187$ countries, including a residual rest of the world, which constitutes the sample for our quantitative analysis.

Total tradable spending of each destination country n is computed as the sum over its imports from each country:

$$X^T_{n,t} = \sum_{i=1}^{N} X^T_{ni,t}. \tag{31}$$

We can then compute the bilateral trade shares, $\pi_{ni,t}$, as the fraction of country n's spending on tradables that is allocated to imports from i:

$$\pi_{ni,t} = \frac{X^T_{ni,t}}{X^T_{n,t}}. \tag{32}$$

We calibrate the share of final spending allocated to tradables as:

$$\alpha = \frac{\sum_{i=1}^{N} X_{i,t}^{T} - (1-\beta^{T}) \sum_{i=1}^{N} \sum_{n=1}^{N} \frac{X_{ni,t}^{T}}{\tau_{ni,t}}}{VA_t + \sum_{i=1}^{N} \sum_{n=1}^{N} (\tau_{ni,t} - 1) \frac{X_{ni,t}^{T}}{\tau_{ni,t}}}. \tag{33}$$

Note that global final spending on tradables, the numerator, is the difference between observed tradable spending and spending on intermediates. The denominator is global income, including tariff revenue. We end up with a value of $\alpha = 0.322$. Given α, we compute each country's total spending as:

$$X_{i,t} = \frac{X_{i,t}^{T} - (1-\beta^{T}) \sum_{n=1}^{N} \frac{X_{ni,t}^{T}}{\tau_{ni,t}}}{\alpha}. \tag{34}$$

Summing across countries gives us nominal global spending, $X_t = 106.6$ trillion USD in the year 2023. We use this value to deflate all other nominal values in the model, in line with our choice of the numéraire. Using the budget constraint implied by national income accounting, each country's total value added is given by:

$$w_{i,t} L_i = (1-\alpha) X_{i,t} + \beta^{T} \sum_{n=1}^{N} \frac{X_{ni,t}^{T}}{\tau_{ni,t}}, \tag{35}$$

Finally, we calibrate two key parameters based on standard values from the literature. We set the trade elasticity to $\theta = 4$ (see Simonovska and Waugh (2014) and Caliendo and Parro (2015)). This parameter governs the sensitivity of trade flows to changes in trade costs and influences the degree of trade reallocation. We set the coefficient of relative risk aversion to $\gamma = 2$, which is near the median of the range of existing estimates (see Elminejad et al. (2025)). This parameter determines the curvature of the utility function and the strength of consumption smoothing in response to uncertainty.

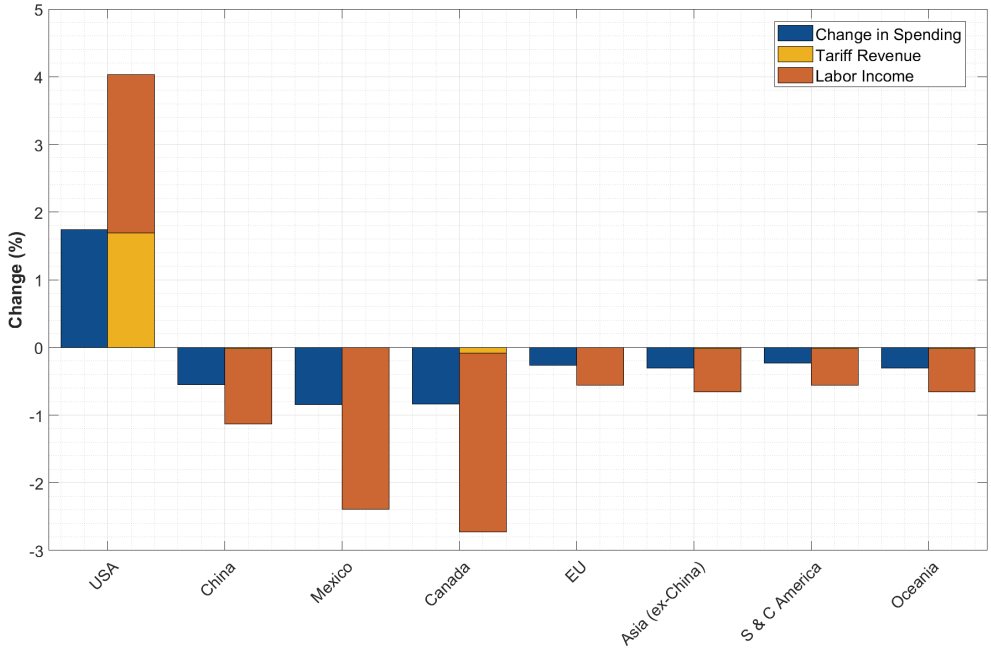
We now turn to a quantitative analysis of how a shock to tariffs impacts spending, income, trade imbalances, prices, and real consumption.

3.3 Tariff Counterfactuals

We now utilize the framework laid out in previous sections to analyze how equilibrium allocations at time t would change if, instead of the event s_t, an alternative event $\tilde{s}_t$ occurs. In particular, we define s_t as the event without a tariff shock, while $\tilde{s}_t$ represents the event of a tariff shock (recall that these events are the final entries in the histories s^t and $\tilde{s}^t$).

We start by analyzing the counterfactual scenario in which $\tau_{USA,i}(\tilde{s}^t) = \tau_{USA,i}(s^t) + 0.1$, except when i is China in which case $\tau_{USA,i}(\tilde{s}^t) = \tau_{USA,i}(s^t) + 0.3$. Specifically, the U.S. tariffs applied to China increase by 30 percentage points and the U.S. tariffs applied to every other country in the world increase by 10 percentage points.

Figure 1: Change in Income and Spending



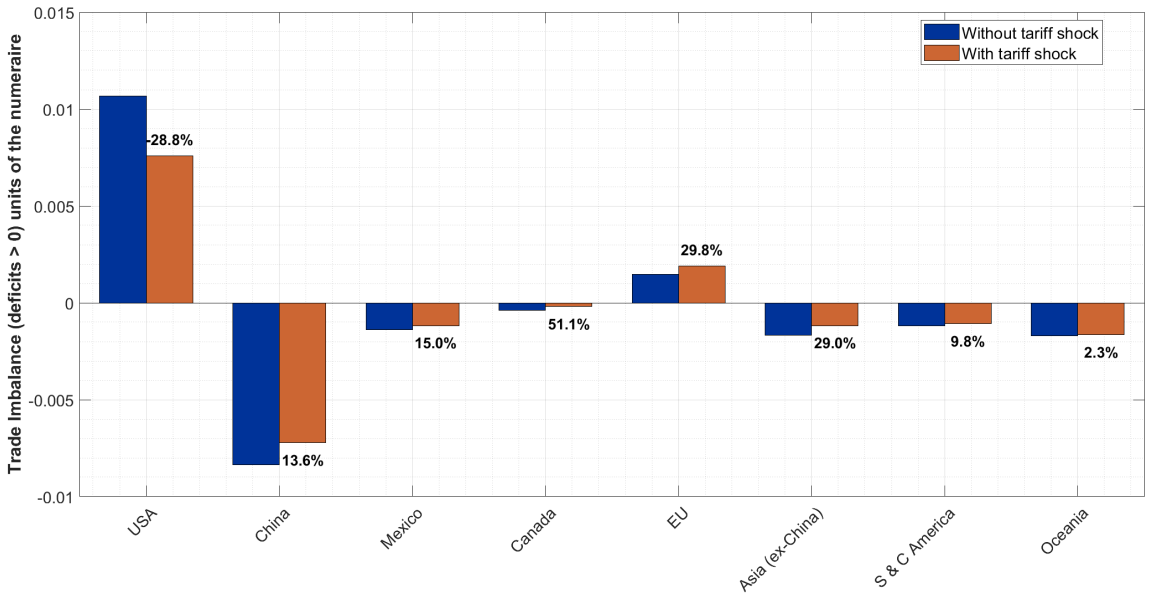
Note: The figure shows the percentage change in spending and income across different countries and regions in the world, in the tariff counterfactual where U.S. tariffs increase by 30 percentage points for China and 10 percentage points for all other countries. The change in spending is displayed by the darker bars on the left. The change in income is displayed by the lighter bars on the right, decomposed along the lines of equation 9. The darker portion of each bar on the right shows the change in income due to the change in labor income, while the lighter portion shows the change in income due to the change in tariff revenues.

Figure 1 illustrates changes in income and spending in the United States, China,

and other countries and regions worldwide. The event of an increase in U.S. tariffs leads to an increase in U.S. income (relative to global income), driven by a significant rise in both wages and tariff revenues, as indicated by the colors in the right-hand bars in the figure. Conversely, the shock to tariffs causes a decline in income shares in other countries and regions, mainly due to terms-of-trade effects, reflected in lower wages in countries other than the United States.

The darker bars on the left in Figure 1 illustrate the percentage change in spending (relative to global spending) across countries and regions. The United States experiences an increase in spending, while other countries and regions see a reduction. Importantly, changes in spending across countries are less pronounced than changes in income. This pattern reflects the role of international assets, which allow countries to smooth consumption in the face of shocks. The eight figures in Appendix B.1 show that the same pattern applies to individual countries within different regions of the world.

Figure 2: Trade Imbalances

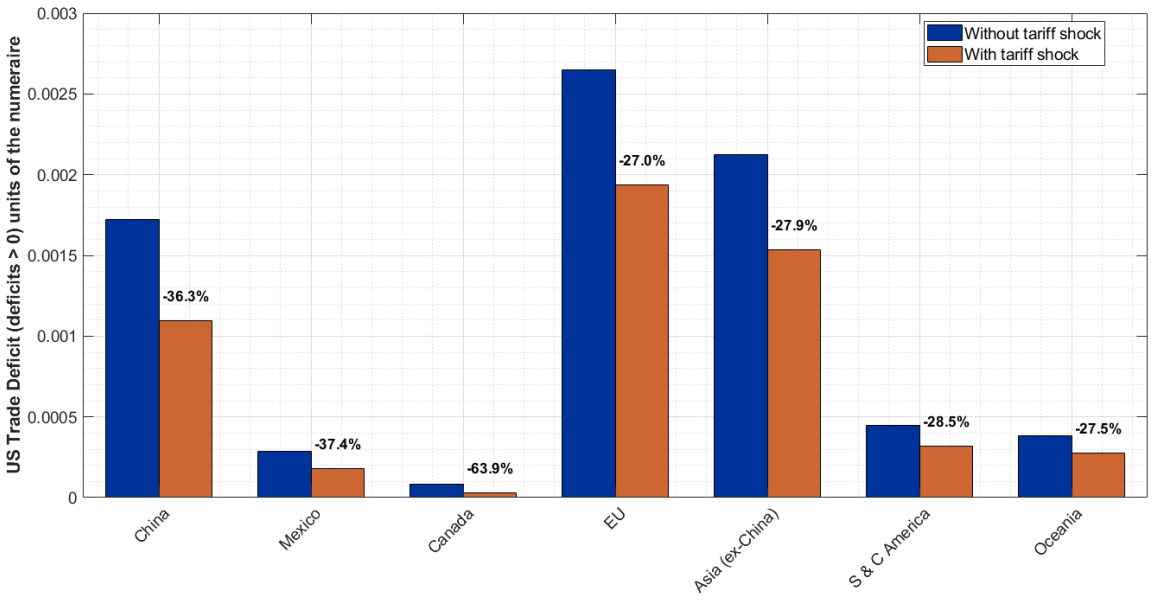


Note: The figure shows trade imbalances, measured relative to global spending, across countries and regions in the baseline (left hand side bars) and under a counterfactual where U.S. tariffs rise by 30 percentage points on China and 10 points on all others (right hand side bars). Trade imbalances are defined as spending minus income. The number next to the right-hand bars represents the absolute value of the percentage change in the imbalance relative to the baseline, with a negative sign shown for the United States.

Figure 2 displays trade imbalances across countries in both states of the world. Due to the tariff shock, countries experiencing an income rise, such as the United States, use assets to smooth consumption which results in a smaller deficit than in the baseline scenario with no tariff shock. The opposite occurs in countries where income declines. This logic explains the movements in trade imbalances due to the tariff shock.

As we saw in Figure 2, the tariff shock generates a decline in the trade deficit of the United States. At the same time, there is a reduction in trade surpluses in other countries and regions of the world. These changes in deficits have a bilateral component. Figure 3 shows that the decline in the overall U.S. trade deficit reflects a broad narrowing of its bilateral deficits. For instance, the U.S. trade deficits with China and Mexico shrink by more than a third; deficits with Europe, Asia, and Latin American countries decline by about one-third; and the deficit with Canada, already small in the baseline, falls by nearly two-thirds—the largest decline in percentage terms.

Figure 3: U.S. Bilateral Trade Imbalances

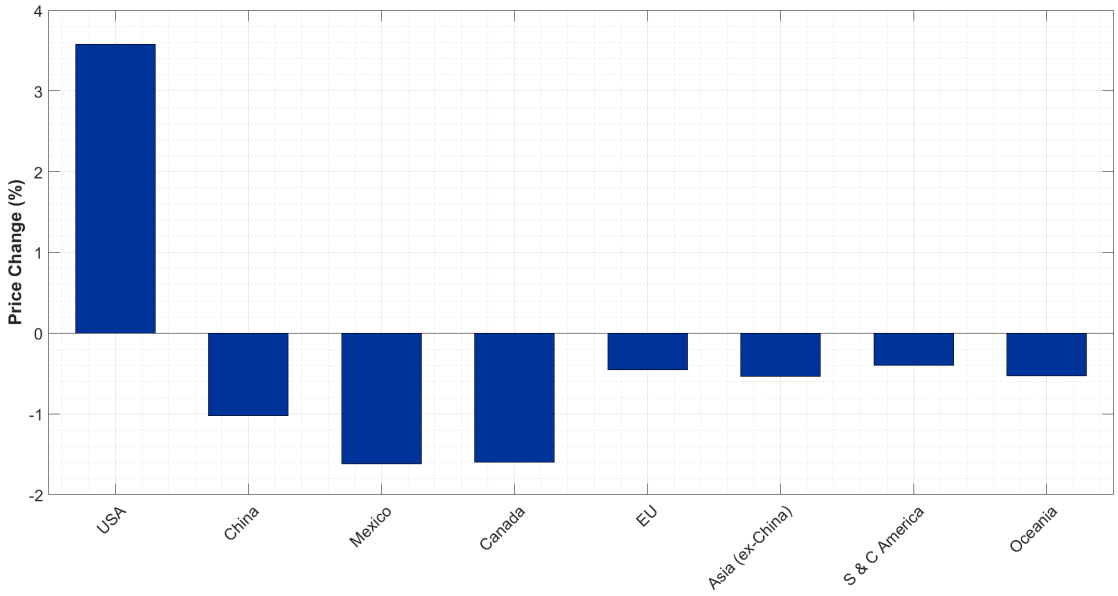


Note: The figure shows the U.S. bilateral trade imbalances, measured relative to global spending, across countries and regions in the baseline (left hand side bars) and under a counterfactual where U.S. tariffs rise by 30 percentage points on China and 10 points on all others (right hand side bars). Trade imbalances are defined as imports minus exports. The number next to the right-hand bars represents the percentage change relative to the baseline.

Figure 4 reports changes in the price level (again relative to global spending) across

countries and regions following the U.S. tariff shock. Prices rise in the United States and fall elsewhere. The increase in U.S. prices reflects the direct effect of higher tariffs on import prices, and the indirect effect of higher U.S. wages on non-tradable goods prices and domestically produced tradable goods prices. In contrast, price levels decline in other countries and regions due to lower global demand and consequently lower wages. These regional price levels are aggregated using expenditure weights. The asymmetry highlights how unilateral tariff increases can induce global relative price adjustments through general equilibrium channels.

Figure 4: Change in Prices

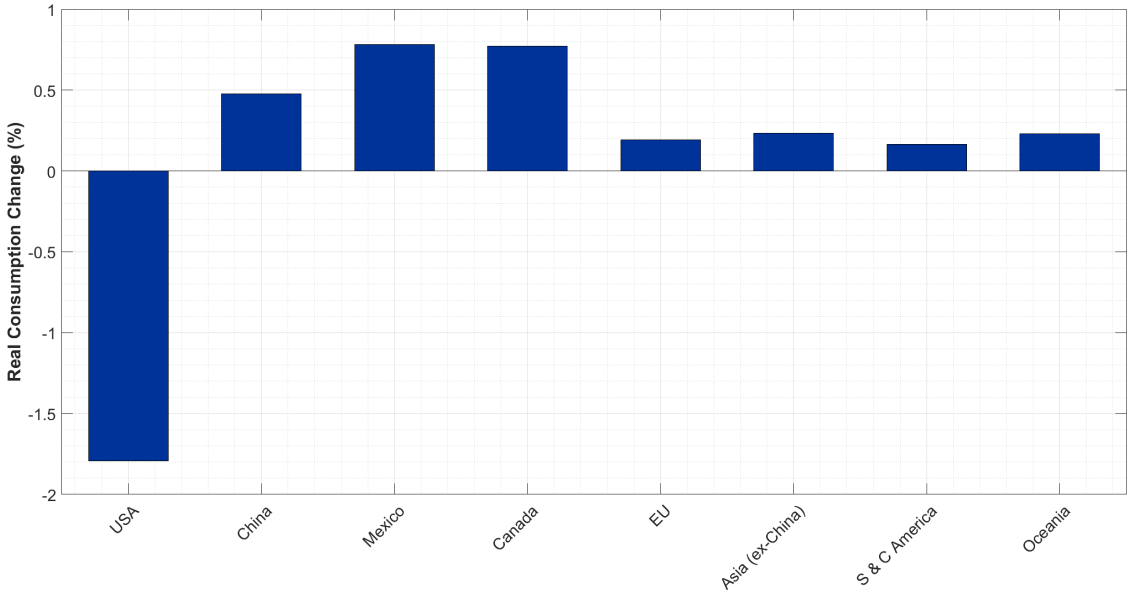


Note: The figure shows the percentage change in price levels across countries and regions of the world in the tariff counterfactual, where U.S. tariffs rise by 30 percentage points on China and 10 points on all others, relative to the observed equilibrium. Price levels across countries within a given region are aggregated using expenditure weights.

Figure 5 presents the percentage change in real consumption (calculated as the ratio of nominal spending to the price level) across countries and regions under the tariff counterfactual. In the United States, real consumption declines by 1.78 percent. Although nominal income increases due to higher tariff revenues, final spending rises less. The associated rise in the domestic price index more than offsets these gains, resulting in lower consumption in real terms.

In contrast, many surplus countries—including China, Mexico, Canada, and others—experience increases in real consumption despite facing declines in income. These countries start with trade surpluses in the baseline scenario. As tariffs reduce their export revenue, they respond by narrowing their surpluses or even running small deficits, effectively reallocating spending across states. This intertemporal adjustment allows them to sustain or even raise current consumption levels. The additional spending more than offsets the income loss, resulting in a net gain in real consumption. Hence, while the United States suffers a decline in real purchasing power, surplus countries increase their purchasing power from the adjustment in trade imbalances triggered by the tariff shock.

Figure 5: Change in Real Consumption



Note: The figure shows the percentage change in real consumption across countries and regions of the world in the tariff counterfactual, where U.S. tariffs rise by 30 percentage points on China and 10 points on all others, relative to the observed equilibrium. Real consumption is computed as the change in spending divided by the country's price level, and prices are aggregated across countries within a given region using expenditure weights.

Taken together, Figures 1 through 5 illustrate the key economic forces that drive outcomes in the tariff counterfactual. The increase in tariffs raises U.S. income directly through tariff revenue and indirectly through a higher wage for labor. Due to complete asset markets this higher income does not translate into equally higher spending,

hence the U.S. trade deficit declines. Since tariffs also raise domestic prices, real consumption falls. Other countries experience income losses but adjust their trade imbalances to support consumption, resulting in real consumption gains for many surplus economies. The tariff shock reshuffles global trade patterns, narrows U.S. bilateral deficits with key partners, and generates asymmetric price and consumption effects across regions, with the United States bearing the real economic cost of its protectionist tariffs.

We now turn to a second tariff counterfactual based on the schedule announced by the United States on April 2, 2025—the *Liberation Day tariffs*. In this scenario, we analyze the effects of a state $\tilde{s}_t$ characterized by the implementation of the announced tariff formula:

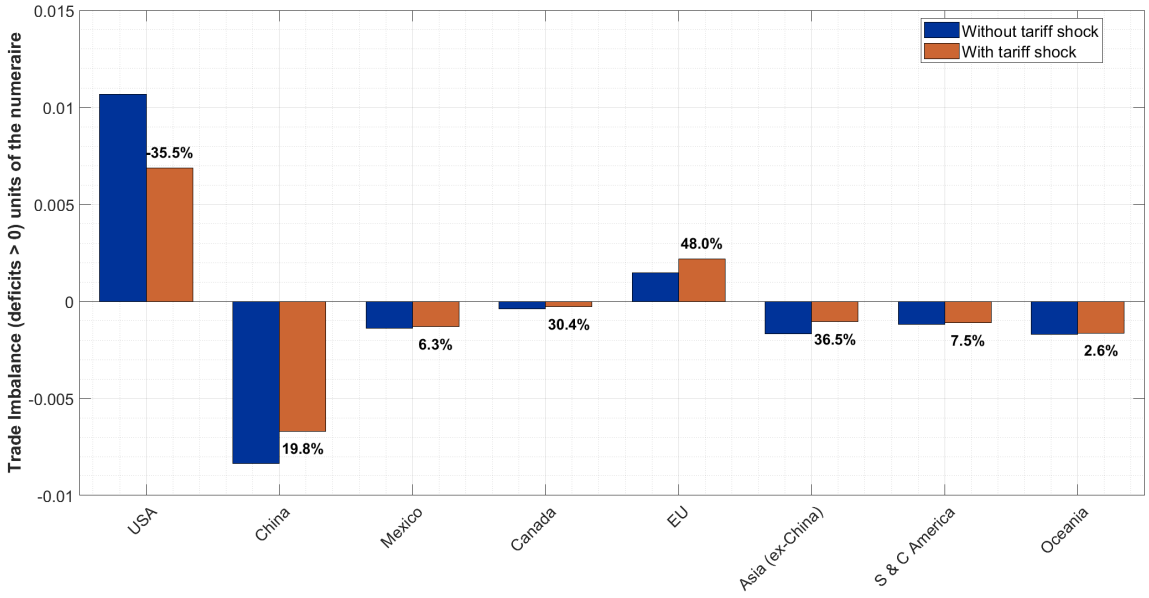
$$\tau_{USA,i}(\tilde{s}^t) = \tau_{USA,i}(s^t) + \max\left\{\frac{1}{2}\frac{D_{USA\,i,t}(s^t)}{M_{USA\,i,t}(s^t)}, 0.1\right\}. \tag{36}$$

That is, the United States raises its tariff on each country by the larger of 10 percentage points or half the bilateral deficit-to-imports ratio, where $D_{USA\,i,t}(s^t)$ is the bilateral trade deficit of the United States with country i and $M_{USA\,i,t}(s^t) = \pi_{USA\,i,t}(s^t)X^T_{USA,t}(s^t)/\tau_{USA\,i,t}(s^t)$ is the value of U.S. imports from i, net of tariffs, both observed in the realized state. We apply this formula to our 2023 data to compute the implied tariff changes and analyze their effects.[18]

Figure 6 reports trade imbalances across countries and regions before and after the Liberation Day tariffs. The U.S. trade deficit declines by slightly more than 35 percent (although it remains large relative to other countries) reflecting the broad-based increase in tariffs and the associated general equilibrium adjustments in income and spending. Most countries with initial trade surpluses—such as China, Mexico, and Canada—exhibit smaller changes in their external positions. In contrast, Europe experiences a notable widening of its trade deficit, reflecting a sharp drop in European exports to the United States, which is not fully offset by exports to other countries. The pattern underscores the asymmetric effects of U.S. tariff increases and their role in redistributing trade imbalances across regions.

[18]The two figures in Appendix B.2 show results based on the actual tariff schedule announced on April 2, 2025, which was constructed using the same formula (36) but with different trade data. These

Figure 6: Trade Imbalances - Liberation Day tariff counterfactual



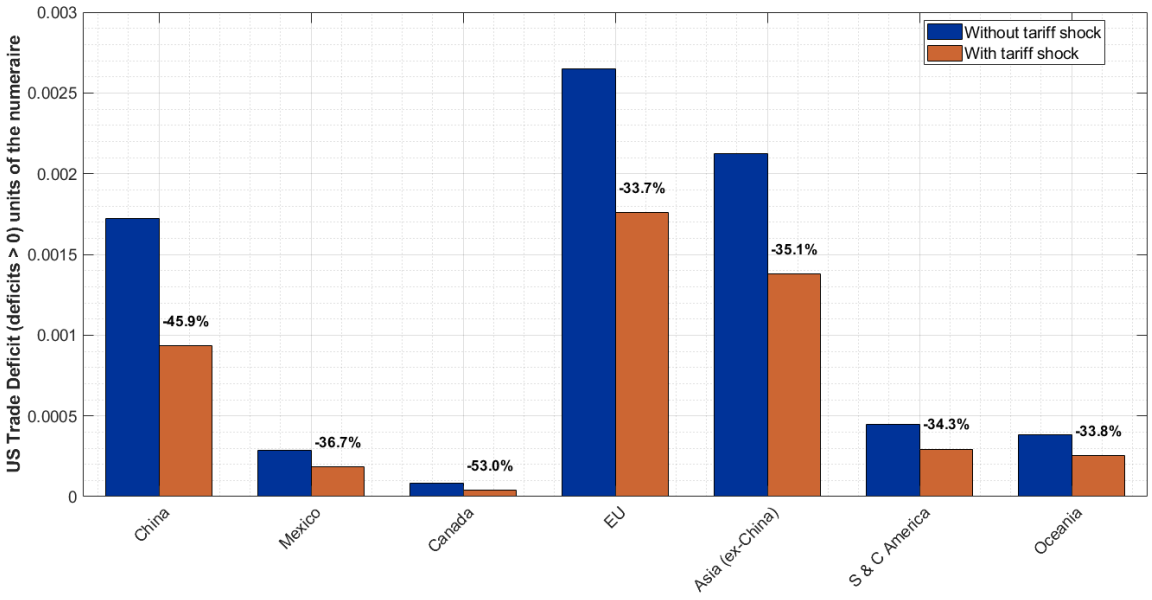
Note: The figure shows trade imbalances, measured relative to global spending, across countries and regions in the baseline (left hand side bars) and under a tariff counterfactual where the U.S. imposes the changes in tariffs announced on April 2, 2025. We applied the formula used to compute these tariff changes to the countries on which the U.S. imposed them, as described in Section 3.3, using the data presented in Section 3.2. The number next to the right-hand bars represents the absolute value of the percentage change in the imbalance relative to the baseline, with a negative sign shown for the United States.

Figure 7 illustrates the U.S. bilateral trade imbalances before and after the Liberation Day tariffs. While overall deficits decline substantially, imbalances with major trading partners—including China, Mexico, and Canada—remain large in absolute terms. This result reflects the fact that, even after significant tariff adjustments, trade remains far from autarky and countries continue to reallocate resources intertemporally. As we have emphasized throughout, the presence of asset trade enables countries to smooth consumption in response to shocks, allowing imbalances to persist even under large tariff increases. The figure reinforces a central implication of the model: higher tariffs reshape the pattern and size of trade imbalances, but do not eliminate them.

Taken together, Figures 6 and 7 highlight the distributional consequences of the Liberation Day tariff schedule on global trade imbalances. The U.S. trade deficit contracts, with the largest bilateral adjustments occurring with its main trading partners—China,

figures are consistent with, and reinforce, the findings presented below.

Figure 7: Bilateral Trade Imbalances - Liberation Day tariff counterfactual



Note: The figure shows the U.S. bilateral trade imbalances, measured relative to global spending, across countries and regions in the baseline (left hand side bars) and under a counterfactual where the U.S. imposes the changes in tariffs announced on April 2, 2025. We applied the formula used to compute these tariff changes to the countries on which the U.S. imposed them, as described in Section 3.3, using the data presented in Section 3.2. Trade imbalances are defined as imports minus exports. The number next to the right-hand bars represents the percentage change relative to the baseline.

Mexico, and Canada. Despite the reductions, tariff shocks reallocate, but do not eliminate, trade imbalances. The tariff shock imposes a significant domestic cost: U.S. prices rise by 4.40 percent, and real consumption declines by 2.72 percent, as the inflationary impact of the tariffs outweighs the increase in nominal spending.

3.4 Autarky Counterfactual

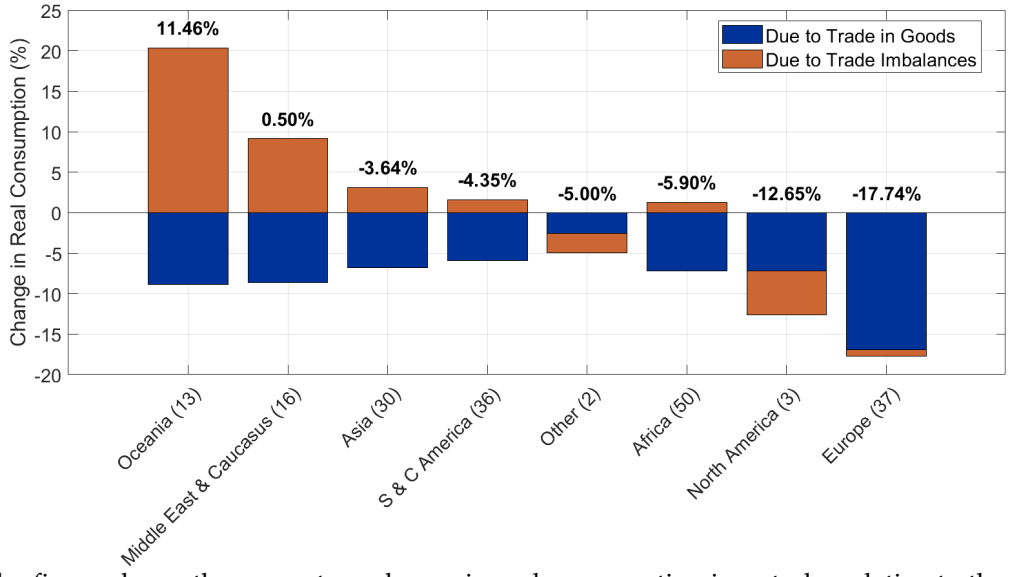
We now turn to our most extreme counterfactual, going to autarky, in which trade imbalances surely vanish. We focus on the change in real consumption, computed as the ratio of the counterfactual level of consumption in autarky to the observed level of consumption.[19] Figure 8 displays these results as percentage changes in real consump-

[19]We use a variant of equation (15):

$$\frac{\hat{X}_{n,t}}{\hat{p}_{n,t}} = \pi_{nn,t}(s^t)^{\alpha/(\theta\beta^T)} \left(\frac{w_{n,t}(s^t) L_n}{X_{n,t}(s^t)} \right). \tag{37}$$

tion for different regions around the world. Specifically, the darker bars display the static losses from eliminating trade in goods, while the lighter bars show the ex-post single-period gains or losses from eliminating trade imbalances. As expected, real consumption declines in each region under prohibitive tariffs (equivalently, prohibitive trade costs), as countries lose the traditional gains from Ricardian specialization. In contrast, the effects of shutting down trade imbalances—i.e., asset trade—can be positive or negative: countries with initial trade deficits lose the additional consumption they could finance through asset trade in the open economy, while countries starting from trade surpluses benefit, since in autarky less of their income is used to finance consumption abroad.

Figure 8: Change in Real Consumption under Autarky



Note: The figure shows the percentage change in real consumption in autarky relative to the observed equilibrium, computed using equation (37) from footnote 19. The darker portion of each bar (in blue) shows the percentage change in real consumption due to trade in goods, given by the first term in (37), and the lighter portion (in red) shows the change due to trade in assets, given by the second term in (37). The numbers above each bar represent the net effect on real consumption.

The numerical magnitudes labeled in Figure 8 are the net effect on real consumption from transitioning to a state with no goods trade and no trade imbalances. Oceania—the first bar—comprises 13 countries, with the results largely reflecting Australia. The region loses static gains from trade, which are more than offset by the gains from

The derivation follows the one in footnote 15 except that, due to intermediates, the inversion yields $\hat{w}_{n,t}/\hat{p}^T_{n,t} = \pi_{nn,t}(s^t)^{1/(\theta\beta^T)}$ and due to nontradables, $\hat{w}_{n,t}/\hat{p}_{n,t} = \left(\hat{w}_{n,t}/\hat{p}^T_{n,t}\right)^{\alpha} = \pi_{nn,t}(s^t)^{\alpha/(\theta\beta^T)}$.

no longer running a large trade surplus, leading to a net gain of about 11.5 percent. North America—the second-to-last bar, largely reflecting the United States—loses both the static gains from trade and the consumption previously financed by its trade deficit, for a net loss exceeding 12 percent in terms of real consumption.

4 Conclusion

This paper has developed a framework for analyzing the effects of aggregate shocks in quantitative multi-country trade models with endogenous trade imbalances. By incorporating Arrow securities into such a model, we show that trade deficits emerge as optimal responses to state-contingent shocks, including uncertain changes in tariffs. Our framework represents a key departure from most quantitative trade models that typically assume either trade balance or exogenous trade deficits.

The paper also extends the exact-hat-algebra methodology to dynamic environments with uncertainty, enabling counterfactual analysis in such settings. We use this model and method to study the effects of tariff shocks.

The quantitative analysis reveals striking results about the effects of recent and proposed U.S. tariff shocks. Our simulations of both hypothetical tariff scenarios and the Liberation Day tariff schedule announced in April 2025 consistently show that U.S. tariff increases lead to reductions in the U.S. trade deficit. Importantly, this reduction does not happen through simple arithmetic—fewer imports minus unchanged exports. Instead, it occurs through general equilibrium adjustments in income, spending, and optimal asset positions. Specifically, we find that targeted tariffs on China combined with broader tariff increases reduce U.S. bilateral deficits with major trading partners by roughly one-quarter to two-thirds.

However, these changes in trade balances come at a significant cost. Despite higher income from tariff revenues, the United States experiences a decline in real consumption due to higher domestic prices. This finding underscores a fundamental tension from recent proposed and actual increases in U.S. tariffs: while tariffs may partly achieve the stated objective of reducing trade deficits, they simultaneously erode the real purchasing power of domestic consumers.

Our results also illuminate the global spillover effects of U.S. tariff increases. Countries initially running trade surpluses may actually benefit in real terms from such tariff changes. These countries optimally reduce their surpluses (or increase their deficits) relative to baseline to smooth consumption in response to income declines, leading to real consumption gains. This finding suggests that the burden of protectionist policies may fall disproportionately on the implementing country rather than its trading partners.

We decompose the real consumption effects of trade into static gains from goods trade and dynamic effects of imbalances. Our autarky counterfactual reveals that both components are quantitatively important, with the intertemporal dimension providing significant departures from the traditional gains from trade.

While our analysis is not normative, it still has relevance for policy. Policymakers should recognize that trade deficits are not inherently problematic when they reflect optimal intertemporal allocation decisions in an uncertain world. Attempts to reduce trade deficits through tariffs impact real consumption by interfering with both efficient specialization in production and efficient risk-sharing arrangements. Therefore, the effectiveness of tariffs in achieving trade balance objectives must be weighed against their cost.

References

Aguiar, M. A., Amador, M., and Fitzgerald, D. (2025). Tariff Wars and Net Foreign Assets. Working Paper 33743, National Bureau of Economic Research. 1

Alessandria, G. and Choi, H. (2021). The Dynamics of the U.S. Trade Balance and Real Exchange Rate: The J Curve and Trade Costs? *Journal of International Economics*, 132:103511. 1

Alessandria, G., Choi, H., and Ruhl, K. J. (2021). Trade Adjustment Dynamics and the Welfare Gains from Trade. *Journal of International Economics*, 131. 4

Alessandria, G. A., Bai, Y., and Woo, S. K. (2024). Unbalanced Trade: Is Growing Dispersion from Financial or Trade Reforms? Working Paper 33101, National Bureau of Economic Research. 1

Arrow, K. J. (1964). The Role of Securities in the Optimal Allocation of Risk-bearing. *The Review of Economic Studies*, 31(2):91–96. 1

Backus, D. K. and Smith, G. W. (1993). Consumption and real exchange rates in dynamic economies with non-traded goods. *Journal of International Economics*, 35(3-4):297–316. 2

Caliendo, L., Dvorkin, M., and Parro, F. (2019). Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock. *Econometrica*, 87(3):741–835. 3

Caliendo, L. and Parro, F. (2015). Estimates of the Trade and Welfare Effects of NAFTA. *The Review of Economic Studies*, 82(1):1–44. 1, 3.2

Corsetti, G., Dedola, L., and Leduc, S. (2008). International risk sharing and the transmission of productivity shocks. *The Review of Economic Studies*, 75(2):443–473. 2

Costinot, A. and Rodríguez-Clare, A. (2014). Trade theory with numbers: Quantifying the consequences of globalization. *Handbook of International Economics*, pages 197–261. 1

Costinot, A. and Werning, I. (2025). How Tariffs Affect Trade Deficits. Working Paper 33709, National Bureau of Economic Research. 1

Cuñat, A. and Zymek, R. (2023). Bilateral Trade Imbalances. *The Review of Economic Studies*, 91(3):1537–1583. 4

Debreu, G. (1959). *Theory of Value: An Axiomatic Analysis of Economic Equilibrium*. Cowles Foundation Monographs Series - John Wiley & Sons, New York. 1

Dekle, R., Eaton, J., and Kortum, S. (2007). Unbalanced trade. *American Economic Review*, 97(2):351–355. 1, 2.2

Dix-Carneiro, R., Pessoa, J. P., Reyes-Heroles, R., and Traiberman, S. (2023). Globalization, Trade Imbalances, and Labor Market Adjustment. *The Quarterly Journal of Economics*, 138(2):1109–1171. 4

Dávila, E., Rodríguez-Clare, A., Schaab, A., and Tan, S. (2025). A Dynamic Theory of Optimal Tariffs. Working Paper 33898, National Bureau of Economic Research. 1

Eaton, J. and Kortum, S. (2002). Technology, Geography, and Trade. *Econometrica*, 70:1741–79. 1

Eaton, J., Kortum, S., and Neiman, B. (2016a). Obstfeld and Rogoff International Macro Puzzles: a Quantitative Assessment. *Journal of Economic Dynamics and Control*, 72:5–23. 2

Eaton, J., Kortum, S., Neiman, B., and Romalis, J. (2016b). Trade and the Global Recession. *American Economic Review*, 106(11):3401–3438. 1

Elminejad, A., Havranek, T., and Irsova, Z. (2025). Relative Risk Aversion: A Meta-Analysis. *Journal of Economic Surveys*. 3.2

Fan, J., Hong, S., and Parro, F. (2023). Learning and Expectations in Dynamic Spatial Economies. University of Rochester , mimeo. 3

Federal Register published document: 2025-06063 (90 FR 15041) (2025). Regulating Imports With a Reciprocal Tariff To Rectify Trade Practices That Contribute to Large and Persistent Annual United States Goods Trade Deficits. 1

Fitzgerald, D. (2012). Trade Costs, Asset Market Frictions, and Risk Sharing. *American Economic Review*, 102(6):2700–2733. 2

Fitzgerald, D. (2024). 3-D Gains from Trade. Working Papers 809, Federal Reserve Bank of Minneapolis. 14

Handley, K. and Limao, N. (2015). Trade and Investment Under Policy Uncertainty: Theory and Firm Evidence. *American Economic Journal: Economic Policy*, 7(4):189–222. 4

Ignatenko, A., Lashkaripour, A., Macedoni, L., and Simonovska, I. (2025). Making America Great Again? The Economic Impacts of Liberation Day Tariffs. Working Paper 33771, National Bureau of Economic Research. 1

Itskhoki, O. and Mukhin, D. (2025). The Optimal Macro Tariff. Working Paper 33839, National Bureau of Economic Research. 1

Kehoe, T. J., Ruhl, K. J., and Steinberg, J. B. (2018). Global Imbalances and Structural Change in the United States. *Journal of Political Economy*, 126(2):761–796. 4

Lucas, R. E. and Stokey, N. L. (1983). Optimal Fiscal and Monetary Policy in an Economy Without Capital. *Journal of Monetary Economics*, 12(1):55–93. 1

Obstfeld, M. and Rogoff, K. (2001). The six major puzzles in international macroeconomics: Is there a common cause? In *NBER Macroeconomics Annual 2000*, volume 15, pages 339–390. MIT Press. 2

Reyes-Heroles, R. (2017). The Role of Trade Costs in the Surge of Trade Imbalances. Federal Reserve Board, mimeo. 1

Sargent, T. and Ljungqvist, L. (2012). *Recursive macroeconomic theory*. MIT Press, 3rd ed. edition. Includes bibliographical references and indexes. 6

Simonovska, I. and Waugh, M. E. (2014). The Elasticity of Trade: Estimates and Evidence. *Journal of International Economics*, 92(1):34–50. 3.2

Steinberg, J. B. (2019). Brexit and the Macroeconomic Impact of Trade Policy Uncertainty. *Journal of International Economics*, 117:175–195. 4

Stockman, A. C. (1988). *Fiscal Policies and International Financial Markets*, pages 197–228. University of Chicago Press, Chicago. 1, 12

Stockman, A. C. and Dellas, H. (1986). Asset Markets, Tariffs, and Political Risk. *Journal of International Economics*, 21(3):199–213. 1

A Taking the Model with Financial Intermediation to the Data

This appendix describes how we take the model with financial intermediation of Section 2.4 to the data, and presents the system of equilibrium conditions in changes for the two counterfactual regimes discussed there: one in which the number of intermediaries $m_{n,t}$ is predetermined and the fixed cost adjusts across states, and one in which the fixed cost is constant across states and $m_{n,t}$ adjusts through entry. Throughout, we work with the quantitative model of Section 3.1, with tradable and non-tradable sectors and intermediate goods.

A.1 Calibration

The data requirements are the same as in Section 3.2, with one addition. Bilateral tariff-inclusive spending on tradables $X^T_{ni,t}$, tariffs $\tau_{ni,t}$, sectoral value added, and the value added shares β^T and β^{NT} enter as before: the recovery of bilateral trade shares $\pi_{ni,t}$, the tradable spending share α, and total spending $X_{n,t}$ proceeds exactly as in equations (31)–(34); none of these steps involves the financial wedge.[20] The trade deficit is computed directly from the goods flows, as in equation (7):

$$D_{n,t} = \sum_{i \neq n} \frac{X^T_{ni,t}}{\tau_{ni,t}} - \sum_{i \neq n} \frac{X^T_{in,t}}{\tau_{in,t}}.$$

The additional data requirement is a measure of payments to labor employed in financial intermediation, $VA^{FI}_{n,t}$. [Data source: TO BE COMPLETED.] In the model, the entry condition implies that these payments exhaust intermediation profits, $VA^{FI}_{n,t} = m_{n,t}\, w_{n,t}(s^t) F_{n,t}(s^t) = V^F_{n,t}(s^t)$, so that profits are observed directly. We do not need to calibrate the number of intermediaries: given γ, all remaining objects follow in closed form. Combining $V^F_{n,t}(s^t) = VA^{FI}_{n,t}$ with the deficit identity (21) yields the baseline

[20] The share α and total spending $X_{n,t}$ are recovered from tradable spending and intermediate use alone, which are unaffected by intermediation.

wedge,

$$\omega_{n,t}(s^t) = \frac{D_{n,t}(s^t)}{D_{n,t}(s^t) - VA^{FI}_{n,t}}, \tag{38}$$

a markup ($\omega > 1$) for deficit countries and a markdown ($0 < \omega < 1$) for surplus countries.[21] Income then follows from (21),

$$Y_{n,t}(s^t) = X_{n,t}(s^t) - \left(D_{n,t}(s^t) - VA^{FI}_{n,t}\right), \tag{39}$$

and the number of intermediaries implied by the wedge equation (18) is

$$m_{n,t} = \frac{\gamma\, D_{n,t}(s^t)\left(D_{n,t}(s^t) - VA^{FI}_{n,t}\right)}{X_{n,t}(s^t)\, VA^{FI}_{n,t}}, \tag{40}$$

which enters the counterfactual systems below. As $VA^{FI}_{n,t} \to 0$, the implied $m_{n,t} \to \infty$, $\omega_{n,t}(s^t) \to 1$, and $Y_{n,t}(s^t) \to X_{n,t}(s^t) - D_{n,t}(s^t)$, recovering the baseline calibration.

Total labor income is the sum of value added in the tradable, non-tradable, and intermediation activities, $w_{n,t}(s^t)L_n = VA^{T}_{n,t} + VA^{NT}_{n,t} + VA^{FI}_{n,t}$. Note that while deficits still sum to zero across countries, the gaps between spending and income do not: summing (21) across countries, $\sum_n \left[Y_{n,t}(s^t) - X_{n,t}(s^t)\right] = \sum_n V^F_{n,t}(s^t)$, so that global income exceeds global spending by aggregate intermediation profits, which are absorbed domestically as payments to compliance labor.

A.2 Counterfactuals with Predetermined $m_{n,t}$

Consider first the regime in which the government sets $m_{n,t}$ to be the same at date t across the two events s_t and $\tilde{s}_t$, with the fixed cost $F_{n,t}$ adjusting across states to satisfy the entry condition. The counterfactual equilibrium in changes solves the following system, which nests equations (25), (29), and (30) as the special case $m_{n,t} \to \infty$. Spending satisfies

$$\hat{X}_{n,t} = \frac{\hat{\omega}^{-1/\gamma}_{n,t}\, \hat{p}^{1-1/\gamma}_{n,t}}{\sum_k X_{k,t}(s^t)\, \hat{\omega}^{-1/\gamma}_{k,t}\, \hat{p}^{1-1/\gamma}_{k,t}}, \tag{41}$$

[21] Model consistency requires $VA^{FI}_{n,t} < |D_{n,t}(s^t)|$: since $V^F_{n,t}(s^t)/|D_{n,t}(s^t)| = 1 - 1/\omega_{n,t}(s^t) < 1$, intermediation profits cannot exceed the imbalance being intermediated. The empirical counterpart of $VA^{FI}_{n,t}$ is accordingly the component of financial-sector labor compensation attributable to the intermediation of external imbalances, not total value added in finance.

where the change in the wedge is

$$\hat{\omega}_{n,t} = \hat{X}_{n,t} \frac{\frac{\gamma}{m_{n,t}} Y_{n,t}(s^t) + \left(1 - \frac{\gamma}{m_{n,t}}\right) X_{n,t}(s^t)}{\frac{\gamma}{m_{n,t}} Y_{n,t}(s^t)\hat{Y}_{n,t} + \left(1 - \frac{\gamma}{m_{n,t}}\right) X_{n,t}(s^t)\hat{X}_{n,t}}, \tag{42}$$

with $m_{n,t}$ given by (40). Prices of tradables, aggregate prices, and bilateral trade shares satisfy the same conditions as in the baseline quantitative model,

$$\hat{p}^T_{n,t} = \left(\sum_i \pi_{ni,t}(s^t)\, \hat{T}_{i,t} \left((\hat{w}_{i,t})^{\beta^T} \left(\hat{p}^T_{i,t}\right)^{1-\beta^T} \hat{d}_{ni,t}\hat{\tau}_{ni,t} \right)^{-\theta} \right)^{-1/\theta}, \tag{43}$$

$$\hat{p}_{n,t} = \left(\hat{p}^T_{n,t}\right)^{\alpha} (\hat{w}_{n,t})^{1-\alpha} \left(\hat{A}_{n,t}\right)^{-(1-\alpha)/\beta^{NT}}, \tag{44}$$

$$\hat{\pi}_{ni,t} = \hat{T}_{i,t} \left(\frac{(\hat{w}_{i,t})^{\beta^T} \left(\hat{p}^T_{i,t}\right)^{1-\beta^T} \hat{d}_{ni,t}\hat{\tau}_{ni,t}}{\hat{p}^T_{n,t}} \right)^{-\theta}, \tag{45}$$

and spending on tradables satisfies

$$X^T_{i,t}(s^t)\hat{X}^T_{i,t} = \alpha X_{i,t}(s^t)\hat{X}_{i,t} + \left(1 - \beta^T\right) \sum_{n=1}^{N} \pi_{ni,t}(s^t)\, \frac{X^T_{n,t}(s^t)}{\tau_{ni,t}(s^t)}\, \hat{\pi}_{ni,t}\, \frac{\hat{X}^T_{n,t}}{\hat{\tau}_{ni,t}}. \tag{46}$$

Labor market clearing accounts for the labor employed in intermediation. Writing goods value added as $VA_{i,t} \equiv (1-\alpha)X_{i,t}(s^t) + \frac{\beta^T}{1-\beta^T}\left(X^T_{i,t}(s^t) - \alpha X_{i,t}(s^t)\right)$, the condition is

$$\left[VA_{i,t} + VA^{FI}_{i,t}\right] \hat{w}_{i,t} = (1-\alpha)X_{i,t}(s^t)\hat{X}_{i,t} + \frac{\beta^T}{1-\beta^T}\left(X^T_{i,t}(s^t)\hat{X}^T_{i,t} - \alpha X_{i,t}(s^t)\hat{X}_{i,t}\right) + V^F_{i,t}(\tilde{s}^t), \tag{47}$$

where counterfactual intermediation profits are, from (19),

$$V^F_{i,t}(\tilde{s}^t) = \frac{\gamma \left[X_{i,t}(s^t)\hat{X}_{i,t} - Y_{i,t}(s^t)\hat{Y}_{i,t}\right]^2}{\gamma\, Y_{i,t}(s^t)\hat{Y}_{i,t} + (m_{i,t} - \gamma)\, X_{i,t}(s^t)\hat{X}_{i,t}}. \tag{48}$$

Finally, the change in income is

$$Y_{i,t}(s^t)\hat{Y}_{i,t} = \left[VA_{i,t} + VA^{FI}_{i,t}\right]\hat{w}_{i,t} + \sum_n \left(\tau_{in,t}(s^t)\hat{\tau}_{in,t} - 1\right)\pi_{in,t}(s^t)\hat{\pi}_{in,t}\,\frac{X^T_{i,t}(s^t)\hat{X}^T_{i,t}}{\tau_{in,t}(s^t)\hat{\tau}_{in,t}}. \quad (49)$$

The system (41)–(49) is solved for $\{\hat{X}_{n,t}, \hat{X}^T_{n,t}, \hat{p}_{n,t}, \hat{p}^T_{n,t}, \hat{\pi}_{ni,t}, \hat{w}_{n,t}, \hat{\omega}_{n,t}, \hat{Y}_{n,t}\}$, conditional on the data recovered above and the parameters $\{\theta, \gamma, \alpha, \beta^T, \beta^{NT}\}$, with $m_{n,t}$ implied by (40). As in the baseline, no knowledge of Arrow security prices, state probabilities, or the Lagrange multipliers is required. The counterfactual deficit follows from (21): $D_{n,t}(\tilde{s}^t) = \omega_{n,t}(s^t)\hat{\omega}_{n,t}\left[X_{n,t}(s^t)\hat{X}_{n,t} - Y_{n,t}(s^t)\hat{Y}_{n,t}\right]$.

A.3 Counterfactuals with Entry: Fixed Cost Constant Across States

Consider next the regime in which the fixed cost is the same in the two events, $F_{n,t}(\tilde{s}^t) = F_{n,t}(s^t)$, and the number of intermediaries adjusts through entry.[22] The entry condition $V^F_{n,t}/m_{n,t} = w_{n,t}F_{n,t}$, holding in both histories with common $F_{n,t}$, implies

$$\frac{V^F_{n,t}(\tilde{s}^t)}{V^F_{n,t}(s^t)} = \hat{m}_{n,t}\,\hat{w}_{n,t}, \quad (50)$$

where $\hat{m}_{n,t} = m_{n,t}(\tilde{s}^t)/m_{n,t}(s^t)$. Substituting (19) evaluated at the two histories, condition (50) becomes a quadratic equation in $\hat{m}_{n,t}$,

$$\hat{w}_{n,t}\,m_{n,t}\,X_{n,t}(s^t)\hat{X}_{n,t}\,\hat{m}^2_{n,t} + \hat{w}_{n,t}\,\gamma\left[Y_{n,t}(s^t)\hat{Y}_{n,t} - X_{n,t}(s^t)\hat{X}_{n,t}\right]\hat{m}_{n,t} - \hat{\Delta}^2_{n,t}\left[\gamma\,Y_{n,t}(s^t) + (m_{n,t} - \gamma)\,X_{n,t}(s^t)\right] = \quad (51)$$

where $\hat{\Delta}_{n,t} \equiv \left[X_{n,t}(s^t)\hat{X}_{n,t} - Y_{n,t}(s^t)\hat{Y}_{n,t}\right] / \left[X_{n,t}(s^t) - Y_{n,t}(s^t)\right]$ is the change in the gap between spending and income. The relevant solution is the positive root. The counterfactual system is then (41)–(49) with two modifications: the change in the wedge (42)

[22] We treat $m_{n,t}$ as a continuous variable in this regime, abstracting from the integer constraint. For a country with balanced trade in the baseline, $V^F_{n,t}(s^t) = 0$ and the entry condition implies $F_{n,t}(s^t) = 0$, leaving $m_{n,t}$ indeterminate; we assign such countries their baseline $m_{n,t}$.

is replaced by

$$\hat{\omega}_{n,t} = \hat{X}_{n,t} \frac{\frac{\gamma}{m_{n,t}} Y_{n,t}(s^t) + \left(1 - \frac{\gamma}{m_{n,t}}\right) X_{n,t}(s^t)}{\frac{\gamma}{m_{n,t}\hat{m}_{n,t}} Y_{n,t}(s^t)\hat{Y}_{n,t} + \left(1 - \frac{\gamma}{m_{n,t}\hat{m}_{n,t}}\right) X_{n,t}(s^t)\hat{X}_{n,t}}, \tag{52}$$

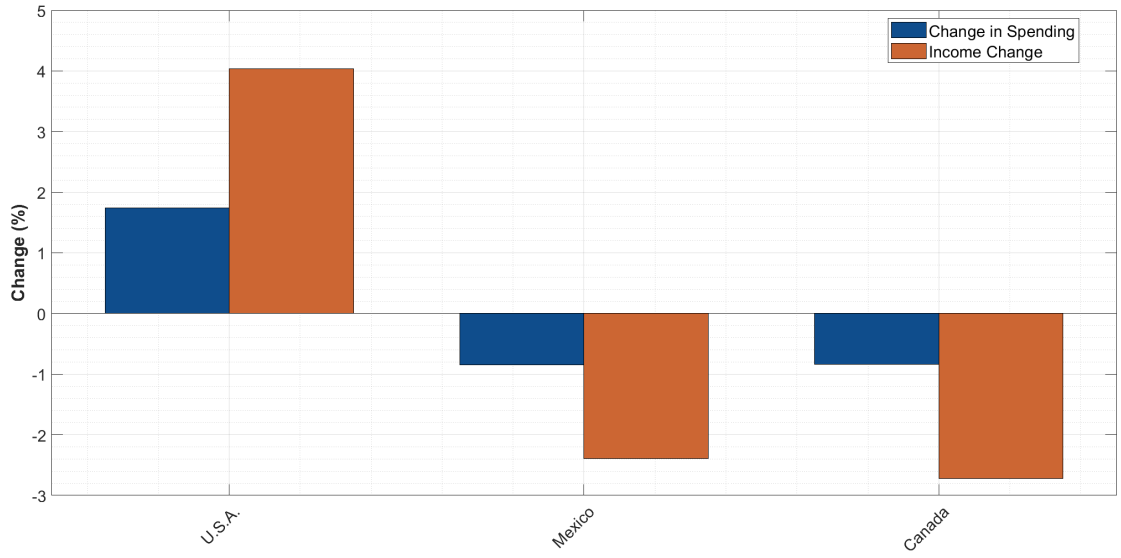
and counterfactual profits (48) are evaluated at $m_{n,t}\hat{m}_{n,t}$ in place of $m_{n,t}$. Equations (51) and (52) involve only observed spending and income, the parameters, and the endogenous changes $\{\hat{X}_{n,t}, \hat{Y}_{n,t}, \hat{w}_{n,t}\}$: the counterfactual methodology therefore extends to endogenous entry as well, again without requiring security prices, probabilities, or multipliers. Relative to the regime with predetermined $m_{n,t}$, entry dampens the response of the wedge: an event that widens the gap between spending and income raises intermediation profits, attracts entry, and thereby limits the increase in the markup.

B Additional Results

B.1 Changes in Income and Spending Across Countries

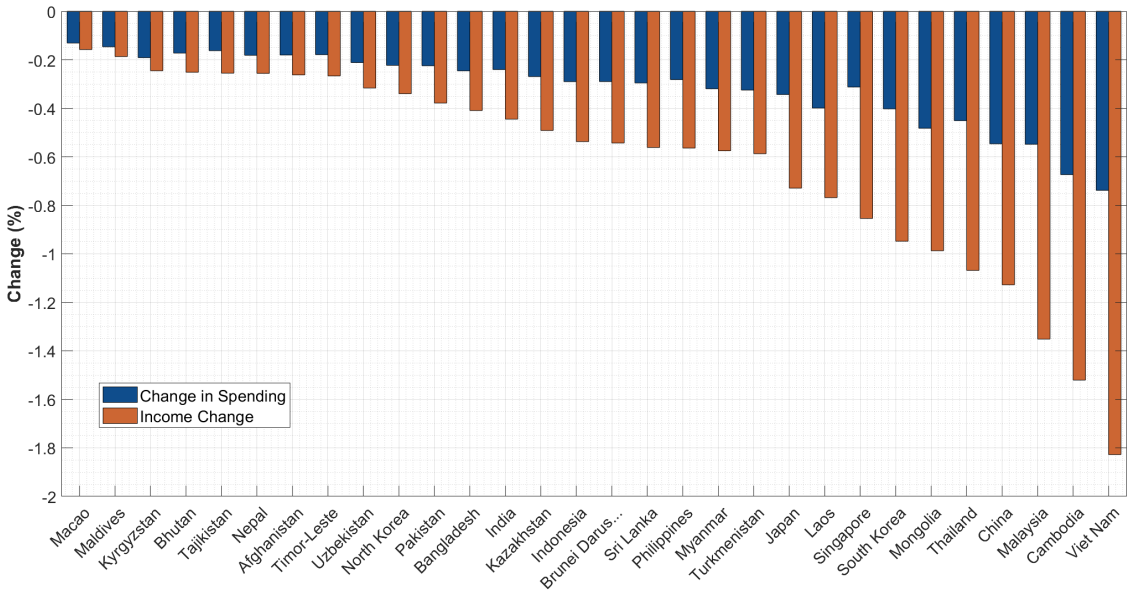
In this section of the appendix, we present the changes in income and spending across individual countries as a result of a tariff shock that increases the tariff applied by the U.S. to China by 30 percentage points and the tariffs applied to the other countries in the world by 10 percentage points.

Figure B.1: Change in Income and Spending in North America



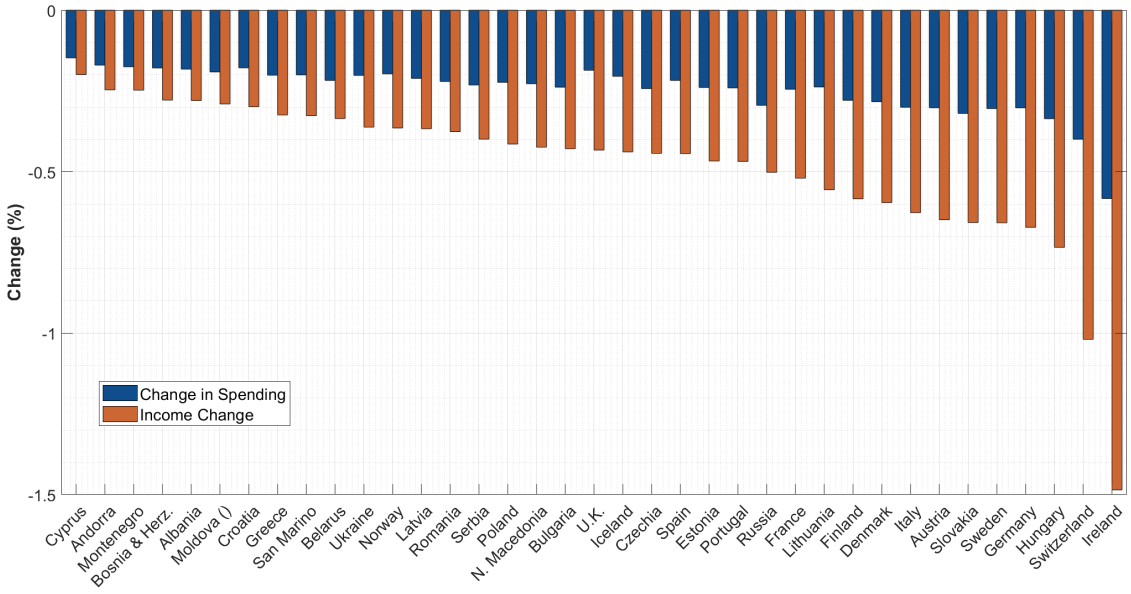
Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in North America.

Figure B.2: Change in Income and Spending in Asia



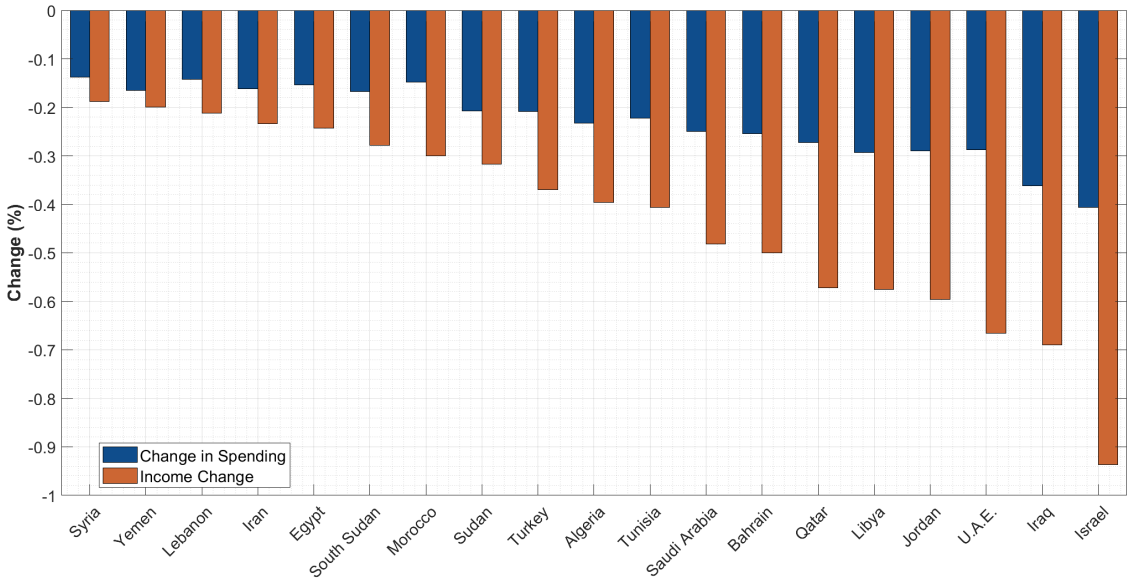
Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in Asia.

Figure B.3: Change in Income and Spending in Europe



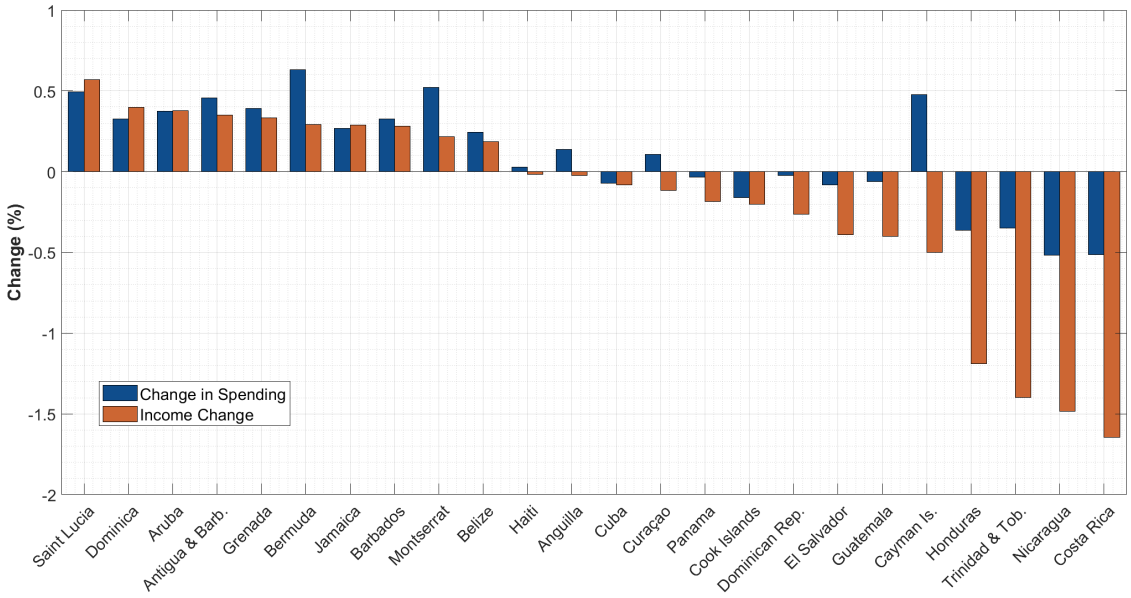
Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in Europe.

Figure B.4: Chng. in Income and Spending in the Middle-East and Africa



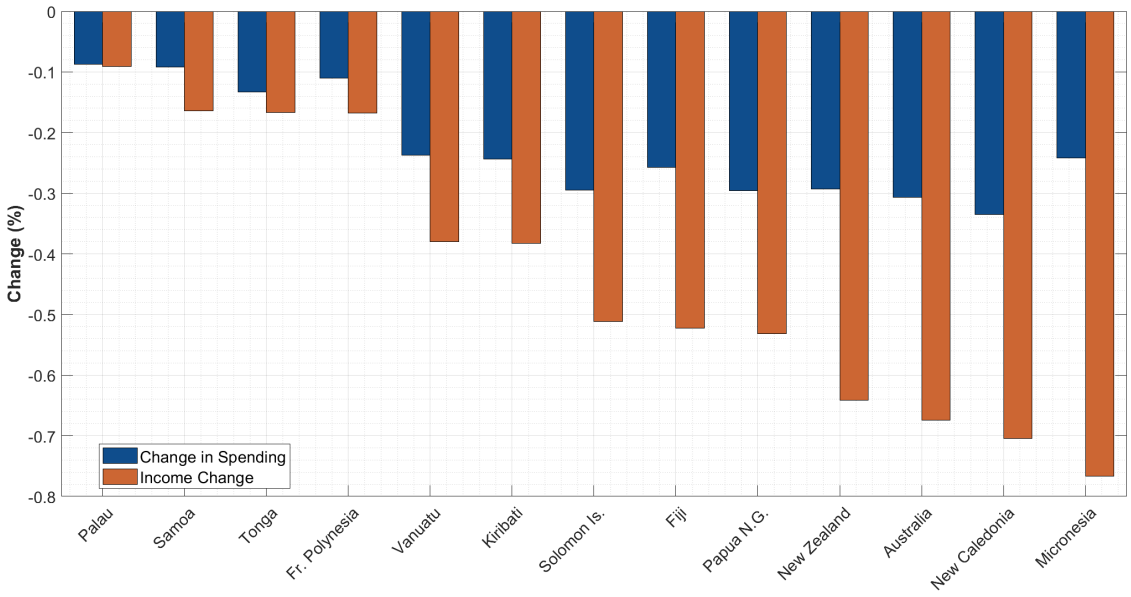
Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in the Middle East and North Africa.

Figure B.5: Change in Income and Spending in the Caribbean



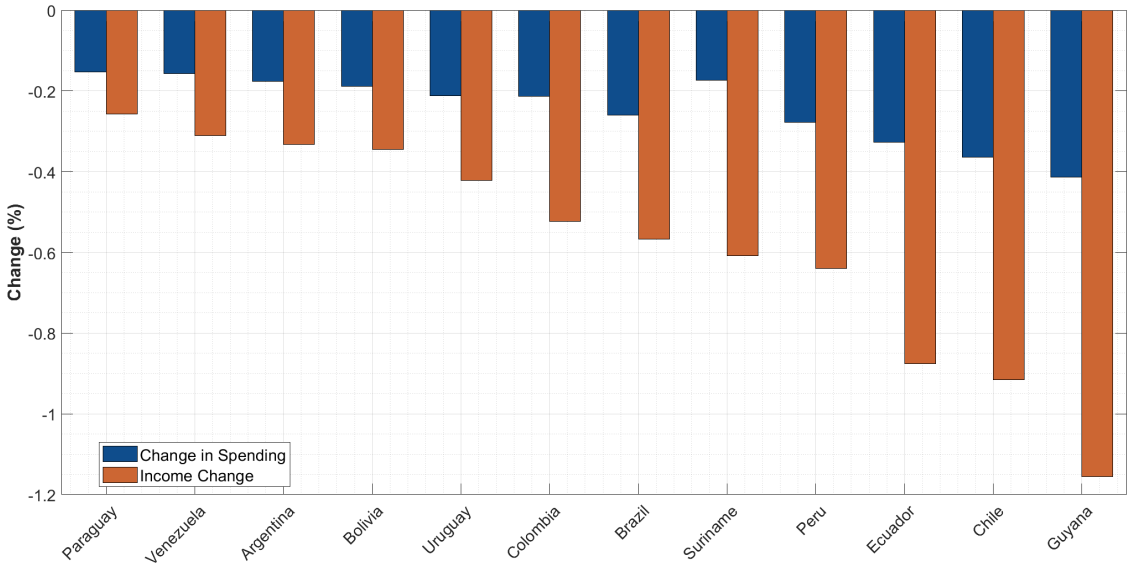
Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in the Caribbean.

Figure B.6: Change in Income and Spending in Oceania



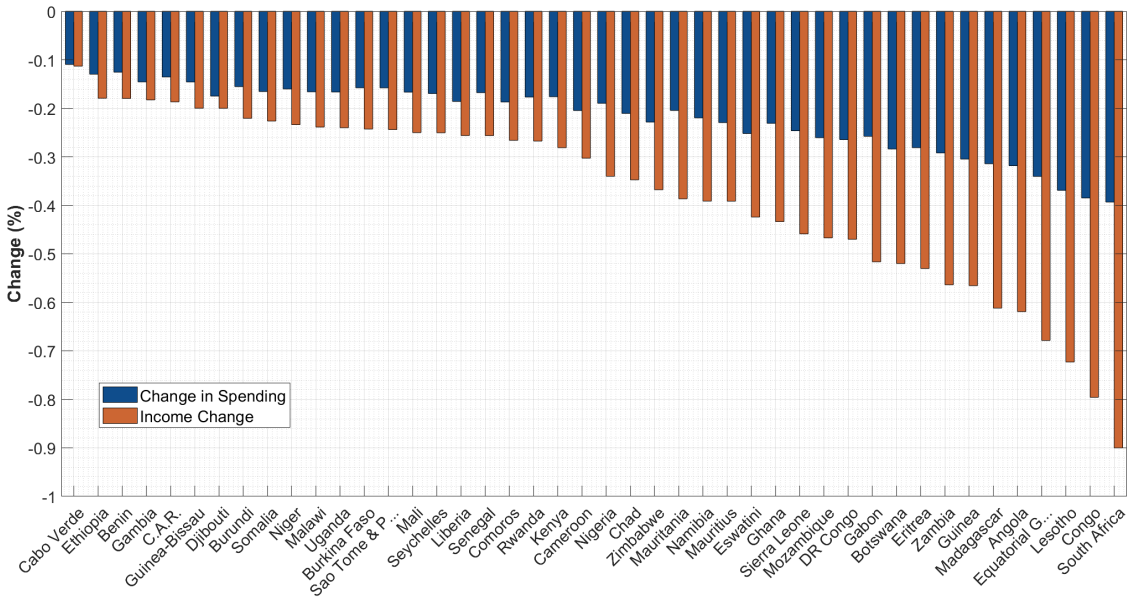
Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in Oceania.

Figure B.7: Change in Income and Spending in South America



Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in South America.

Figure B.8: Change in Income and Spending in Sub-Sahara Africa

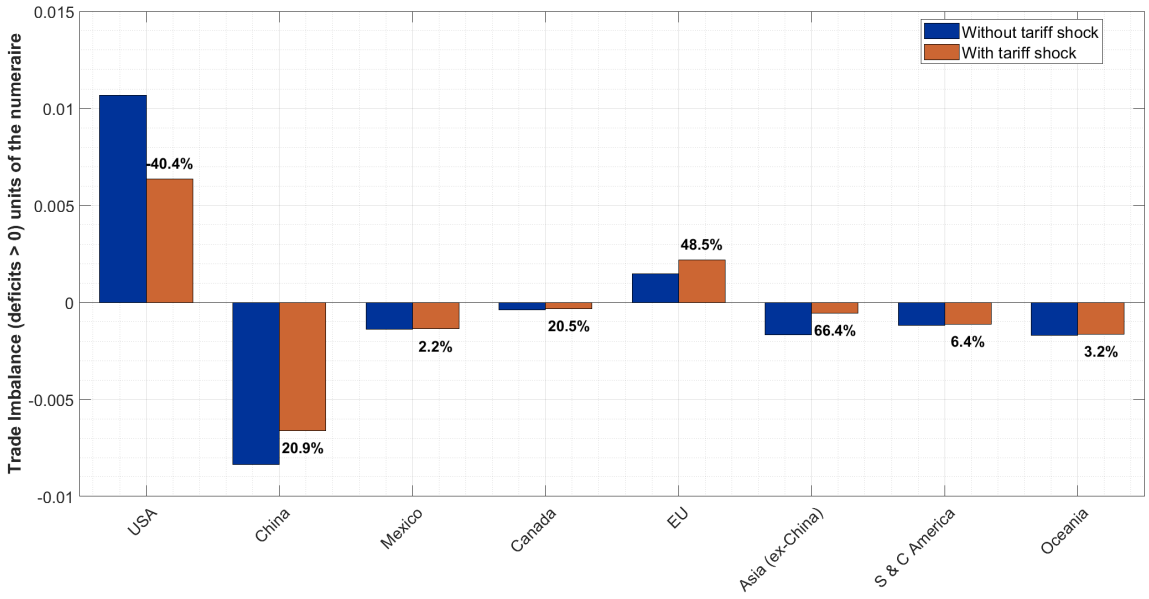


Note: The figure shows the percentage change, in the tariff counterfactual relative to the observed equilibrium, in aggregate spending and aggregate income across countries in Sub-Saharan Africa.

B.2 Changes in Trade Imbalances due to Liberation Day Tariffs

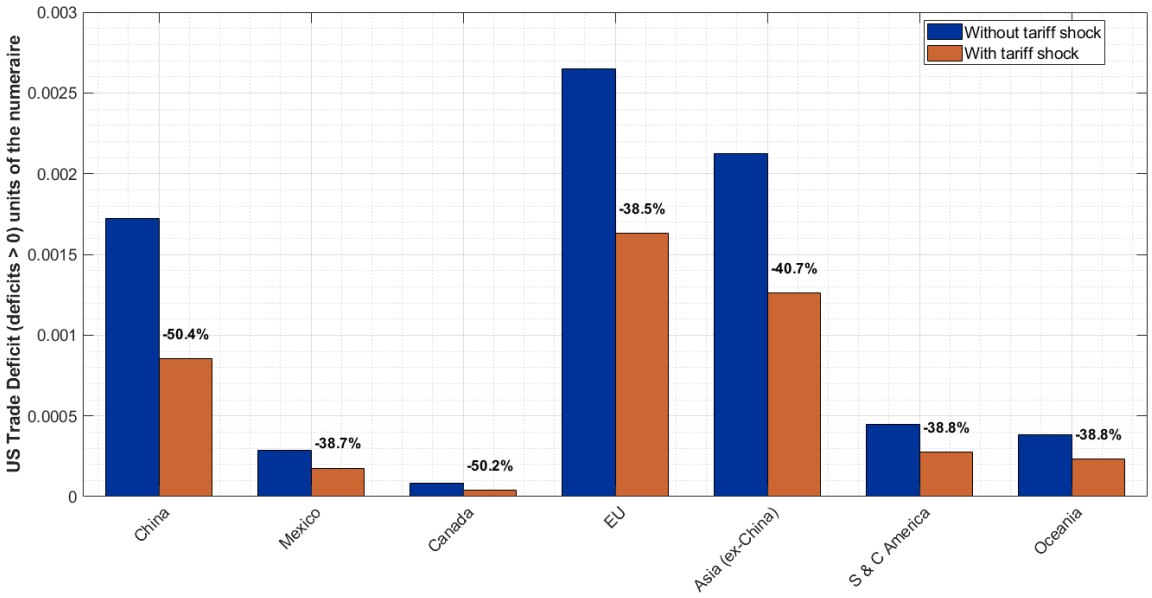
In this section of the appendix, we present the changes in trade imbalances resulting from the Liberation Day tariff changes announced on April 2, 2025, using the tariff changes announced that day. Figure B.9 shows the changes in trade imbalances for the United States and other countries and regions around the world, while Figure B.10 shows the changes in bilateral U.S. trade deficits.

Figure B.9: Trade Imbalances - Liberation Day tariff counterfactual



Note: The figure shows trade imbalances, measured relative to global spending, across countries and regions in the baseline (left hand side bars) and under a tariff counterfactual that imposes the changes in tariffs announced on April 2, 2025 (right hand side bars). The number next to the right-hand bars represents the absolute value of the percentage change in the imbalance relative to the baseline, with a negative sign shown for the United States.

Figure B.10: U.S. Bilateral Imbalances - Liberation Day tariff counterfactual



Note: The figure shows the U.S. bilateral trade imbalances, measured relative to global spending, across countries and regions in the baseline (left hand side bars) and under a tariff counterfactual that imposes the changes in tariffs announced on April 2, 2025 (right hand side bars). Trade imbalances are defined as imports minus exports. The number next to the right-hand bars represents the percentage change relative to the baseline.