Trade Costs and Inflation Dynamics*

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May 2025

Abstract

We study how trade cost shocks influence inflation. Using bilateral trade flows from detailed global input-output data and a gravity framework, we estimate trade cost shocks and their effects on CPI inflation. Higher trade costs for final goods cause large but short-lived inflation spikes, while increased costs for intermediate inputs trigger more persistent inflation. A multi-country model of inflation with trade in final goods and intermediate inputs replicates these patterns. We show that trade cost shocks and tariffs on imported inputs transmit through global value chains and worsen monetary policy trade-offs. We use the model to quantify the effects of trade costs during the 2018–2019 U.S.-China trade war and to estimate the contribution of trade costs during the post-pandemic inflation surge. Novel data on U.S. domestic sourcing shares allow us to estimate trade cost shocks for the U.S. using Bayesian methods.

JEL Codes: E1, E3, E5, F4, F6

*First version: February 2024. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System. We thank seminar participants at the University of Washington, the Federal Reserve Board, the Dallas Fed, the LAJCB Conference, CEBRA 2024 Annual Meetings, 2025 ASSA/AEA Annual Meetings, Brandeis University, West Coast Workshop in International Finance, the Mid-Atlantic Trade Workshop, and SCIEA Meeting at the NY Fed. We are particularly grateful to our discussants Matteo Cacciatore, Thuy Lan Nguyen, and Julian Di Giovanni, and to Francesco Bianchi, Daniel Xu, Carter Mix, Martin Uribe and Stephanie Schmitt-Grohé for comments and suggestions.

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1 Introduction

The global economy is deeply interconnected. Over the past half century, economic integration by low- and middle-income countries and the deepening of global production networks—also referred to as global value chains (GVCs)—fueled world trade flows, particularly those of goods used in intermediate stages of production.[1] In this integrated global economy, shocks to the costs of transaction and transport associated with the exchange of goods across borders—that is, broadly-defined trade costs—can have important macroeconomic consequences. Recent events, such as shifts in U.S. trade policy since 2017, disruptions in GVCs following the COVID-19 pandemic, or trade fragmentation triggered by geopolitical events such as the Russian invasion of Ukraine in 2022, highlight the potential consequences of trade cost shocks for real economic activity and inflation. Yet, existing work has focused on the real effects of trade costs, with scant attention paid to how these shocks impact inflation.[2] This gap reflects the emphasis in the literature on the role of productivity and demand shocks for open economies and the divide between international trade models and the workhorse framework for the analysis of inflation dynamics and monetary policy.[3]

This paper studies how trade cost shocks shape inflation dynamics in a global economy. We follow two complementary approaches. Empirically, we exploit global input-output data to measure trade costs in both final and intermediate goods across countries and time and estimate the causal effects of shocks to these costs on inflation. On the theory front, we develop a dynamic general equilibrium model of trade and inflation to quantify and elucidate the mechanisms through which trade cost shocks propagate to inflation. Thus, our study contributes to bridging the divide in the literature between international trade and international monetary economics.

Our analysis proceeds in three steps. First, we estimate bilateral trade costs for final goods and intermediate inputs by combining detailed sectoral data from global input-output tables with gravity equations derived from a static Armington model of trade in final and intermediate goods.[4]

[1] World exports rose from 16 percent of world GDP in the 1970s to 29 percent by the late 2010s. Hanson (2012) and Reyes-Heroles et al. (2020) document the rise of low- and middle-income countries in global trade. Antràs and Chor (2022) survey the literature on GVCs. World imports of intermediate goods accounted for at least half of world trade every year from 1996 to 2022 (Cuba-Borda et al., 2025).

[2] Recent exceptions that consider the effects on inflation of trade cost shocks are Comin and Johnson (2020), Barattieri et al. (2021), Di Giovanni et al. (2023), Comin et al. (2024), and Kalemli-Özcan et al. (2025). Furceri et al. (2018) studies empirically the macroeconomic implications of tariff shocks.

[3] For the role of productivity shocks see Backus et al. (1992) and Heathcote and Perri (2002). Stockman and Tesar (1995) and Bai and Ríos-Rull (2015) study the implications of demand shocks. A relatively small number of works study the implications of trade costs for outcomes other than inflation (Fitzgerald, 2012; Eaton et al., 2016b; Reyes-Heroles, 2017; Alessandria and Choi, 2021). See Galí (2015) for an introduction to the workhorse framework to study inflation, economic fluctuations, and monetary policy.

[4] See Head and Mayer (2014) for an overview of gravity models in international trade.

Using bilateral trade flows and aggregate spending data together with an estimate of the trade elasticity, we apply the ratio-type estimator of Head and Ries (2001) to infer bilateral trade costs across 44 countries from 1995 to 2020. This approach captures the cross-country variation in bilateral trade flows that cannot be explained by either importer- or exporter-specific characteristics and recovers bilateral trade costs as the factor that explains the remaining variation as implied by a structural gravity equation—that is, we recover bilateral residuals.

Our estimated bilateral trade costs vary across time and space. The evolution of trade costs provides evidence of a process of increasing globalization, which has stalled since 2010. Across space, bilateral trade costs are sizable and heterogeneous, particularly for low- and middle-income countries relatively isolated from international trade markets in the 1990s. Our measure of bilateral trade costs also captures changes in trade policies, such as the tariff increases between the U.S. and China between 2018 and 2019.

We then study the causal relationship between changes in trade costs and inflation using panel local projection methods, as in Jordà (2005). To do so, we construct country-wide import costs by aggregating bilateral trade costs.[5] Thus, our measure of import costs also varies across time and space. We show that our measure of import costs is correlated with effective tariff rates across countries, providing reassurance that changes in trade policies are reflected in our measure of costs. We exploit the variation in import costs to identify the causal effect of trade costs on inflation. Our local projections specification controls for time- and country-fixed effects and additional macroeconomic covariates. Our empirical strategy effectively controls for importer- and exporter-specific characteristics across countries year-by-year, giving us confidence that we can identify a causal relationship between trade costs and inflation.

Our findings provide novel evidence that higher import costs translate into higher inflation. We also find that the resulting inflation dynamics depend on the nature of the trade cost shocks. While higher trade costs for final goods lead to large but short-lived increases in inflation, higher trade costs for intermediate inputs generate more modest but longer-lasting inflation. Quantitatively, a ten percentage point rise in relative import costs of final goods leads to an average relative increase in inflation of 0.7 percentage points within one year that dissipates quickly thereafter. The same increase in the import cost of intermediate inputs increases inflation by 0.6 percentage points in the first year, but in this case, inflation remains elevated by about 0.2 percentage points for up to five

[5] Our approach resembles those of Frankel and Romer (1999) and Frankel and Rose (2002), who aggregate predicted bilateral trade flows based on geographic characteristics in gravity models.

years. We also explore the effects of higher trade costs on GDP and show that increases in import costs trigger declines in output. Thus, our analysis provides evidence that the macroeconomic effects of higher trade costs—which can be triggered by non-policy and policy-related factors like tariffs—mirror those of adverse supply shocks.

In the second step of our analysis, we develop a dynamic multi-country general equilibrium model of trade and inflation that features international trade in both final and intermediate goods and staggered price and wage adjustments. The goal of developing this framework is twofold. First, we aim to study the transmission mechanisms through which trade cost shocks propagate to inflation and the macroeconomy more generally. Second, we use our model to provide complementary estimates of the macroeconomic effects of higher trade costs on inflation, given that our empirical estimates only identify relative effects—that is, our empirical analysis is subject to the "missing intercept" problem that arises from including time-fixed effects in our panel local projections.

Our general equilibrium model embeds the static Armington model of trade into a dynamic framework. Each country produces a unique homogeneous good that can be traded across borders, subject to good-specific iceberg-type trade costs and *ad valorem* tariffs. Goods can be used as final goods or intermediate inputs in producing nontradable differentiated goods in each country. The model implies static gravity equations for final and intermediate goods that are in line with those that we exploit to measure trade costs empirically. Firms producing nontradable differentiated goods adjust prices infrequently, and households face nominal wage rigidities in labor markets. International trade in financial assets is restricted to non-state-contingent bonds denominated in U.S. dollars. We assume that monetary policies follow standard Taylor-type rules. We calibrate the model to observed trade flows across five regions: the U.S., China, advanced non-U.S. economies, Asian emerging market economies (EMEs) excluding China, and other EMEs. To elucidate the mechanisms common across countries that shape the effects of trade costs shocks on inflation, we keep heterogeneity across countries limited in our calibration and only allow countries to differ in their sizes and trade flows with their trading partners.

Our model reproduces the inflation dynamics caused by the higher trade costs we estimate in the data. In the model, increases in trade costs on intermediate inputs trigger more persistent inflation because these increases lead to persistently higher marginal costs for domestic producers, which rise as higher input prices propagate through global value chains. These higher marginal costs are passed through slowly to consumer prices as domestic producers gradually adjust prices to reflect higher marginal costs. In contrast, the model generates large but short-lived increases in inflation in response to higher trade costs for final goods, as these higher costs immediately pass through to final consumer prices via higher prices of imported final goods—leading to dynamics that resemble a one-time rise in the price level.

We also use our model to analyze the macroeconomic dynamics in response to trade shocks under an alternative monetary policy rule that targets inflation of domestically produced goods only, rather than all consumption goods, including imported final goods. We show that in the presence of shocks to trade costs of intermediate inputs, this alternative rule does not have the stabilization properties suggested in previous literature (Corsetti et al., 2010), nor does it "see through" temporary increases in inflation driven by the imposition of tariffs—an issue that has featured prominently in past monetary policymaking discussions.[6]

In the third and final step of our analysis, we use the model to estimate the global economic impact of the 2018-19 U.S.-China trade war and the role of trade costs in driving the U.S. inflation surge post-2020. The fact that our model accommodates multiple countries and that it is amenable to estimation makes it a useful tool to study these events. Moreover, this analysis highlights how our model can be used to understand episodes related to tariff changes and those involving broader trade costs. In our first experiment, the increase in U.S.-imposed tariffs and the retaliation observed in 2018-2019 led to a rise in U.S. inflation of up to 0.3 percentage points per year and a decline in the level of U.S. GDP of around 0.4 percent. Because the inflation response is persistent, the price level rises by up to 30 percent more than what is implied by rules of thumb based on estimates of the pass-through of tariffs to import prices (Amiti et al., 2019; Fajgelbaum and Khandelwal, 2022). Hence, our model analysis underscores the role of general equilibrium effects of higher import costs of intermediate inputs on prices. In the second experiment, we construct novel quarterly data that helps identify variation in U.S. trade costs and use Bayesian methods to estimate the role of trade costs in the post-pandemic surge in inflation. We find that shocks to trade costs contributed to preventing deflation in the early phases of the pandemic and added about one percentage point to inflation in 2022 and 2023, thus helping explain the persistence of the inflation surge experienced after the COVID-19 pandemic.

Relation to the Literature. This paper is most closely related to recent work that incorporates trade in intermediate goods and production networks to study the effects of trade and trade costs on inflation.[7] Comin and Johnson (2020) study how trade integration in final

[6]See, for example, the alternative scenarios in the Federal Reserve's September 2018 Tealbook: `https://www.federalreserve.gov/monetarypolicy/files/FOMC20180131tealbooka20180119.pdf`.

[7]A body of existing work—partially motivated by Obstfeld and Rogoff (2000)—studies the real macroeconomic

and intermediate goods has shaped the long-term trend of U.S. inflation. Barattieri et al. (2021) study the short-run macroeconomic effects—including inflation—of protectionist policies in Canada. Di Giovanni et al. (2023) study the drivers of inflation during the COVID-19 pandemic through the lens of a multi-country and sector New Keynesian model. Kalemli-Özcan et al. (2025) develop a multi-country New-Keynesian model with multiple sectors and input-output linkages to study the interaction between monetary policy and trade.[8]

Relative to this body of work, our contribution is threefold. First, we document how broadly-defined trade costs, nesting non-policy and policy-related trade barriers, vary across time and space. Second, we exploit panel data for a large number of countries to document the effects of trade cost shocks on inflation and provide novel evidence about the magnitude and persistence of the inflationary effects of these shocks. We show that trade cost shocks act as negative supply shocks, leading to higher inflation and lower output in the short run. Third, we develop and estimate a multi-country general equilibrium New Keynesian model that elucidates the mechanisms that explain our empirical results and that enables us to quantify the effects of increases in tariffs and other types of trade disruptions.[9]

Our paper also contributes to the recent literature on the macroeconomic consequences of tariffs and their implications for monetary policy. Furceri et al. (2018) and Caldara et al. (2020) provide empirical evidence of the macroeconomic effects of tariffs and uncertainty induced by them. Erceg et al. (2023) analyze the interaction between trade and fiscal policies in open economies. Auclert et al. (2025) study the short-run macroeconomic effects of tariffs. Some of this work has focused primarily on the monetary policy implications of tariffs in open economy New Keynesian models (Bergin and Corsetti, 2023; Bianchi and Coulibaly, 2025; Werning et al., 2025).

Our paper differs from the above literature along key dimensions. First, we study the effects of shocks to broadly defined trade barriers rather than focusing on tariff shocks. Our measure of trade cost shocks nests tariff shocks, is consistent with gravity models of international trade (Head and Mayer, 2014), and avoids issues related to missing tariff data (Teti, 2025). Second, we provide empirical estimates of the effects of these shocks on the macroeconomy using panel data. Third, we

effects of trade costs in the presence of trade in intermediates and production networks (Fitzgerald, 2012; Reyes-Heroles, 2017; Eaton et al., 2016b; Alessandria et al., 2023).

[8] Additional related work considers the effects of import constraints (Comin et al., 2024) and import competition (Amiti et al., 2024) on inflation; the effects of globalization on international inflation co-movement (Ho et al., 2022) and inflation dynamics (Bianchi and Civelli, 2015; Hottman and Reyes-Heroles, 2023).

[9] Our focus on the transmission of trade cost shocks through value chains in intermediate inputs aligns with evidence in Flaaen and Pierce (2019), which shows that the 2018-19 U.S.-China trade war had significant effects on U.S. manufacturing prices and employment through this channel.

emphasize the multi-country feature of our framework, which allows us to take into account trade diversion following trade cost shocks. Fourth, we estimate our model using Bayesian techniques to quantify the role of trade disruptions in shaping the recent surge in U.S. inflation.

Lastly, this paper is also related to the literature in international trade using gravity models to estimate trade costs. Within this literature, a small number of works have exploited the evolution of estimates of trade costs over time to study their effects on the macroeconomy (Jacks et al., 2008, 2011; Fitzgerald, 2012; Eaton et al., 2016b,a; Reyes-Heroles, 2017). We contribute to this line of work by establishing a causal link between trade cost shocks and inflation dynamics.[10]

Roadmap. The rest of the paper is organized as follows. Sections 2 and 3 describe our procedure to identify trade costs and estimate the effects of trade cost shocks on inflation. Section 4 presents the model and its calibration. Sections 5 and 6 analyze the predictions of the model and quantify the effects of tariffs and trade shocks during the 2018-2019 U.S.-China trade war post-pandemic inflation surge. Section 7 concludes.

2 Trade Costs Across Time and Space

2.1 Measuring Trade Costs

Trade costs are the centerpiece of our analysis. Observing or directly measuring the total cost of shipping goods across borders is impossible (Anderson and van Wincoop, 2004). Therefore, to measure these costs, we follow the literature in international trade that infers trade costs based on observed trade flows and gravity equations implied by a type of static trade model usually referred to as Gravity model.[11] While this approach requires imposing a lot of structure on the elements of a model that dictate bilateral trade flows across countries, it allows us to back out trade costs as model residuals in a very transparent fashion. In addition, our approach allows us to circumvent any issues related to obtaining reliable direct measures of trade costs and to compare trade costs across space and over time.

In the following section, we present the trade bloc of the open economy dynamic model that we will develop to study the mechanisms through which trade cost shocks shape inflation dynamics. Section 4 will make clear how we embed the static bloc into our dynamic framework. The static

[10] Our approach is also related to Frankel and Romer (1999) and Frankel and Rose (2002), who estimate the effects of openness and currency unions, respectively, on output relying on the gravity model of trade and cross-sectional data.

[11] Gravity models constitute the workhorse framework in international trade to estimate bilateral trade flows and their determinants (Head and Mayer, 2014).

bloc of the model delivers gravity equations that allow us to recover trade costs from observed trade flows. More specifically, we consider a standard Armington model of trade for our static bloc.[12] The equilibrium of this bloc delivers predictions for bilateral trade flows for both final and intermediate goods in any given period t that depend only on prices of goods and aggregate spending in period t. Hence, the model implies static gravity equations. However, in the dynamic model that we present in Section 4, prices and aggregate expenditures are determined endogenously and in line with optimal dynamic decisions.

2.2 Model I: Intratemporal Trade and Gravity

In any given period $t = 1, 2, \ldots$, the world is comprised of multiple countries indexed by $i, h \in \mathcal{I} = \{1, \ldots, N\}$. Each country produces a unique tradable good that is available to all countries—that is, there is *national product differentiation*. There are two types of economic agents in each country: households and firms. Goods produced in any country can be bought either by households or firms in all countries around the world. Households buy goods for final use and firms buy them to use as intermediate inputs. In country i, households aggregate goods across sources into a single nontradable composite consumption good, $C_{i,t}$. Similarly, firms aggregate goods to obtain a composite intermediate input to be used in production, $M_{i,t}$. This aggregation is done according to a constant elasticity of substitution (CES) aggregator given by

$$Q_{i,t} = \left(\sum_{h=1}^{N} (Q_{ih,t})^{\frac{\eta^Q - 1}{\eta^Q}} \right)^{\frac{\eta^Q}{\eta^Q - 1}}, \tag{1}$$

where $Q \in \{C, M\}$ and $\eta^Q > 1$. In (1), $Q_{ih,t}$ denotes the use by country i of goods of type $Q \in \{C, M\}$ produced in h at time t, where C and M stand for final and intermediate goods, respectively.

Let $P_{i,t}$ denote the price of the goods produced and sold in country i expressed in local currency units. If $\mathcal{E}_{ih,t}$ denotes the nominal bilateral exchange rate between countries i and h expressed in terms of country i's currency units per unit of country h's currency, then the price of a good produced and sold in country h in terms of country i's currency is defined by $P_{ih,t} \equiv \mathcal{E}_{ih,t} P_{h,t}$.

Trade across countries is subject to iceberg-type trade costs given by $\tau^Q_{ih,t} \geq 1$, implying that for one unit of good of type $Q \in \{C, M\}$ produced in h to be delivered to i, $\tau^Q_{ih,t}$ units have to be

[12] Our model is isomorphic to one in which trade arises from Ricardian comparative advantages as in Eaton and Kortum (2002).

shipped at time t. That is, $\tau^{Q}_{ih,t} - 1$ units of the good disappear when it is shipped internationally from country h to country i.[13] We normalize domestic trade costs such that $\tau^{Q}_{ii,t} = 1$ for every i and $Q \in \{C, M\}$.

We assume that international goods markets are perfectly competitive, which implies that the Law of One Price (LOP) holds across countries. Hence, the price in local currency units that country i has to pay to acquire one unit of the good produced in country h, $P^{Q}_{ih,t}$, is given by

$$P^{Q}_{ih,t} = \tau^{Q}_{ih,t} P_{ih,t}, \tag{2}$$

for goods of type $Q \in \{C, M\}$.[14]

Households and firms in country i seek to minimize expenditure on final and intermediate goods, respectively, when choosing $\{Q_{ih,t}\}_h$ for $Q \in \{C, M\}$. The solution to this minimization problem delivers conditional demand functions for goods of type $Q \in \{C, M\}$ given by

$$Q_{ih,t} = \left(\frac{\tau^{Q}_{ih,t} P_{ih,t}}{P^{Q}_{i,t}} \right)^{-\eta^{Q}} Q_{i,t}, \tag{3}$$

where

$$P^{Q}_{i,t} \equiv \left(\sum_{h=1}^{N} \left(\tau^{Q}_{ih,t} P_{ih,t} \right)^{1-\eta^{Q}} \right)^{\frac{1}{1-\eta^{Q}}} \tag{4}$$

denotes the ideal price index for composite goods Q. Let $X^{Q}_{ih,t} \equiv P^{Q}_{ih,t} Q_{ih,t}$ denote expenditure by country i on goods of type Q produced in country h—that is, bilateral imports by i from h. Then, $X^{Q}_{i,t} = \sum_{h=1}^{N} X^{Q}_{ih,t} = P^{Q}_{i,t} Q_{ih,t}$ denotes total expenditure by country i on Q-type goods. Equation (3) then implies that

$$X^{Q}_{ih,t} = \left(\frac{\tau^{Q}_{ih,t} P_{ih,t}}{P^{Q}_{i,t}} \right)^{-(\eta^{Q}-1)} X^{Q}_{i,t}, \tag{5}$$

which determines bilateral trade flows given current trade costs, prices, and aggregate expenditure.

Let $\omega^{Q}_{ih,t}$ denote the share of expenditure by country i on goods of type Q produced in country

[13] In section 4, we introduce into the model tariffs that differ from non-tariff barriers.

[14] Note that our assumption that (2) holds implies that bilateral trade costs, $\tau^{Q}_{ih,t}$, in our model also capture any bilateral factors driving deviations from the LOP including destination-specific markups by exporters.

h, $\omega^Q_{ih,t} \equiv \frac{X^Q_{ih,t}}{X^Q_{i,t}}$. Equation (5) implies that these shares are given by

$$\omega^Q_{ih,t} = \left(\frac{\tau^Q_{ih,t} P_{ih,t}}{P^Q_{i,t}} \right)^{-(\eta^Q - 1)}, \tag{6}$$

where the trade elasticity in this model is given by $\eta^Q - 1$. Note that (6) is a gravity-type equation, implying that bilateral trade flows across countries can be expressed in terms of importer i characteristics, exporter h characteristics, and a measure of bilateral trade frictions inclusive of the bilateral nominal exchange rate, $\tau^Q_{ih,t}\mathcal{E}_{ih,t}$, summarizing all frictions that impede trade across any two countries. We proceed now to describe how we can exploit (6) to infer bilateral trade costs relying only on data for bilateral trade flows.

Note from (6) that we can use a country's domestic sourcing share, given by $\omega_{ii,t}$, to control for the price of the goods produced in the exporting country (denominated in local currency units) by dividing $\omega^Q_{ih,t}$ by $\omega^Q_{hh,t}$. More specifically, given (6) for importer i and exporter h, we can express bilateral trade costs between these countries as a function of importer i's bilateral trade share, the exporter h's domestic sourcing share, and prices as follows:

$$\tau^Q_{ih,t} = \left(\frac{\omega^Q_{ih,t}}{\omega^Q_{hh,t}} \right)^{-\frac{1}{\eta^Q - 1}} \frac{P^Q_{i,t}}{\mathcal{E}_{ih,t} P^Q_{h,t}}. \tag{7}$$

Hence, the equilibrium of our model implies that, given data on bilateral trade shares, domestic sourcing shares, and relative prices across countries for each type of good $Q \in \{C, M\}$, we can recover bilateral trade costs in any given period t conditional on a value of the parameter $\eta^Q > 1$.[15]

Relative prices across countries are difficult to measure, and time series for these prices are scarce. These issues imply that it is difficult to gather reliable time series data for these prices.[16] However, we can circumvent these issues by further manipulating equation (7) to obtain a measure of bilateral trade frictions that only depends on bilateral trade flows and not prices. By switching the roles of the importing and exporting countries in (7) to control for relative price differences, we obtain a measure of trade frictions between individual country pairs given by

$$\mathcal{T}^Q_{ih,t} \equiv (\tau^Q_{ih,t}\tau^Q_{hi,t})^{\frac{1}{2}} = \left(\frac{\omega_{ih,t}}{\omega_{hh,t}} \frac{\omega_{hi,t}}{\omega_{ii,t}} \right)^{-\frac{1}{2(\eta^Q - 1)}}, \tag{8}$$

[15] See Reyes-Heroles (2017) for an application of this procedure.

[16] See Jacks et al. (2011) and Jacks et al. (2008) for other works exploiting the availability of historical data to construct HR indices for the period 1870-2000.

which defines what the literature refers to as the Head-Ries (HR) index for country pair (i, h) (Head and Ries, 2001; Eaton et al., 2016b). The HR index measures bilateral trade frictions in period t by considering the geometric mean of bilateral trade cost $\tau^{j}_{ih,t}$ for any pair of countries. Note that $\mathcal{T}^{Q}_{ii,t} = 1$, which is consistent with the notion that trade with oneself is costless and that, under the assumption of symmetric trade costs, the index becomes the actual bilateral trade cost. While this measure has multiple appealing features, it cannot account for asymmetries in bilateral trade costs. However, for a given importer i, changes in these bilateral measures will reflect changes in import costs against all of i's trading partners. We exploit this feature of this bilateral measure of frictions in Section 2.5 to construct a measure of import costs at the country level. From now on, whenever we refer to bilateral trade costs, we will be referring to $\mathcal{T}^{Q}_{ih,t}$.

Our procedure to construct bilateral trade frictions separates the fraction of variation in bilateral trade flows across countries that is not driven by either importer- or exporter-wide characteristics and assigns this fraction of variation to bilateral trade costs—that is, a bilateral residual. Hence, variation across space in our measured frictions is explained by bilateral factors—these could be geographical characteristics typically considered in gravity model such as distance between two countries—and controls for country-wide factors, such as differences in country size or inflation, which could also explain part of trade flows. In that sense, our bilateral trade costs capture factors that could be exogenous to aggregate supply or demand shocks.[17] In Section 3 we describe the strategy we follow to identify the causal effect of these shocks on inflation.

Note that there are two important requirements for constructing bilateral trade costs. First, we require data on countries' "domestic" trade flows, $X^{Q}_{ii,t}$—or equivalently domestic sourcing shares, $\omega^{Q}_{ii,t}$—for final and intermediate goods. Data for bilateral trade flows at the good and sectoral levels are provided by multiple datasets, but this is not the case for domestic trade. Second, we require measures of the elasticities, η^{Q} for $Q \in \{C, M\}$, a natural requirement given that our procedure is similar to inferring prices from quantities. In the following section, we describe the data that allow us to compute domestic trade and discuss our choice of values for elasticities. Given values for elasticities, our data will enable us to construct bilateral trade costs for many countries over three decades.

[17] See Frankel and Romer (1999) for a similar approach to identify exogenous variation in trade.

2.3 World Input-Output Data and Trade Elasticities

We use data on world input-output tables. These data allow us (i) to compute international bilateral trade flows, (ii) to compute domestic sourcing flows that are consistent with international trade flows and production data, and (iii) to distinguish these flows between goods used either as final goods or as intermediates in production.

Our main data source is the Inter-Country Input-Output Tables (ICIO) published by the OECD. The ICIO provides global input-output tables, which map flows of production and expenditure within countries and flows of international trade between countries, broken down by economic activity and country, globally.[18] The ICIO considers 76 countries and the rest of the world aggregate (ROW) from 1995 through 2020.

We aggregate the ICIO data to 41 countries—40 individual countries and one ROW aggregate. This aggregation allows us to compare our measures of bilateral trade costs with those obtained using the World Input-Output Database (WIOD) (Timmer et al., 2015), a dataset widely used in the existing literature.[19] We exclude non-tradable goods from our analysis—basically, service sectors—and consider tradable sectors, which we aggregate to obtain flows for final goods—consumption or investment—separately from those used as intermediate inputs. Based on these data, we construct domestic and bilateral expenditure share—$\omega^{Q}_{ih,t}$ for all i and h—for final and intermediate goods, $Q \in \{C, M\}$, which we then use to compute bilateral trade costs according to (8) for a given value of the elasticity η^{Q}.[20]

For our baseline trade elasticities (see also section 4.5), we assume that elasticities do not vary across types of goods, $\eta \equiv \eta^{C} = \eta^{M}$, and that $\eta = 5$ implying a trade elasticity equal to four, $\eta - 1 = 4$. This value is in line with the estimates in the trade literature that are obtained by relying on static Gravity models (Head and Ries, 2001; Simonovska and Waugh, 2014; Caliendo and Parro, 2014), and closer to the higher-end estimates of Boehm et al. (2023) for the long-run trade elasticity. We consider this a reasonable value for the elasticity because it is consistent with values in the literature estimated using variation in trade flows across countries—the same variation that we use to identify bilateral trade costs. Appendix C.3 explores the robustness of our main empirical results established in Section 3 to alternative values of η. In addition, we show in Section 5.1 that for our baseline value of η, the dynamic model that we propose replicates our empirical

[18] See details here: `https://www.oecd.org/en/data/datasets/inter-country-input-output-tables.html`.

[19] We choose the ICIO as our primary data source because it covers a longer time period than the WIOD, which only provides data until 2014.

[20] See Appendix A for further details on data cleaning and manipulation.

results remarkably well.

2.4 Stylized Facts

We now proceed to describe the trends and features of our measure of bilateral trade costs. We establish three facts that help us to elucidate how these trends and features reflect changes in policy and non-policy related trade barriers over time, across space, and across types of countries. We will rely precisely on variation in bilateral trade costs across time and space to identify the effects of trade cost shocks on inflation and other macroeconomic variables in Section 3. We start by exploring how these costs evolved over time.

Fact 1: Bilateral trade costs declined significantly between 1995 and 2008 and stabilized thereafter, remaining unchanged until 2020.

Figure 1 plots the evolution of the distribution of bilateral trade costs. The solid lines in Figure 1a plot the median costs for final (red line) and intermediate (blue line) goods in the cross-section of countries for any given year. These costs are expressed as a percentage of the sales price of the good—in terms of our definition in (8), the figure shows $(\mathcal{T}^{Q}_{ih,t} - 1) \times 100$ for $Q \in \{C, M\}$. According to our estimates shown in panel (a), median bilateral trade costs across countries for both final and intermediate goods fell approximately 80 percentage points from 1995 to 2008. These changes are also reflected by the black lines in Figure 2a, which show changes in trade costs relative to their 1995 levels. This is a significant decline given that in 1995 these costs were approximately 380 and 420 percent for final and intermediate goods, respectively.[21] The solid lines in Figure 1a and the black lines in Figure 2a also show that, since 2008, median trade costs have remained pretty much unchanged. Hence, the long-run evolution of global trade costs is consistent with a long period of globalization that stalled after 2010.[22] The evolution of the distribution of bilateral trade costs constructed using WIOD data is very similar to the one shown in Figure 1a (Appendix B, Figure A.1).

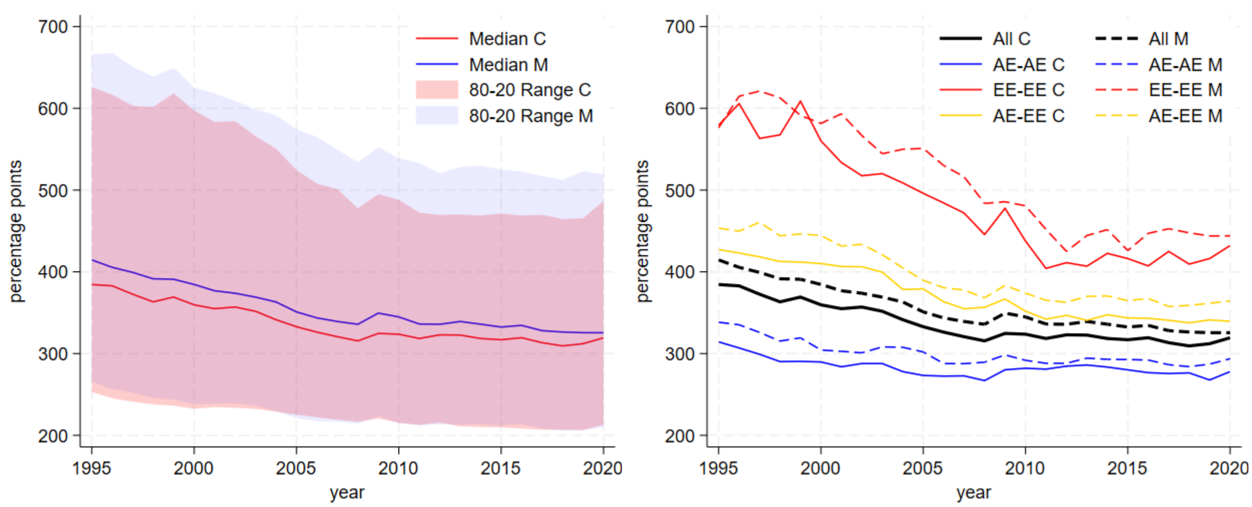
Our second fact is about how variation in these costs across space has evolved over time. Hence, we focus on the evolution of the cross-sectional dispersion in bilateral trade costs.

[21] In terms of magnitudes, our estimates of bilateral trade costs are in line with previous literature showing that these are large (Anderson and van Wincoop, 2004). It is worth emphasizing that these magnitudes are not unreasonable given that our measure of trade costs includes all frictions that impede trade across any two countries.

[22] A steady process of globalization can be traced back to 1965 using historical WIOD data (Appendix B).

Figure 1: Evolution of Global Bilateral Trade Costs

(a) Evolution of distribution (all 41 countries)   (b) Evolution of medians by country group



Note: Trade costs are expressed as a percentage of the sales price of the good. That is, the figures show the evolution of $(\mathcal{T}_{ih,t}^{Q} - 1) \times 100$ for $Q \in \{C, M\}$. All C denotes all countries, AE-AE refers to trade between two Advanced Economies, EE-EE refers to trade between two Emerging Economies, and AE-EE refers to trade between two economies of different types.

Fact 2: The dispersion in bilateral trade costs across country pairs remained stable from 1995 to 2020.

Figure 1a plots the evolution of the dispersion of trade costs over time. The charts plot the 20-80 percentile bands for final consumption (red shaded area) and intermediate inputs (blue shaded area). Variation in bilateral trade costs is substantial at any given point in time and it remains sizable over the years. For instance, the ratio of 80th-percentile trade costs to those in the 20th percentile was about 2.5 for both final and intermediate goods in 1995. This ratio barely declined to 2.3 by 2019 before experiencing a small increase in 2020. Hence, there's substantial and persistent variation in trade costs across space.

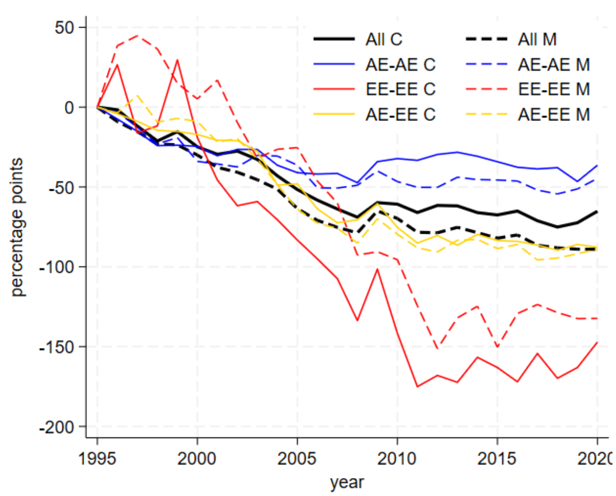
We can split our sample of countries into Advanced Economies (AE) and Emerging Market Economies (EE) to explore how bilateral trade costs across different country-types have evolved over time. We classify trade flows between any two countries as either between AEs, between EEs, or between different types of countries (AE/EE of EE/AE). The next fact establishes the trends in trade costs for these three types of trade flows.

Fact 3: From 1995 to 2010, bilateral trade costs for trade flows between pairs of EEs declined considerably more than those for trade between pairs of AEs or AE-EE/EE-AE pairs. Since 2010, bilateral trade costs for any type of country pair remained relatively unchanged. Moreover, trade costs across AE-EE/EE-AE pairs for intermediate goods decreased by more than those for final goods. However, this has not been the case for the other types of country pairs.

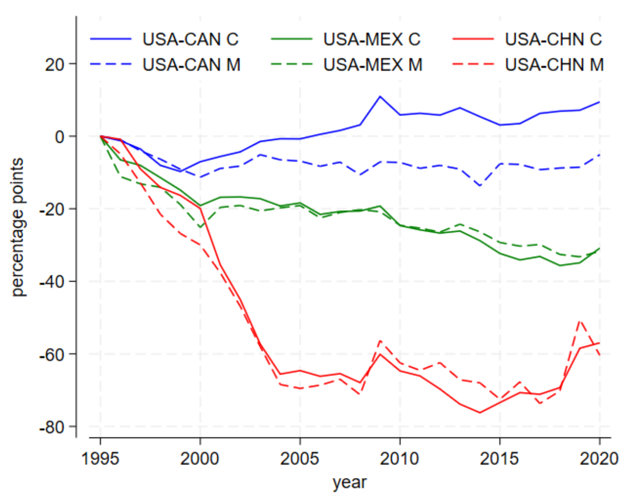
Figures 1b plots the evolution of median bilateral trade costs for specific types of country pairs. Trade between EEs faces the highest costs. However, in terms of changes since 1995, shown in Figure 2a, median costs for this type of country pair also experienced the largest decline over the 1995-2020 period. These trends align with the fact that trade between EEs has grown the most over the last 25 years (Reyes-Heroles et al., 2020). Interestingly, trade costs across AEs remained relatively stable, reflecting the fact that these countries were already substantially integrated prior to 1995. Figure 2a also shows that integration between EEs has occurred more rapidly for final than intermediate goods, but this has not been the case for the other types of country pairs.

Figure 2: Changes in Trade Costs (relative to 1995)

(a) Changes in median trade costs by country group



(b) Changes in bilateral trade costs for selected U.S. trading partners



Note: Trade costs are expressed as a percentage of the sales price of the good. That is, the figure shows the evolution of $(\mathcal{T}^{Q}_{ih,t} - 1) \times 100$ for $Q \in \{C, M\}$. All C denotes all countries, AE-AE refers to trade between two Advanced Economies, EE-EE refers to trade between two Advanced Economies, and AE-EE refers to trade between two economies of different types.

Our measure of trade costs does not only capture long-run trends in global trade integration—as established by Facts 1 through 3—but it can also capture changes in trade policies. Let us consider the case of bilateral trade costs for the U.S. shown in Figure 2b. The figure plots the changes since 1995 in U.S. bilateral trade costs with its three main trading partners—Canada (blue lines), Mexico (green lines), and China (red lines). Focusing first on the case of Canada and Mexico, note that bilateral trade costs with the U.S. declined substantially between 1995 and 2000, in line with the integration process sparked by the North American Free Trade Agreement (NAFTA) signed in 1994. Turning to the case of China, note that these costs experienced large declines from 1995 until around 2007. These declines are in line with the literature on the emergence of China in international trade markets, particularly as an exporter to the U.S. (Autor et al., 2013). During the 2018–19 period, U.S.–China trade costs for intermediate and final goods increased by 20 and 11 percentage points, respectively. Our estimated changes in bilateral trade costs are in line with the 16 percentage point increase in the weighted average tariff imposed by the U.S. on China and China's partial retaliation, as well as the fact that these increases were tilted toward intermediate goods (Bown, 2021). Hence, bilateral trade costs also capture recent changes in trade policies.

In summary, bilateral trade costs capture changes over time in policy and non-policy related trade barriers that vary across countries. Moreover, a sizable share of the variation in these costs is not driven by global factors—such as shipping technologies—nor by time-invariant country-pair-specific factors. A regression of bilateral trade costs on country-pair and time-fixed effects, $\mathcal{T}^Q_{ih,t} = \gamma^Q_t + \gamma^Q_{ih} + \varepsilon^Q_{ih,t}$, implies that around 20 percent of variation in trade costs is not explained by the fixed effects γ^Q_t or γ^Q_{ih}. Our aim is to exploit this variation in trade costs across time and space to identify their causal effect on inflation. As it will be made clear in Section 3, our estimates will control for these kinds of factors.

2.5 Import Costs

The methodology we follow to estimate the effects of changes in trade costs on inflation is based on panel data local projections (Jordà, 2005). Hence, we aggregate bilateral trade costs into country-specific import costs for final and intermediate goods. These import costs will inherit the variation across time and space from a country's bilateral trade costs that we documented in Section 2.4. More specifically, we construct country-specific import costs $\tau^Q_{i,t}$ for $Q \in \{C, M\}$ by aggregating bilateral trade costs using import weights.[23] More specifically, our import costs are given by

$$\tau_{i,t}^{Q} = \sum_{h=1}^{N} \left(\frac{X_{ih,t}^{Q}}{\sum_{k \neq i} X_{ik,t}^{Q}} \right) \mathcal{T}_{ih,t}^{Q}, \tag{9}$$

for $Q \in \{C, M\}$.

A key question is if our measure of import costs can systematically capture variation in directly measurable trade policies such as tariffs. This question is particularly relevant given the observed increases in tariffs around the globe since 2017. Hence, we compare our measure of import costs with data for effective tariffs. We collect data for tariff rates from 1996 to 2018 at the sectoral level provided by Reyes-Heroles et al. (2020) and aggregate these data into a single country-specific effective tariff rate using sectoral import shares. For the case of the U.S., we also compute an alternative measure of its effective tariff rate for the period 1995-2020 using the Bureau of Economic Analysis (BEA) data on customs duties and imports of goods.

Figure 3 plots our measure of total U.S. import costs against the two measures of U.S. effective tariff rates. To obtain total import costs, we simply consider an import-weighted average of import costs for final and intermediate goods. The figure shows there is a clear and strong positive correlation between import costs and both measures of effective tariff rates. To explore this correlation for our sample of countries, we consider the following pooled regression

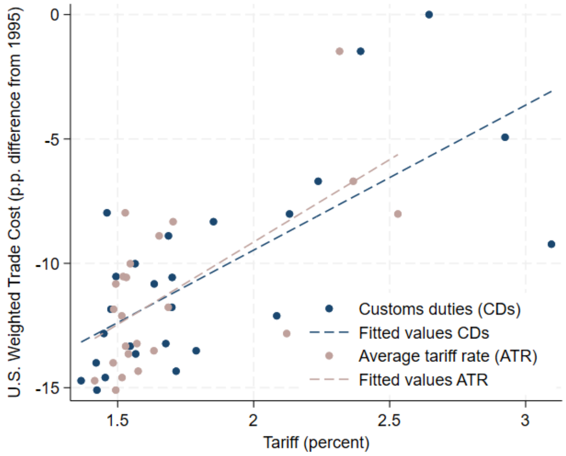
$$\log \tau_{i,t} = \gamma_i + \beta \times \log(1 + \text{tariff}_{i,t}), \tag{10}$$

where $\tau_{i,t}$ denotes country i's import costs at time t and $\text{tariff}_{i,t}$ stands for its corresponding tariff. We estimate a value of $\beta = 1.1$ that is statistically significant at the 1 percent level and we cannot reject β being different from one. Hence, we conclude that our measure of import costs reflects variation in effective tariff rates.

In the following section, we now turn to the causal effect of higher trade costs on inflation and other macroeconomic variables. In estimating these effects, our aim is to control for other forces that could be driving differences in inflation across countries.

[23] We could consider alternative weighting schemes including time-invariant uniform weights similar to the uniform weights in Frankel and Romer (1999).

Figure 3: Trade Costs and Effective Tariffs in the U.S.



Note: U.S. trade costs in years 1995-2020 (y-axis) against effective U.S. import tariff rate from NIPA (blue dots and line) and effective tariff rates from Reyes-Heroles et al. (2020) aggregated using sectoral import weights for the period 1996-2018.

3 Estimating the Effect of Trade Costs on Inflation

3.1 Estimation Strategy

To estimate the causal effects of changes in import costs on inflation, we rely on panel data local projections (Jordà, 2005) and estimate the following panel specification:

$$y_{i,t+h} = \delta^Q_{i,h} + \delta^Q_{t,h} + \beta^Q_h \cdot \Delta\tau^Q_{i,t} + \gamma^Q_h \cdot \Delta\tau^{\not{Q}}_{i,t} + \Gamma'^Q_h Z_{i,t-1} + \varepsilon^Q_{i,t+h} \qquad \text{for } h \geq 1, \tag{11}$$

where $y_{i,t+h}$ is the dependent variable of interest for country i in period $t+h$. Our main coefficient of interest in equation (11) is β^Q_h, which captures the average h-period ahead response of $y_{i,t+h}$ following an initial one-period change in trade costs relative to other countries. We focus on the dynamic effects of trade costs on CPI inflation, π_t, in which case the dependent variable is $y_{i,t+h} = \pi_{i,t+h}$. We also study the impact of higher trade costs on the level of GDP, in which case we define $y_{i,t+h} = \log(GDP_{i,t+h}) - \log(GDP_{i,t-1})$. Appendix C presents the empirical impulse-response functions for other macroeconomic outcomes including exports, imports, the real exchange rate, and the trade balance.

Our estimation strategy allows us to identify the relative effects of an increase in country i's import costs relative to another country's costs. In that sense, our estimates only capture the macroeconomic effects of increases in import costs under particular assumptions because time-fixed effects in (11) absorb the global effects of trade costs shocks. However, the general equilibrium model that we develop and calibrate in Section 4 allows us to circumvent this issue and provide model-based estimates for the macroeconomic effects of increases in trade costs. Moreover, the multi-country nature of the model permits us to test how the predictions of the model compare to our estimates of β_h^Q obtained from (11).

To isolate the dynamic impact of trade costs, we control for unobserved sources of variation using country- (δ_i) and time-fixed effects (δ_t). Given that our measure of trade costs is expressed as a percent of the final sale price, the coefficient β_h^Q measures the effect of a one percentage point increase in trade costs. We scale the response coefficients such that the total import costs of final and intermediate goods increase by 10 percentage points. We report estimates for $h = 1, ..., 5$ years.[24] We also control for other factors that may simultaneously affect inflation, like the potential correlation between trade costs across good types. To account for this correlation, we include $\Delta\tau_{i,t}^{\not{Q}}$ in the regression. For example, when $Q = C$ and $y_{i,t} = \pi_{i,t}$, our estimate of β_h^C recovers the effects on inflation of a one-time increase in trade costs on final goods, holding changes in trade costs for intermediate inputs, $\not{Q} = M$, constant. The vector $Z_{i,t-1}$ controls for other observable characteristics of country i, including lagged values of trade cost changes, $\Delta\tau_{i,t-1}^{Q}, \Delta\tau_{i,t-1}^{\not{Q}}$, the lagged value of the dependent variable, $y_{i,t-1}$, lagged unemployment rate, and lagged GDP growth. To account for episodes that may have led to macroeconomic turmoil, like inflation surge or a GDP collapse, but are unrelated to changes in trade costs, we include country-year dummy observations from the Global Crises Database.[25]

3.2 The Dynamic Effect of Trade Cost Shocks

Inflationary Response. Figure 4 shows that an increase in trade costs in final goods or intermediate inputs leads to a contemporaneous rise in CPI inflation. Panel (a) shows that a 10 percentage point increase in a country's trade costs of final goods relative to the trade costs of its trading partners leads to a 0.65 percentage point increase in CPI inflation within the first year. Panel (b) shows that an equally sized rise in trade costs of intermediate inputs leads to a 0.58 percentage point increase in CPI inflation on impact. The shaded areas represent the 70 percent confidence intervals and show that the contemporaneous effects are statistically different from zero.

[24] We estimate Equation 11 following Correia (2016) with heteroskedasticity-robust standard errors.

[25] We control for years in which yearly inflation was above 50 percent, years explicitly recorded as an inflation crises and periods classified as a currency crises. See https://www.hbs.edu/behavioral-finance-and-financial-stability/data/Pages/global.aspx

We highlight two features of the inflation response to higher trade costs. First, the persistence of the inflationary effects differs depending on the type of trade cost shock. Higher trade costs of final goods—say, due to tariffs imposed on goods like washing machines—lead to short-lived effects on CPI inflation, which dissipate after one year. In contrast, higher trade costs of intermediate inputs—say, due to a shortage in semiconductors or tariffs imposed on imported Chinese battery cells—have more persistent effects on CPI inflation that take several years to peter out. This novel empirical result has important implications for policymakers in charge of monetary policy decisions as we explore in section 5.3.[26]

Second, the impact response of CPI inflation varies depending on the type of trade cost shock. An increase in import costs for final goods is larger relative to the inflationary effect of an increase in the costs of intermediate inputs. This difference is neither economically nor statistically significant for a horizon of $h = 1$ as shown in Figure 4. However, the estimates for a horizon of $h = 0$ shown in columns (2) of the first panel of Table A.2 in Appendix C show that this difference is clearly significant in economic terms, with $\beta_0^C = 1.28$ and $\beta_0^M = 0.75$.[27] This difference is in line with the intuition that higher costs of imported consumption goods affect the CPI directly. Meanwhile, higher import costs of intermediate inputs indirectly affect the CPI through production costs.

GDP Response. Figure 5 shows our estimates for the effects of higher trade costs on GDP. In this case, the coefficient β_h^Q measures the cumulative percent response of GDP in period $t + h$ following an increase in trade costs in period t. Panel (a) shows that higher trade costs of final goods lead to a modest GDP decline of less than 0.5 percent in years 1-3, but this response is not statistically different from zero. Panel (b) shows that the hit to GDP is more pronounced following an increase in the trade cost of intermediate inputs.

Given our main empirical results, we develop a dynamic model in section 4 to compare its predictions to our empirical estimates. Our calibrated model replicates the empirical estimates in this section.[28] We use the model to highlight the transmission mechanism of trade cost shocks to the macroeconomy. We also show that the response of firms' marginal costs plays a crucial role in shaping the inflationary response.

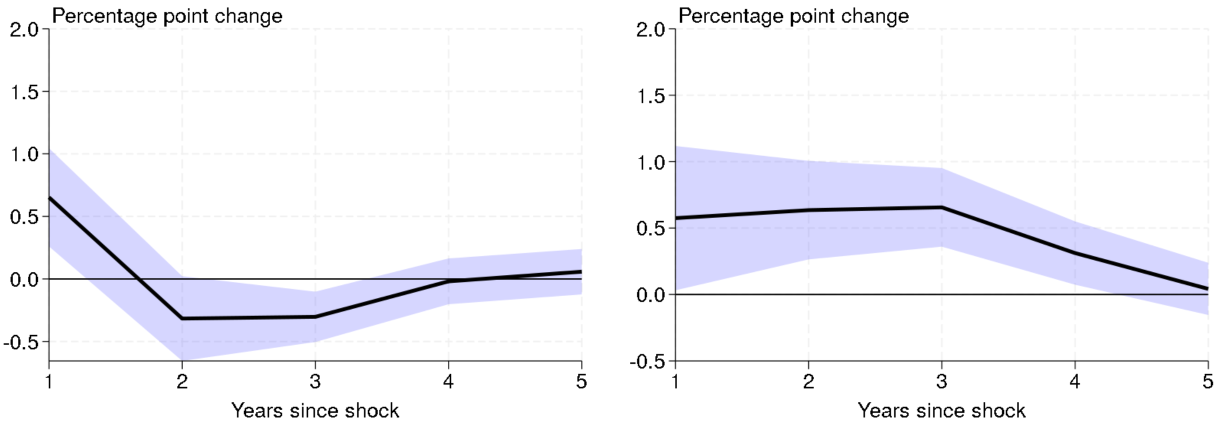
[26] The difference in persistence is not driven by differences in the persistence of the shocks as shown in Figure A.5 of Appendix C.

[27] We do not show the estimates for $h = 0$ in Figure 4 because of time-aggregation issues that arise with annual data and that make it difficult to interpret the estimates for $h = 0$.

[28] Model-based impulse-response functions are also in line with our empirical impulse-responses presented in Appendix C for exports, imports, the real exchange rate, and the trade balance.

Figure 4: Response of Inflation to a 10 Percentage Point Increase in Trade Costs

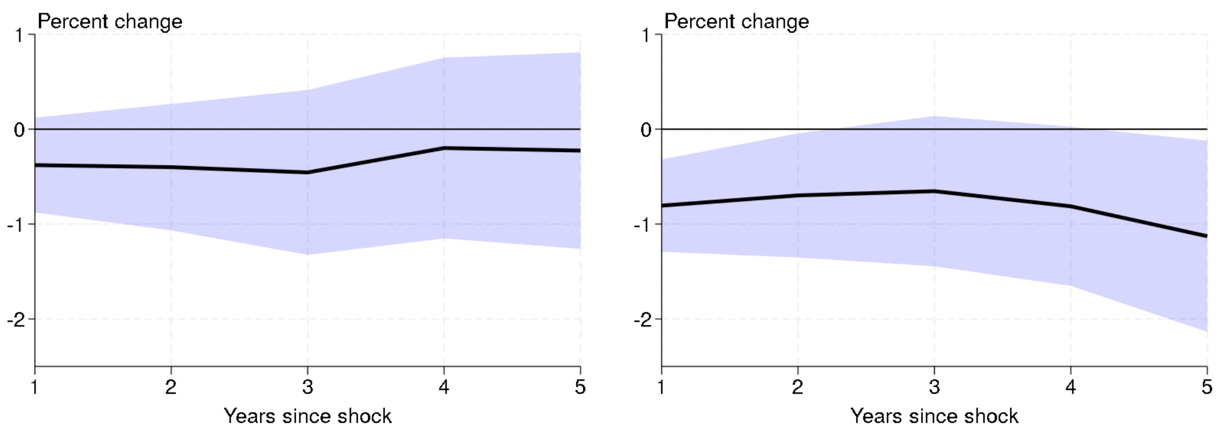
(a) Response to Trade Costs in Final Goods (b) Response to Trade Costs in Intermediate Goods



Note: The figure shows the consumer price index (CPI) response to a 10 percentage point increase in trade costs. Solid lines show estimated β_h^Q coefficient. Shaded areas show 70 percent confidence intervals.

Figure 5: Cumulative Response of GDP to a 10 Percentage Point Increase in Trade Costs

(a) Response to Trade Costs in Final Goods (b) Response to Trade Costs in Intermediate Goods



Note: The figure shows the cumulative response of log(GDP) to a 10 percentage point increase in trade costs. Solid lines show estimated β_h^Q coefficient. Shaded areas show 70 percent confidence intervals.

4 The Model

We develop a dynamic model to understand key mechanisms through which changes in trade costs can affect inflation and macroeconomic outcomes.

We build on the New Keynesian literature and extend a multi-country New Keynesian model with nominal price and wage rigidities to also feature trade in final consumption goods and intermediate inputs. Our New Keynesian bloc is similar to canonical open economy models (see Corsetti et al. (2010) for a review). The trade bloc of our model—as described in section 2.2—deviates from standard open economy New Keynesian models by allowing for trade in different types of goods. We will consider not only trade in final goods but also trade in intermediates. A central aspect of this bloc of the model is that it delivers gravity-type bilateral trade equations, which align with how we measure trade costs in section 2.

We embed the static trade model described in Section 2.2 into a dynamic framework. To recap, time is discrete and indexed by $t = 1, 2, \ldots$, and the world is comprised of N countries indexed by $i, h \in \mathcal{I} = \{1, \ldots, N\}$. We assume that each of these countries has population ξ_i, for $i = 1, ..., N$, and we normalize world population to unity in every period. We assume country 1 to be the United States. In addition to trading final consumption goods and intermediate inputs—as described in section 2.2—countries also trade in financial assets under incomplete international financial markets. More precisely, countries can only trade a risk-free international bond denominated in (real) dollars, country 1's currency, across borders. Aside from the fact that country 1's currency is the one used in international financial markets, countries are otherwise symmetric. We proceed now to describe the structure of a generic country i.

4.1 Households

There is a continuum of households indexed by ℓ in each country. Within a country, households engage in monopolistic competition when supplying differentiated labor services to the production sector, as in Erceg et al. (2000). That is, goods-producing firms regard each household's labor as an imperfect substitute for the labor services of other households. Hence, the objective function of a household ℓ in country i is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[U_i(C_{i,t}) - V_i(L^{\ell}_{i,t}) \right], \tag{12}$$

where $C_{i,t}$ is as specified in (1) for $Q = C$.[29] As a reminder, $C_{i,t}$ is a CES aggregate of $C_{ih,t}$—country i household's consumption of the good produced in country h—across source countries $h = 1, \ldots, N$. In (12), $L^{\ell}_{i,t}$ denotes labor services (hours) provided by household ℓ in country i.

[29]As is standard in this class of models, complete financial markets within country i ensure that all households ℓ consume the same amount, so we omit the ℓ index in $C_{i,t}$.

Household ℓ in country i seeks to maximize (12) subject to the budget constraint

$$\sum_{h=1}^{N} \tau_{ih,t}^{C} P_{ih,t} C_{ih,t} + B_{ii,t} + \frac{B_{i1,t}}{\mathcal{E}_{1i,t}} \leq W_{i,t}^{\ell} L_{i,t}^{\ell} + R_{i,t-1} B_{ii,t-1} + R_{1,t-1} \Psi_{i,t-1} \frac{B_{i1,t-1}}{\mathcal{E}_{1i,t}} + T_{i,t} \tag{13}$$

for all t, where $B_{ii,t}$ denotes holdings of domestically-traded bonds for country i, $B_{i1,t}$ denotes holdings of country 1's bond denominated in U.S. dollars, $\mathcal{E}_{ih,t}$ denotes country i's nominal exchange rate against country h—as defined in section 2.2—and $T_{i,t}$ are transfers to households in country i.[30] We allow risk premia to vary across countries through the term $\Psi_{1,t-1}$ in (13). These risk premium terms are such that $\Psi_{1,t} = 1$ and $\Psi_{i,t} \geq 1$ for $i \neq 1$. More specifically, we assume that for $i \neq 1$, $\Psi_{i,t}$ is given by

$$\Psi_{i,t} \equiv (1 - \psi \frac{b_{i1,t}}{\mathcal{Q}_{1i,t} Y_{i,t}}) \varepsilon_{i,t}^{\psi}, \tag{14}$$

where $b_{i1,t} \equiv \frac{B_{i1,t}}{P_{1,t}^{C}}$ denotes country i's borrowing in units of country 1's good, $Y_{i,t}$ denotes total tradable output in country i, $\varepsilon_{i,t}^{\psi}$ is an exogenous shock to the risk premium of country i, and $\mathcal{Q}_{ih,t}$ denotes the real exchange rate between country i and country h defined as

$$\mathcal{Q}_{ih,t} \equiv \frac{\mathcal{E}_{ih,t} P_{h,t}^{C}}{P_{i,t}^{C}}, \tag{15}$$

where $P_{i,t}^{C}$ is as defined in (4).

Note that in (13), we express prices paid for final consumption goods i, $P_{ih,t}^{C}$, explicitly in terms of the trade costs for final consumption goods, $\tau_{ih,t}^{C}$—as defined in section 2.2—and the bilateral prices that exclude the costs of shipping goods across borders, $P_{ih,t}$. We do so to emphasize how changes in these trade costs directly affect the prices paid by final consumers and, therefore, directly impact their behavior and welfare. We now impose additional structure on these trade costs and assume that they are comprised of exogenous iceberg trade costs, $d_{ih,t}^{C} \geq 1$, and exogenous *ad valorem* tariffs, $\kappa_{ih,t}^{C} \geq 0$, such that total trade costs are given by $\tau_{ih,t}^{C} = d_{ih,t}^{C}(1 + \kappa_{ih,t}^{C})$.

Note that, conditional on $C_{i,t}$, equation (3) for $Q = C$ determines demand for consumption goods across country sources, where $P_{i,t}^{C}$ is given by (4) for $Q = C$. Hence, conditional on aggregate expenditure and prices, all bilateral trade flows are fully determined by equation (6). Aggregate spending, in turn, is determined by the household's intertemporal optimality condition for bonds

[30] Transfers to households include those from firms and the government. The specific transfers are provided in section 4.4.

denominated in domestic currency. The Euler equation characterizes this condition:

$$U_i'(C_{i,t}) = \beta R_{i,t}\mathbb{E}_t\left[\frac{U_i'(C_{i,t+1})}{\pi_{i,t+1}}\right], \tag{16}$$

where $\pi_{i,t} \equiv \frac{P_{i,t}^C}{P_{i,t-1}^C}$ denotes CPI inflation.

For countries that trade bonds denominated in a currency other than their domestic currency, that is, for countries other than country 1, a household's optimal portfolio choice is characterized by an uncovered interest parity (UIP) condition, which in real terms is given by

$$R_{i,t}\mathbb{E}_t\left[\frac{U_i'(C_{i,t+1})/U_i'(C_{i,t})}{\pi_{i,t+1}}\right] = R_{1,t}\Psi_{i,t}\mathbb{E}_t\left[\frac{U_i'(C_{i,t+1})/U_i'(C_{i,t})}{\pi_{1,t+1}\frac{\mathcal{Q}_{1i,t+1}}{\mathcal{Q}_{1i,t}}}\right]. \tag{17}$$

Hence, given our assumption about $\Psi_{i,t}$ in (14), we have that the uncovered interest rate parity condition between countries i and 1 will not hold if $\frac{b_{i1,t}}{\mathcal{Q}_{1i,t}Y_{i,t}}$ deviates from $\frac{1}{\psi}$.

4.1.1 Wage Setting

Following Erceg et al. (2000), we assume that there is an 'employment agency/union' in each country that combines households' labor services (hours) into an aggregate homogeneous labor input supplied to final producers, which we denote by $L_{i,t}$. The agency combines labor services across households according to

$$L_{i,t} = \left(\int_0^1 {L_{i,t}^\ell}^{\frac{\epsilon_w-1}{\epsilon_w}} d\ell\right)^{\frac{\epsilon_w}{\epsilon_w-1}}, \tag{18}$$

where $\epsilon_w > 1$. Given a profile of wages across household types, $\{W_{i,t}^\ell\}_\ell$, the agency seeks to minimize its hiring costs by demanding labor services of type ℓ household according to

$$L_{i,t}^\ell = \left(\frac{W_{i,t}^\ell}{W_{i,t}}\right)^{-\epsilon_w} L_{i,t}, \tag{19}$$

where

$$W_{i,t} = \left(\int_0^1 {W_{i,t}^\ell}^{1-\epsilon_w} d\ell\right)^{\frac{1}{1-\epsilon_w}}, \tag{20}$$

and $W_{i,t}$ can be interpreted as the aggregate wage index in country i.

Households in each country compete in a monopolistic fashion in the labor market and therefore can set wages to maximize their utility. However, we assume that in any given period t, household ℓ can only reset its nominal wage, $W^{\ell}_{i,t}$, with probability $1-\theta_w$, and that with probability θ_w, household ℓ's nominal wage has to be the same as in the previous period. Consider a household that can reset its nominal wage in period t. This household will choose its optimal reset nominal wage, $\overline{W}_{i,t}$, to maximize

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta_w^k \left(U_i(C_{i,t}) - V_i(L^{\ell}_{i,t+k|t}) \right), \tag{21}$$

where

$$L^{\ell}_{i,t+k|t} = \left(\frac{\overline{W}_{i,t}}{W_{i,t+k}} \right)^{-\epsilon_w} L_{i,t+k} \tag{22}$$

denotes labor demand in period $t+k$ for a wage setter that last reset its wage in period t.

The optimal reset nominal wage has to be such that the following first-order condition holds:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta_w^k L^{\ell}_{i,t+k|t} U_i'(C_{i,t+k}) \left(\frac{\overline{W}_{i,t}}{P^C_{i,t+k}} - \frac{\epsilon_w}{\epsilon_w - 1} \frac{V_i'(L^{\ell}_{i,t+k|t})}{U_i'(C_{i,t+k})} \right) = 0. \tag{23}$$

Note that in the case in which workers can adjust wages in every period, $\theta_w^k = 0$, then we obtain the usual optimality condition that equates the real wage, $\overline{W}_{i,t}/P^C_{i,t}$, to the marginal rate of substitution, $V_i'(L^{\ell}_{i,t+k|t})/U_i'(C_{i,t+k})$, adjusted by the monopolistic distortion associated with a positive markup, $\epsilon_w/(\epsilon_w - 1)$. Since a measure θ_w of firms keep their price unchanged and $1-\theta$ reset it optimally, the aggregate wage index, $W_{i,t}$, is such that $W_{i,t}^{1-\epsilon_w} = \theta_w (W_{i,t-1})^{1-\epsilon_w} + (1-\theta_w)(\overline{W}_{i,t})^{1-\epsilon_w}$.

4.2 Firms

There are two types of firms in each country. For the first type, a unit continuum of firms indexed by $v \in [0,1]$ produce differentiated goods that cannot be traded across borders. In country i, these goods are produced using the homogeneous labor supplied in country i and a bundle of intermediate inputs. The second class of firms consists of perfectly competitive identical retail firms that produce a final homogeneous good that can be traded internationally, subject to trade costs. These firms produce tradable goods by aggregating the differentiated goods produced by domestic firms. We first describe the technology and problem faced by the first type of firms and then proceed to describe these issues for the second type.

4.2.1 Differentiated Firms: Nontradables

Firm $v \in [0, 1]$ in country i produces nontradable goods according to the production function

$$Y_{i,t}^{v} = A_{i,t}\left[(1-\nu)^{\frac{1}{\varepsilon_y}} {L_{i,t}^{v}}^{\frac{\varepsilon_y - 1}{\varepsilon_y}} + \nu^{\frac{1}{\varepsilon_y}} {M_{i,t}^{v}}^{\frac{\varepsilon_y - 1}{\varepsilon_y}}\right]^{\frac{\varepsilon_y}{\varepsilon_y - 1}}, \tag{24}$$

where $A_{i,t}$ denotes exogenous productivity that does not vary across firms, $L_{i,t}^{v}$ is labor input, and $M_{i,t}^{v}$ is the amount of an intermediate input bundle used in production.[31] The intermediate input, in turn, consists of an aggregate of goods produced in all countries according to the CES aggregator specified in (1) for $Q = M$. Note that, as long as $\eta^{M} < \infty$, intermediate inputs are not perfectly substitutable across countries.

Given prices of country-specific tradable goods in global markets, $\{P_{i,t}\}_{i=1}^{N}$, retail firms in country i will seek to minimize the total cost of intermediate inputs,

$$\sum_{h=1}^{N} \tau_{ih,t}^{M} P_{ih,t} M_{ih,t}, \tag{25}$$

subject to (1) for $Q = M$ and for a given level of $M_{i,t}$. As for the case of the trade costs faced by households, we assume that the trade costs faced by firms are comprised of exogenous iceberg trade costs, $d_{ih,t}^{M} \geq 1$, and exogenous *ad valorem* tariffs, $\kappa_{ih,t}^{M} \geq 0$, such that total trade costs are $\tau_{ih,t}^{M} = d_{ih,t}^{M}(1 + \kappa_{ih,t}^{M})$. The solution to the minimization problem yields demands for goods from different countries, $M_{ih,t}$, according to (3), with an ideal price index for the intermediate input bundle, $P_{i,t}^{M}$, as specified in (4) for $Q = M$.

Note that, even though households and firms import exactly the same good from any given country, they pay different prices to the extent that trade costs differ between final and intermediate goods.

Differentiated firms choose the amount of labor and the intermediate input bundle to minimize

[31] We will restrict attention to a first-order approximation of the model and ignore second-order price dispersion terms. Hence, in this section, we can treat the aggregate production function as being analogous to the individual-producer production function (the difference between the two arises from price dispersion and is therefore of second order).

total production costs given by

$$W_{i,t}L^v_{i,t} + P^M_{i,t}M^v_{i,t}, \tag{26}$$

subject to (24). Given nominal wages and the price of the intermediate input bundle in country i, $P^M_{i,t}$, the solution to the cost minimization problem delivers the marginal cost faced by retail firms, which is the same across firms and given by

$$MC_{i,t} = \frac{1}{A_{i,t}}\left[(1-\nu){W_{i,t}}^{1-\varepsilon_y} + \nu(P^M_{i,t})^{1-\varepsilon_y}\right]^{\frac{1}{1-\varepsilon_y}}. \tag{27}$$

Note that changes in trade costs of intermediate inputs affect the nominal marginal cost of the firms directly through their effects on the price of the intermediate input bundle, $P^M_{i,t}$. Therefore, an increase in trade costs leading to a higher $P^M_{i,t}$ will increase firms' marginal costs and decrease production efficiency. Before analyzing the price-setting behavior by firms producing differentiated goods, we describe the technology and problem of the representative retailer producing the homogeneous tradable good.

4.2.2 Retail Firms: Tradables

To produce tradable goods, the representative retail firm in country i aggregates differentiated goods available in i according to

$$Y_{i,t} = \left(\int_0^1 {Y^v_{i,t}}^{\frac{\epsilon-1}{\epsilon}} dv\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{28}$$

where $\epsilon > 0$. The output of the homogeneous good in country i can then be used for final consumption or as an intermediate input in the production of differentiated goods, either domestically or abroad.

Given the prices of different varieties, final good producers maximize profits subject to (28). The solution to this maximization problem delivers the demand for variety v in country i:

$$Y^v_{i,t} = \left(\frac{P^v_{i,t}}{P_{i,t}}\right)^{-\epsilon} Y_{i,t}, \tag{29}$$

where

$$P_{i,t} = \left[\int_0^1 P_{i,t}^{v\ 1-\epsilon} dv \right]^{\frac{1}{1-\epsilon}} \tag{30}$$

defines the nominal price of a unit of the homogeneous good produced in country i in terms of its own currency, and $P_{i,t}^v$ denotes the nominal price charged by firm v in country i, also in terms of local currency units. As stated in section 2.2, excluding trade costs, the price of country i's imports from any country h is given by the price country h producers set domestically, adjusted for the exchange rate between the two countries. Accordingly,

$$P_{ih,t} = \mathcal{E}_{ih,t} P_{h,t}. \tag{31}$$

4.2.3 Price Setting by Differentiated Firms

Differentiated firms, in country i, set prices to sell their goods to retailers.[32] However, in line with our assumption of staggered wage adjustments, we assume that firm v can only reset its price in period t with probability $1-\theta$, and with probability θ it must keep its price unchanged relative to last year's.

Let $\overline{P}_{i,t}$ denote the optimal price for a firm that is able to reset its price in period t. Such a firm in country i will set this price to maximize

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta^k \frac{U'_{i,t}(C_{i,t})}{P_{i,t+k}^C} \left(\overline{P}_{i,t} - MC_{i,t+k} \right) \left(\frac{\overline{P}_{i,t}}{P_{i,t+k}} \right)^{-\epsilon} Y_{i,t+k}, \tag{32}$$

where the marginal cost is specified in (27). The optimal price set by those firms able to adjust prices must be such that the following optimality condition holds:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta^k \frac{U'_{i,t}(C_{i,t})}{P_{i,t+j}^C} P_{i,t+k}^{\epsilon} Y_{i,t+k} \left[\overline{P}_{i,t} - \frac{\epsilon}{\epsilon-1} MC_{i,t+k} \right] = 0. \tag{33}$$

Note that under flexible prices ($\theta = 0$), this condition reduces to the usual pricing condition, setting prices equal to a markup over marginal cost. Since a measure θ of firms keep their price unchanged and $1-\theta$ reset prices optimally, from (30) we obtain that $P_{i,t}$ satisfies the law of motion

[32] Note that in this model, firms engaging in international trade are perfectly competitive. Therefore, firms do not set prices in international markets. However, our assumptions are equivalent to allowing for price setting in international markets under producer currency pricing (PCP). That is, firms set prices in the currency of the country in which they produce and let their prices in the foreign currency adjust with the exchange rate.

$P_{i,t}^{1-\epsilon} = \theta P_{i,t-1}^{1-\epsilon} + (1-\theta)\overline{P}_{i,t}^{1-\epsilon}.$

4.3 Monetary policy

We assume that central banks in all countries follow conventional Taylor-type monetary policy rules. More specifically, the central bank in country i sets the nominal interest rate according to the inertial policy rule given by

$$R_{i,t} = (R_{i,t-1})^{\phi_r} \left(\frac{1}{\beta} (\pi_{i,t})^{\phi_\pi} \left(\frac{GDP_{i,t}}{GDP_{i,t}^{flex}} \right)^{\phi_y} \varepsilon_{i,t}^r \right)^{1-\phi_r}, \tag{34}$$

where $GDP_{i,t}$ denotes real value added in country i, and $GDP_{i,t}^{flex}$ corresponds to the same object in the potential economy with flexible prices.[33] In (34), $\phi^r > 0$ determines the inertia in the monetary policy response, $\phi^\pi > 0$ and $\phi^y > 0$ parameterize the elasticities of the policy rate with respect to changes in inflation and GDP deviations from the central banks zero inflation target and the natural level of GDP, respectively; $\varepsilon_{i,t}^r$ is an exogenous shock to the monetary policy rule.

4.4 Market clearing and balance of payments

Tradable goods produced in country i are sold either domestically or abroad to country i's trading partners. Domestic or foreign buyers of these goods then consume them or use them as intermediate inputs. Hence, the market-clearing conditions for these goods are given by

$$\xi_i Y_{i,t} = \sum_{h=1}^{N} \xi_h (d_{hi,t}^C C_{hi,t} + d_{hi,t}^M M_{hi,t}) \tag{35}$$

for $i = 1, ...N$, where the population terms ξ_i reflect the fact that all variables are expressed in per-capita terms. Note that (35) accounts for the goods that are lost when traded across countries because of the iceberg-type trade costs $d_{hi,t}^Q \geq 1$ for $Q \in \{C, M\}$.

We can derive the balance of payments condition for every country i, other than country 1 ($i \neq 1$), that determines the evolution of their holdings of dollar-denominated bonds. To do so, we

[33] Real value added in country i is given by $GDP_{i,t} = \frac{P_{i,t}}{P_{i,t}^C} Y_{i,t} - \frac{P_{i,t}^M}{P_{i,t}^C} M_{i,t}$.

aggregate domestic budget constraints and obtain

$$\sum_{h=1}^{N} \tau^{C}_{ih,t} P_{ih,t} C_{ih,t} + \frac{B_{i1,t}}{\mathcal{E}_{1i,t}} = W_{i,t} L_{i,t} + R_{1,t-1} \Psi_{i,t-1} \frac{B_{i1,t-1}}{\mathcal{E}_{1i,t}} + T_{i,t}, \tag{36}$$

where transfers to households in country i include tariff revenues that are rebated lump-sum to households,

$$\mathcal{K}_{i,t} = \sum_{h=1}^{N} \left(\kappa^{C}_{ih,t} \frac{\tau^{C}_{ih,t} P_{ih,t} C_{ih,t}}{1 + \kappa^{C}_{ih,t}} + \kappa^{M}_{ih,t} \frac{\tau^{M}_{ih,t} P_{ih,t} M_{ih,t}}{1 + \kappa^{M}_{ih,t}} \right), \tag{37}$$

and firms profits, $\Pi_{i,t}$, such that $T_{i,t} = \mathcal{K}_{i,t} + \Pi_{i,t}$. Given that profits are given by $\Pi_{i,t} = P_{i,t} Y_{i,t} - W_{i,t} L_{i,t} - \sum_{h=1}^{N} \tau^{M}_{ih,t} P_{ih,t} M_{ih,t}$, (36) can be rewritten as

$$\sum_{h=1}^{N} d^{C}_{ih,t} P_{ih,t} C_{ih,t} + \frac{B_{i1,t}}{\mathcal{E}_{1i,t}} = P_{i,t} Y_{i,t} - \sum_{h=1}^{N} d^{M}_{ih,t} P_{ih,t} M_{ih,t} + R_{1,t-1} \Psi_{i,t-1} \frac{B_{i1,t-1}}{\mathcal{E}_{1i,t}}, \tag{38}$$

which does not depend on tariffs because we have imposed that all tariff revenues are rebated lump-sum to households, which is equivalent to the government running a balanced budget. Hence, we obtain that the evolution of holdings of U.S. bonds for country i—prescribed by the balance-of-payments condition—is given by

$$B_{i1,t} - B_{i1,t-1} = \mathcal{E}_{1i,t} \left(EX_{i,t} - IM_{i,t} \right) + \left(R_{1,t-1} \Psi_{i,t-1} - 1 \right) B_{i1,t-1}, \tag{39}$$

where $EX_{i,t} = P_{i,t} Y_{i,t} - P_{i,t} C_{ii,t} - P_{ii,t} M_{ii,t}$ and $IM_{i,t} = \sum_{h \neq i} d^{C}_{ih,t} P_{ih,t} C_{ih,t} + \sum_{h \neq i} d^{M}_{ih,t} P_{ih,t} M_{ih,t}$, denote exports and imports. Condition (39) simply states that country i's current account is equal to its trade balance plus its net foreign investment income.

4.5 Calibration

Our baseline calibration considers five country blocks, $N = 5$, with countries 1 through 5 representing the United States, China, the advanced non-U.S. economies, the Asian emerging market economies, and the rest of the emerging market economies, respectively. Our calibration strategy restricts heterogeneity across countries in steady state to two sets of parameters: countries' sizes, ξ_i, and degrees of openness determined by countries' levels of bilateral trade costs in steady state as discussed in this section. All other values of model parameters will be the same across countries. By following this strategy, we aim to elucidate the common mechanisms across countries that shape the effects of trade costs shocks on inflation and other macroeconomic outcomes.

For households' preferences, we allow for habit formation in consumption. Thus, we consider a more general case than in the model presented in section 4, and replace $U_i(C_{i,t})$ with

$$U_i(C_{i,t}, C_{i,t-1}) = \frac{(C_{i,t} - hC_{i,t-1})^{1-\sigma} - 1}{1-\sigma},$$

where $h \geq 0$ modulates the degree of habit formation and $\sigma > 0$ is the inverse of the intertemporal elasticity of substitution (IES). For the disutility of labor, we choose the functional form

$$V_i(L^{\ell}_{i,t}) = \frac{{L^{\ell}_{i,t}}^{1+\varphi}}{1+\varphi},$$

where $\varphi > 0$ is the inverse of the labor supply elasticity.

The population parameters, ξ_i, are set to replicate the weights of these five regions in world GDP. For our numerical experiments, we consider a log-linear approximation of the model around its steady state under balanced trade. Hence, we assume that trade costs can be expressed as $\tau^Q_{ih,t} = \bar{\tau}^Q_{ih}\varepsilon^Q_{ih,t}$, where $\bar{\tau}^Q_{ih}$ are time-invariant parameters such that $\sum_{h=1}^{N}\left(\bar{\tau}^Q_{ih}\right)^{1-\eta^Q} = 1$ for all i, and $\varepsilon^Q_{ih,t}$ are stationary shocks to trade costs for $Q \in \{C, M\}$.[34] Note that, by equation (6), we have that in steady state $(\bar{\tau}^Q_{ih})^{1-\eta^Q} = \omega^Q_{ih}$, which implies we can recover the steady state level of the trade costs from observed trade shares.[35]

Given our assumption that trade is balanced in the steady state, we can only use half of the expenditure shares from the data to pin down the steady state trade costs, with the rest being determined by the restriction that trade must be balanced.[36] We choose the model's parameters by relying on previous literature or targeting long-run moments in the data. Table 1 lists the parameter values for our calibration. Starting with our choice for preference parameters, our values for the

[34] Note that the normalization $\sum_{h=1}^{N}\left(\bar{\tau}^Q_{ih}\right)^{1-\eta^Q} = 1$ for each country i differs from the normalization $\tau^Q_{ii,t} = 1$ that we assumed when constructing bilateral trade costs for the empirical analysis. The normalization choice is innocuous for the predictions of our model.

[35] In terms of the equilibrium conditions of the model, this assumption is equivalent to assuming that equation (1) is given by

$$Q_{i,t} = \left(\sum_h (\omega^Q_{ih})^{\frac{1}{\eta^Q}} (Q_{ih,t})^{\frac{\eta^Q-1}{\eta^Q}}\right)^{\frac{\eta^Q}{\eta^Q-1}},$$

and $\tau^Q_{ih,t} = \varepsilon^Q_{ih,t}$ for $Q \in \{C, M\}$.

[36] The ω's can be chosen recursively such that a steady state with balanced trade and unity prices exists.

Table 1: Calibrated Parameters

Parameter	Description	Value
Preferences		
β	Discount factor	0.99
σ	Inverse IES	0.5
h	Habit	0.75
φ	Inverse labor supply elasticity	2
η^C	Elasticity of substitution for final consumption	5
ϵ	Elasticity of substitution across retailers	6
ϵ_w	Elasticity of substitution across labor varieties	6
Technology		
ν	Share of intermediates in production	0.4
ε_y	Elasticity of substitution labor-intermediates	0.5
η^m	Elasticity of substitution for intermediate inputs	5
Prices and wages		
θ	Price rigidity	0.8
θ_w	Wage rigidity	0.8
Monetary policy		
ϕ_π	Taylor rule inflation coefficient	1.5
ϕ_y	Taylor rule output coefficient	0.2
ϕ_r	Taylor rule inertia	0.75
ψ	Risk premium elasticity to NFA	0.001
Trade costs		
ρ_τ	Trade cost shock autocorrelation	0.95
Global Value Chain		
$[\omega^C_{11}, \omega^C_{12}, \omega^C_{13}, \omega^C_{14}]$	Consumption trade weights, country 1	[.94,.012,.004,.021]
$[\omega^M_{11}, \omega^M_{12}, \omega^M_{13}, \omega^M_{14}]$	Intermediates trade weights, country 1	[.88,.025,.007,.04]
$[\omega^C_{22}, \omega^C_{23}, \omega^C_{24}]$	Consumption trade weights, country 2	[.95,.009,.02]
$[\omega^M_{22}, \omega^M_{23}, \omega^M_{24}]$	Intermediates trade weights, country 2	[.94,.01,.014]
$[\omega^C_{33}, \omega^C_{34}]$	Consumption trade weights, country 3	[.94,.014]
$[\omega^M_{33}, \omega^M_{34}]$	Intermediates trade weights, country 3	[.81,.045]
ω^C_{44}	Consumption trade weights, country 4	.94
ω^M_{44}	Intermediates trade weights, country 4	.89
Country Sizes		
$[\xi_1, \xi_2, \xi_3, \xi_4, \xi_5]$	Region populations	[.20,.19,.19,.27,.14]

discount factor, β, the inverse of the IES, σ, habit formation, h, and the inverse of the labor supply elasticity, φ, are all standard in the literature on open economy macro models (Bodenstein et al., 2023). For the trade elasticity for final goods, η^C, and for the trade elasticity for intermediate, η^M inputs, we choose a value equal to 5, in line with the long-run trade elasticity we use to recover trade costs in Section 2.[37]

[37]Model predictions are little changed with the trade elasticity in the range of estimates in Boehm et al. (2023)

For the technological parameters, our choices are also standard and similar to those in the literature. Regarding the New Keynesian bloc of our model, the values for the elasticities of substitution across retailers and labor varieties (ϵ, ϵ_w), and for rigidities of prices and wages (θ, θ_w), come from (Bodenstein et al., 2023). To calibrate the technologies of differentiated firms, we follow Comin and Johnson (2020) and measure the share of value added to consumption from the U.S. National Income and Product Accounts to set the steady-state value of ν. We assume that labor and intermediate inputs are complementary ($\epsilon_y < 1$), and the trade elasticity for intermediates is equal to that of final goods. For the policy parameters, we assume standard values for the response of the policy rate to deviations of inflation from the central bank's target $\phi_\pi > 1$, the deviations of output from its natural level $\phi_y < 1$, and the persistence parameter $0 < \phi_r < 1$. We allow for a small amount of risk premia in steady-state $\psi > 0$, which implies that exogenous deviations from UIP have negligible macroeconomic implications.

For the parameters determining the trade shares, we set four parameters for the U.S., three for China, and so on, and let the trade balance condition in steady state determine the rest. We choose the values of these parameters based on data on global input-output linkages from the ICIO database. These values are shown at the bottom of Table 1.

5 The Transmission of Trade Cost Shocks

To highlight the model's predictions about the effects of trade disruptions, we first examine the impact of increasing trade costs in the model, mimicking the empirical analysis in Section 3. We explore the transmission mechanism of trade costs focusing on the U.S. and discuss the role of the monetary policy response in shaping the response to tariffs and iceberg trade costs.

5.1 Model vs Data

In Section 3, we showed that higher trade costs lead to increased inflation and lower GDP. Here we compare our model to the data. Because our empirical specification is informative about the relative effects of higher trade costs across countries, it is not enough to compute a generic impulse response from the model. Instead, we exploit the multi-country nature of our model to construct relative impulse responses across regions to mimic Equation 11.

We use the model to simulate the average country in our dataset in terms of trade openness. We use region 1 in our model as a reference country and simulate a 10 percentage point increase in bilateral trade costs with all its trading partners. Relative to the calibration of Table 1, we adjust the trade shares to capture greater openness of the average country in the data relative to the U.S.[38] We collect the simulated path for the variables of interest in deviations from steady-state, $\hat{y}_{j,t+h}$, for $j = 1, \ldots, 5$ corresponding to the five regions in the model and $h = 1, \ldots, 20$, because our model's frequency is quarterly. The estimated effect of interest is given by $\frac{\sum_{j=2}^{N}(\hat{y}_{1,t+h} - \hat{y}_{j,t+h})}{N-1}$. Our calibration of trade shocks implies that trade-weighted U.S. import costs rise by twelve percentage points, while import costs of the other regions rise by about two percentage points on average. We repeat this simulation separately for trade costs affecting final goods and intermediate inputs.[39] This procedure ensures we construct a model estimate comparable to our empirical results.

Figure 6 shows the dynamic response of inflation (top panels) and GDP (bottom panels) in the model and in the data. The green-circled lines correspond to our model's simulations. The vertical whiskers depict the empirical estimates. The model's responses lie within the 70% confidence bands from our empirical results for nearly all horizons. One exception is that the inflation response following an increase in intermediate trade costs is somewhat less persistent in the model than in the data. This is partly due to substantial heterogeneity in inflation dynamics worldwide, which our model doesn't capture. Also, our model's reference country has a relatively low share of intermediates in production ($\nu = 0.4$) under our calibration. The share of intermediate inputs in production varies widely across countries and sectors (Reyes-Heroles et al., 2020). For instance, in manufacturing-intensive countries like China, the share of intermediates of production $\nu = 0.6$ amplifies the inflationary response to trade shocks on intermediate inputs. Inflation persistence also differs substantially around the world. In the U.S., pre-pandemic inflation dynamics were consistent with the view that households and firms put negligible weight on past inflation developments, whereas in other advanced economies inflation tends to be more persistent, perhaps because of greater price and wage indexation (de Michelis et al., 2024). We discuss the robustness of the model fit to various parameters in the Appendix D.

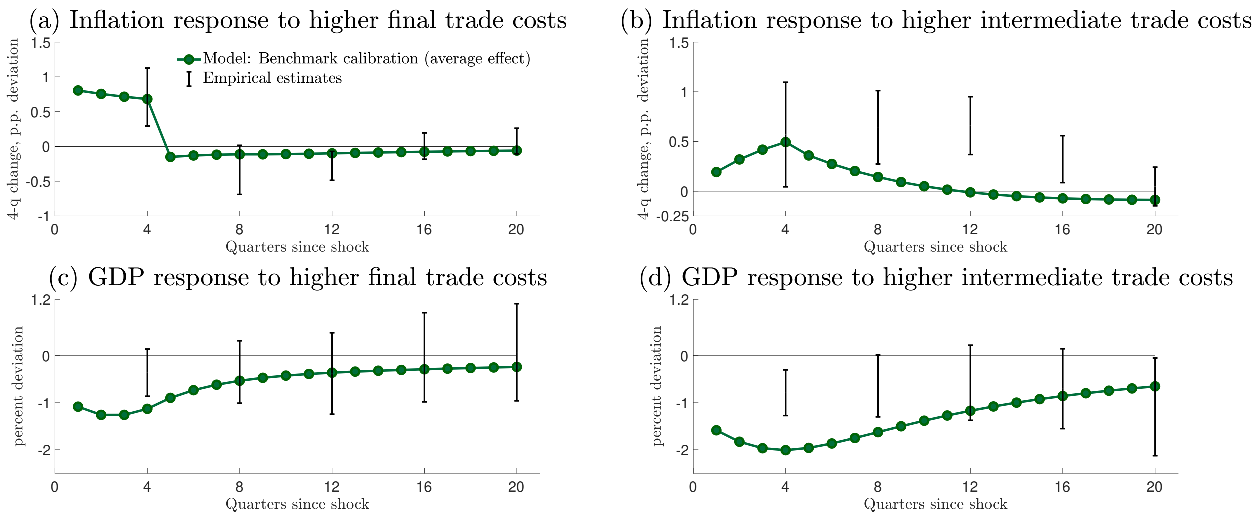
5.2 Unpacking the Mechanism

We now explore the transmission mechanism of higher trade costs and use the model to provide quantitative statements about the macroeconomic effects on a particular country. Hence, this

[38] We set the domestic sourcing share of country 1 to $\omega_{11} = 0.91$, and $\omega_{11}^{M} = 0.73$, and adjust the trade shares with other blocks accordingly to obtain an import-to-GDP ratio of 34%, while in the data the average import-to-GDP ratio across countries is 38.5% over the period 1995-2020.

[39] Alternatively we could estimate Equation 11 using model simulated data. However, our calibration imposes limited heterogeneity across countries for this approach to generate sufficient variation.

Figure 6: Model vs Data



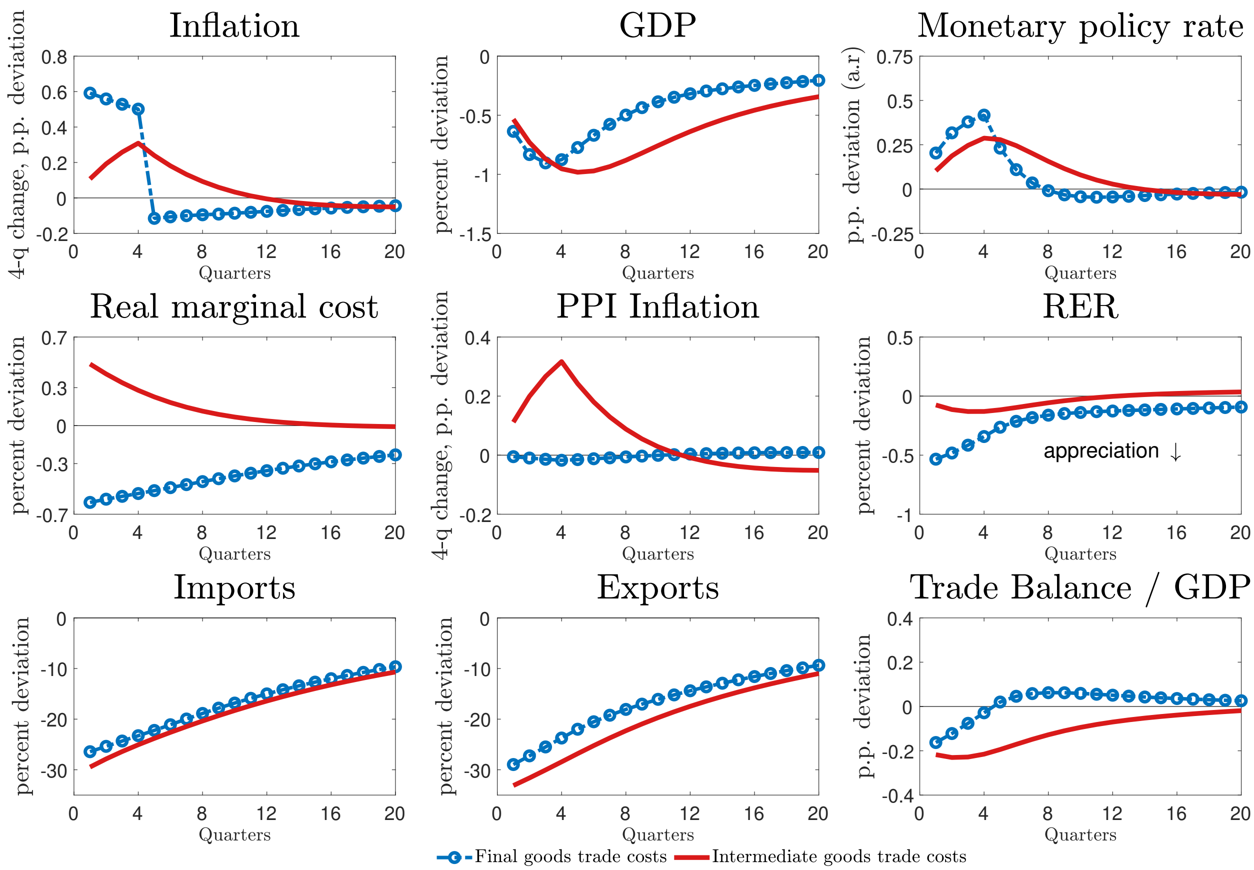
Note: Empirical and model-based estimates of the effects of a 10 percentage point increase in bilateral trade costs of the average country with all its trading partners. Trade shares in the simulation capture the average country's openness to trade in final goods and intermediate inputs. Vertical whiskers correspond to empirical estimates reported in Section 3.

experiment incorporates the global effects that were absorbed by the time-fixed effects when we estimated the panel local projections in (11) of Section 2. We focus on the United States under the calibration in Table 1 and consider a bilateral 10 percentage point increase in trade costs against all trading partners. We assume a symmetric increase in the trade costs foreigners pay for U.S. imports, in line with how we construct bilateral costs in our empirical analysis.

Figure 7 shows the dynamic effects of trade cost shocks to final consumption goods (blue circled line) and trade cost shocks to intermediate inputs (red solid line). The key observation is that when trade costs increase for consumption goods, inflation rises by about 0.5 percentage points in the first year, which is close to our empirical estimates for relative effects. However, the effects are short-lived, with 4-quarter inflation falling slightly below the steady state after four quarters. Thus, the effects are akin to a one-time increase in the price level that materializes upon impact of the shock and slowly reverts as the shock itself is unwound. In contrast, when the trade cost shock affects intermediate inputs, inflation initially rises 0.3 percentage points, but the effect is much more persistent. While the higher persistence is in line with our empirical estimates for relative effects, our macroeconomic estimate of the effects on CPI inflation after one year (0.3) is approximately half of our relative estimate (0.58), implying that the time-fixed effects $\delta_{t,h}^{M}$ absorbed a significant part of the macroeconomic effects of an increase in import costs of intermediate inputs.

The more persistent inflation response arises because higher import costs raise domestic

Figure 7: Effects on the U.S. of a 10 p.p. increase in trade costs



Note: Effects of a 10 percentage point increase in the U.S.'s trade costs from all trading partners on final consumption goods (blue circled line) and intermediate inputs (red solid line).

producers' marginal costs—not only directly, through pricier imported inputs, but also indirectly via "second-round" effects in the input-output network. With higher input costs, more expensive domestic goods propagate through the global value chain. In each market, the effect mirrors an exogenous decline in aggregate total factor productivity or cost-push shock (Auclert et al., 2025; Werning et al., 2025). Although firms can substitute imported intermediate inputs with domestic alternatives, such as labor, these are imperfect substitutes, generating inefficiencies. As a result, real marginal cost increases. The persistent rise in real marginal cost leads to sustained inflation, which is amplified by sluggish price adjustments.

In contrast, increased trade costs for consumption goods lead to lower real wages and reduced marginal cost. GDP falls in both scenarios due to tighter monetary policy and weaker external demand, but the contraction in GDP is more pronounced in response to trade costs affecting intermediate inputs. Imports and exports contract sharply in both cases, with the trade balance deteriorating slightly in the initial periods, partly due to a mild exchange rate appreciation.[40]

To summarize, and in line with our empirical results, increases in trade costs lead to a contraction in GDP. Moreover, higher trade costs of intermediate inputs generate more persistent inflation relative to the inflationary effects of trade costs on final goods. This result has notable policy implications, as shocks leading to more persistent inflation may worsen the policy trade-off and create larger risks of partially de-anchoring longer-run inflation expectations.

5.3 Trade Costs and Monetary Rules

In this section, we compare the effects of higher trade costs under our baseline monetary policy rule—which responds to CPI inflation, that is, inflation in the consumer price index inclusive of imported final consumption goods—to an alternative rule that responds to inflation of domestically-produced goods only, which we label PPI rule (for producer price index). Such a rule is attractive because it is easy to implement and has been shown to have desirable stabilization properties in open economies.[41] In the context of monetary policy, an often-cited appeal of this type of rule is that it "sees through" temporary increases in inflation driven by the imposition of tariffs.[42] We show here that the presence of trade costs on intermediate inputs calls that reasoning into question.

The top row of Figure 8 compares outcomes under our baseline CPI rule (blue circled lines) with those under the PPI rule (green dotted lines), when trade costs apply only to final consumption goods.[43] Under the CPI rule, the monetary policy rate rises significantly, while under the PPI rule the policy rate barely moves. Thus, monetary policy effectively "sees through" the inflation increase due to trade costs, resulting in a noticeably smaller GDP decline in the short run. The second row performs the same experiment, now with trade costs on intermediate inputs. In stark contrast to the previous case, the outcomes are now virtually identical under both rules, with higher trade costs leading to persistently higher inflation and persistently lower GDP. The reason is that higher trade costs on intermediate inputs lead to higher marginal costs for all domestic producers, which are eventually passed through as higher prices of domestic goods. Thus, in the presence of trade costs on intermediate inputs, a PPI rule will not effectively see through the increase in trade

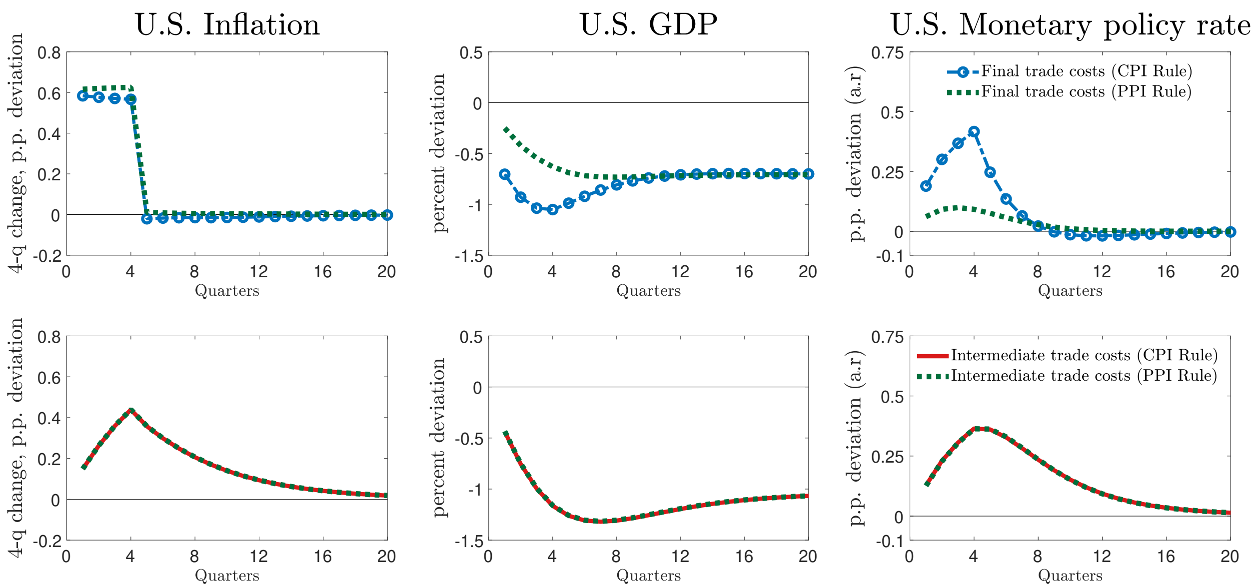
[40] This appreciation is in line with our empirical estimates in Appendix C.

[41] See Corsetti et al. (2010)

[42] See, for example, the Risks and Uncertainty section of the September 2018 Tealbook published by the Federal Reserve Board.

[43] We assume here that the increase in trade costs is permanent, which resembles the imposition of a permanent tariff by the home country. See Appendix E for the case when trade costs are transitory.

Figure 8: CPI vs. PPI Targeting with Permanent Increase in Trade Costs



Note: Effects of a permanent 10 percentage point increase in the U.S.'s trade costs from all trading partners under alternative monetary policy rules.

costs.

Our analysis of the monetary policy response to trade costs relates to recent work focusing on the effect of tariffs (Bergin and Corsetti, 2023; Bianchi and Coulibaly, 2025; Werning et al., 2025). Tariffs can be seen as policy-induced trade costs that, in addition to generating inefficiencies, raise government revenue. Hence, as discussed in the previous section, higher tariffs should lower GDP net of tariff revenues and increase inflation. One additional difference is that, in contrast to trade costs, tariffs do not generate resource costs, as shown in Equation 39. Nonetheless, the performance of the PPI targeting rule in response to higher tariffs is qualitatively similar to the results presented for higher trade costs. In Appendix F, we repeat the experiment in this section and show that higher tariffs on intermediate inputs also worsen monetary policy trade-offs.

6 Quantifying the Effect of Trade Shocks

The model developed and calibrated in Section 4 is particularly well suited to analyze the effects of changes in trade costs on inflation and GDP during two salient episodes: the U.S.-China Trade war of 2018-2019 and the post-pandemic inflation surge of 2020-2023. In this section, we use our model to quantify the inflationary effects of trade costs during these two recent events and emphasize the features of our model that make it optimal to carry out these analyses.

6.1 U.S.-China Trade War: 2018-2019

In 2018 and 2019, the U.S. and China imposed tariffs and other trade barriers on each other, and reached a partial agreement in 2020. We use our multi-country model to gauge the implications of increased trade barriers between these countries. Two key features of our model make it ideal to analyze these implications. First, relative to a two-country model, our multi-country model can incorporate the trade diversion patterns generated by the bilateral nature of the U.S.-China trade war. Second, our model allows for differences in changes in tariffs between final and intermediate goods—a feature of the 2018-19 U.S.-China trade war (Bown, 2021). Measured changes in tariffs, together with changes in our measure of U.S.-China bilateral trade costs between 2018 and 2019, allow us to construct shocks that are tailor-made to be fed into our model.

We calibrate the size of the trade shocks based on the tariffs imposed by the U.S. on China and China's retaliatory response to the U.S. (Fajgelbaum et al., 2019; Bown, 2021). Table 2 summarizes our calibration. Throughout the various waves of the trade dispute, the U.S. increased tariffs on Chinese imports by 20 percentage points. In response, China raised tariffs on U.S. exports by 10 percentage points. We target these average tariff changes and assume that in the model, the U.S. imposes a 13 percent tariff on final goods and a 25 percent tariff on intermediate inputs imported from China. This choice reflects the actual nature of the trade war, with approximately two-thirds of imported goods affected by U.S. tariffs being intermediate inputs (Fajgelbaum and Khandelwal, 2022). In terms of retaliation, we assume that China imposes a tariff of 10 percent on final goods and of 15 percent on intermediate inputs. This assumption reflects that China's response was, on average, half of the U.S. action and was targeted towards U.S. intermediate exports. Our calibration implies that the average bilateral tariff increase for each good-type—more precisely, the geometric average of bilateral tariffs, which is in line with our measure of bilateral trade costs in (8)—matches the observed increase in the bilateral trade costs we recovered from the data in Section 2. In the simulation, the tariff increases are transitory, with an expected duration of five years, as in our baseline calibration.

In our simulation, U.S. inflation rises, and U.S. GDP growth slows (Figure 9). The effect on inflation is significant: The increase in trade costs drives U.S. inflation up by 0.3 percentage points above the baseline and causes it to remain persistently elevated. The contribution of trade costs in final goods (the blue bars) is short-lived and vanishes after a year.[44] By contrast, the contribution

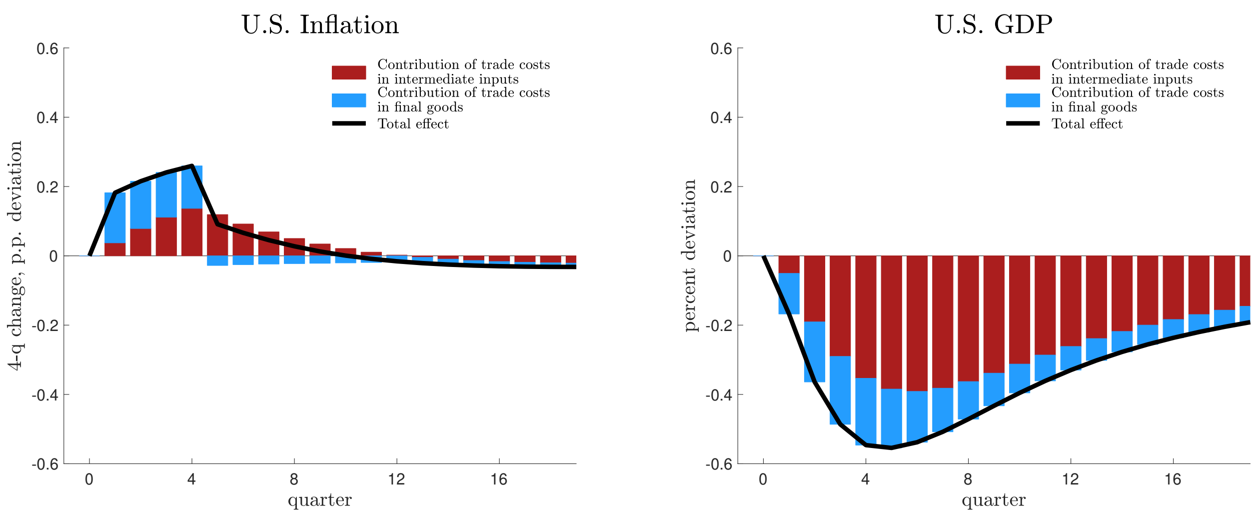
[44]The figure shows four-quarter inflation rates. Therefore, a one-time rise in the price level occurring in the initial quarter shows up as an increase in four-quarter inflation for the following four quarters.

Table 2: Calibration of U.S.-China Trade War Simulation

	Tariffs			Trade Costs
	U.S. → China (a)	China → U.S. (b)	Average tariff $[(1+a)(1+b)]^{\frac{1}{2}}-1$	U.S. ↔ China (2018-2019)
Final Goods	13	10	11	10.9
Intermediate Inputs	25	15	20	19.7
Trade weighted average	21	10	11	10.9

of higher trade costs in intermediates (the red bars) induces a persistently elevated inflation rate. As the costs of importing inputs from China rise, U.S. firms react by making greater use of inputs sourced from other regions, including the U.S. itself. These different inputs, however, are not perfect substitutes for inputs imported from China, leading to lower production efficiency for U.S. firms. Consequently, U.S. marginal costs increase persistently, resulting in higher inflation for longer. The associated higher policy rates contribute to a persistent drag on GDP relative to the baseline (right panel).

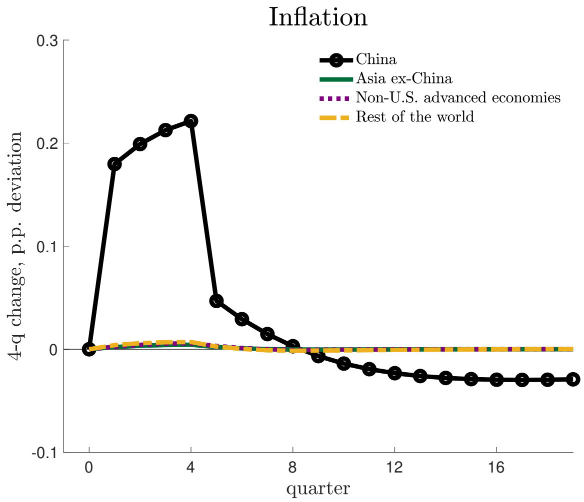
Figure 9: Increase in U.S.-China trade costs, effects on U.S.



Note: The figure shows the effects of an 13 and 25 percentage point increase in U.S. tariffs on Chinese imports of final and intermediate goods, respectively, together with increases of 10 and 15 percentage points in China's imports from the U.S. of final and intermediate goods, respectively. The blue bars show the contributions of final goods trade costs, and the red bars show the contributions of intermediate goods trade costs.

Figure 10 shows the effects on inflation and GDP in China and the rest of the non-U.S. regions. China experienced a larger hit to GDP than the U.S. did and a smaller increase in inflation. These facts reflect that China's retaliation was only partial, and that exports constitute a larger

Figure 10: Increase in U.S.-China trade costs, effects on non-U.S. regions



Note: The figure shows the effects of a 13 and 25 percentage point increase in U.S. tariffs on Chinese imports of final and intermediate goods, respectively, together with increases of 10 and 15 percentage points in China's imports from the U.S. of final and intermediate goods, respectively. The impulse responses show the response of inflation and GDP for China in black, Asian economies excluding China in green, advanced economies excluding the U.S. in purple, and the rest of the world in yellow.

share of China's GDP compared to the U.S. The GDP in regions other than the U.S. and China experienced a boost, as firms and households in the U.S. and China partially diverted trade flows toward imports from these countries. The non-U.S. advanced economies, which have the U.S. as an important trading partner, as well as the rest of the world, experienced larger activity increases compared to the non-China Asian economies. In turn, inflation rises in the foreign economies—reflecting both higher input costs and some depreciation of their currencies against the dollar—but the increase is very modest.

6.2 Post-Pandemic Trade Costs and Inflation

In this section, we explore the contribution of trade cost shocks during the 2021-2022 surge in U.S. inflation, in the aftermath of the COVID-19 pandemic. This period provides a natural laboratory to explore the inflationary effects of disruptions in trade flows resulting from factors such as supply chain disruptions, bottlenecks, and higher shipping costs among others. All these factors are captured by iceberg trade cost shocks in our model, which we separately identify from other supply and demand forces at play during this period.

To quantify the contributions of trade cost shocks, domestic shocks, and foreign shocks in driving U.S. inflation and GDP growth during 2021-2022, we rely on a two-country version of our model. Restricting ourselves to two countries allows us to estimate the model using quarterly data for the U.S. and a ROW aggregate. We construct quarterly series starting in 1999 for U.S. domestic sourcing shares of final and intermediate goods, which, together with other more common macroeconomic series, permit us to quantify the role of trade cost shocks.

Data. Relative to our analysis in Section 2, we assemble novel quarterly data on the evolution of U.S. domestic sourcing shares in final goods and intermediate inputs. Constructing quarterly sourcing shares is challenging because gross output measures at such a frequency are generally unavailable. We follow a procedure similar to Eaton et al. (2016b) to overcome this challenge.[45] Figure 11 shows the evolution of our quarterly measure of the domestic sourcing shares. The blue line is the domestic sourcing share in final goods, and the red line is the sourcing share in intermediate inputs. Domestic sourcing shares declined through 2008, consistent with the continuing expansion of global trade. Thereafter, the sourcing share for final goods remained steady, whereas the domestic sourcing share in intermediate inputs trended upward, in line with the slowdown in globalization. Relative to the related analysis by Comin and Johnson (2020) using annual data for the U.S., our quarterly measure has the advantage of capturing higher frequency movements in sourcing shares, which are key to teasing out the different drivers of inflation.[46]

In addition to the new series on domestic sourcing shares, we estimate the model using standard macroeconomic variables. For both blocs, we collect quarterly real GDP growth and CPI inflation and a measure of nominal interest rates.[47] We measure the RoW aggregate as a trade-weighted average of the major U.S. trading partners as in Bodenstein et al. (2023). Appendix G provides additional details and data sources.

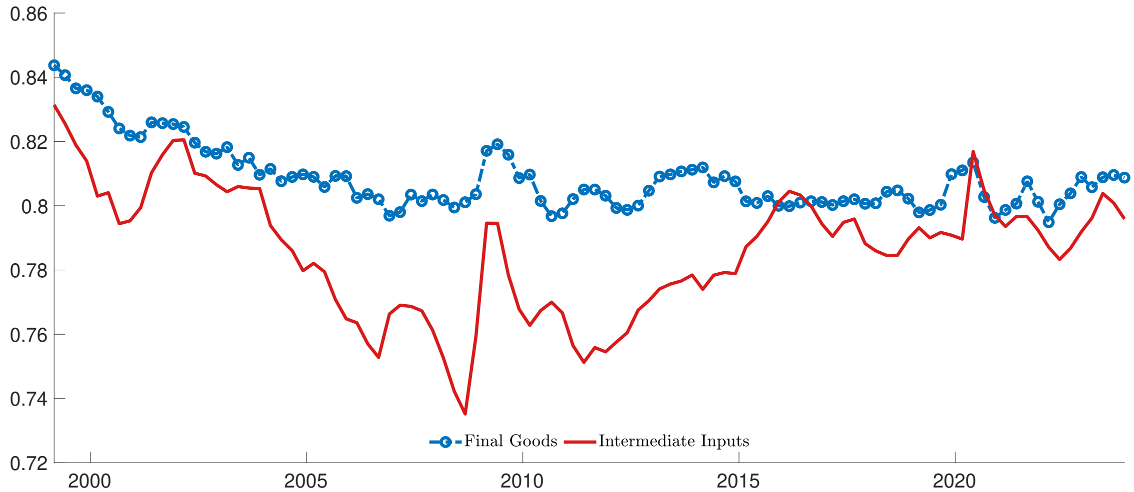
Shock inference and identification. We maintain the model calibration reported in Table 1. In addition to trade cost shocks, we incorporate three additional shocks: technology, domestic demand, and monetary policy shocks. These shocks follow an autoregressive process with normally distributed innovations. We use a two-step Bayesian inference procedure to estimate the parameters governing these shocks and the realized unobserved disturbances. First, we estimate the shock process parameters using data from 1999:Q1 to 2019:Q4, avoiding outliers induced by the pandemic lockdown in 2020. Second, we extend our sample through 2023:Q4 to recover the full time series

[45] As in Section 2, we focus on manufacturing industries and interpolate annual figures from the BEA's input-output tables using industrial production. See Appendix G.2.

[46] Because manufacturing industries are more tradable than services, the sourcing shares are lower relative to the whole U.S. economy. We link the demeaned sourcing shares in the data to the model. See Appendix G for details.

[47] For the U.S., we use the Wu-Xia shadow federal funds rate to account for the tightness of monetary policy during the period of zero interest rates. For the countries in the rest of the world, we use a short-term nominal interest rate or policy rate when available.

Figure 11: U.S. Quarterly Domestic Sourcing Shares



Notes: U.S. sourcing shares interpolated from BEA input-output tables. The blue line corresponds to the domestic sourcing share of final goods. The red line depicts the domestic sourcing share for intermediate inputs. Sourcing shares corresponds to tradable sectors in accordance with the standard NICS classification. See Appendix G for details.

of smoothed shocks. See Appendix G for details and parameter estimates.

Figure 12 shows that data on domestic sourcing shares are central to identifying trade cost shocks and differentiating their contribution from other sources of aggregate supply fluctuations. The figure shows impulse responses to a total factor productivity shock (blue line), a trade cost shock for final goods (red line), and a trade cost shock for intermediate inputs (yellow line).

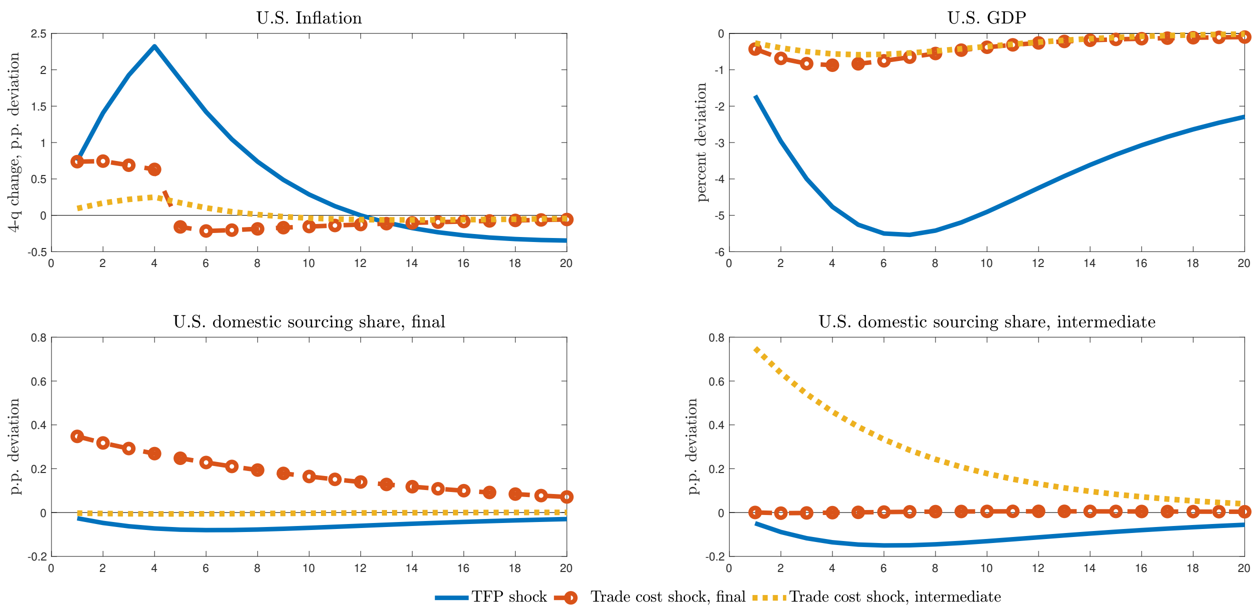
The main source of identification comes from the correlation between inflation and GDP with domestic sourcing shares. As shown in the top panels of Figure 12, adverse total factor productivity shocks and adverse trade costs shocks produce a negative correlation between inflation and GDP, but the magnitude of the effects is quite different. Total factor productivity shocks have stronger and more persistent effects on these variables relative to the impact of trade cost shocks. Importantly, as shown by the bottom panels, total factor productivity shocks lower the domestic sourcing share through the expenditure switching channel induced by the appreciation of the exchange rate. In contrast, trade cost shocks have the opposite effect on the domestic sourcing shares, with adverse trade cost shocks generating an increase in the domestic sourcing shares induced by the reallocation of demand for final goods and intermediate inputs produced domestically. In addition, trade costs shocks generate large movements in sourcing shares and relatively modest changes in GDP and inflation, while the converse is true for TFP shocks. These observations help understand how the model identifies the historical contributions of these shocks to inflation, discussed next.[48]

Shock decomposition. Exploiting the identification from the domestic sourcing shares we analyze the drivers of inflation in the post-pandemic period. Figure 13 shows the shock decomposition of inflation and GDP growth for the period 2018:Q1-2023:Q4. For ease of interpretation, we classify shocks into three groups: *trade costs shocks*, combining trade costs to final goods and intermediate inputs; *domestic shocks*, collecting shocks to total factor productivity, consumption demand, and monetary policy; *foreign shocks*, which encompass all disturbances originating in the foreign economy, including shocks to the UIP condition.

Our estimates reveal that trade costs significantly influenced inflation dynamics during the pandemic and its aftermath. In the early stages, higher trade costs helped counteract deflationary pressures from collapsing demand. As the economy reopened, trade costs partially retraced, alleviating inflationary pressures. Most U.S. inflation in the later part of 2021 and the first half of 2022 stemmed from domestic factors, while trade cost shocks had a more limited effect during

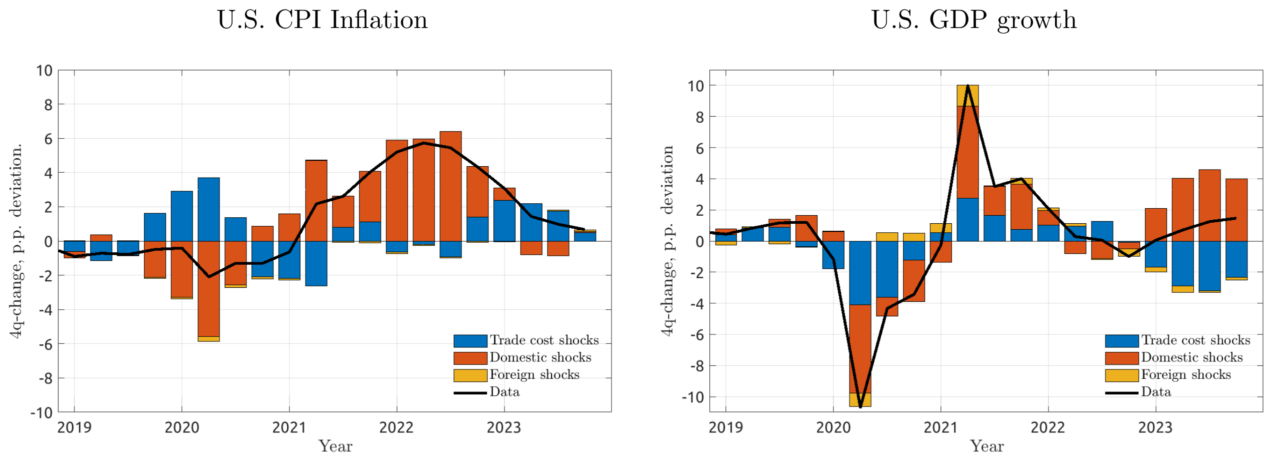
[48] Appendix A.13 shows impulse responses to demand-side shocks in the estimated model.

Figure 12: Identification of Trade Cost Shocks



Notes: Impulse response to a one standard deviation to total factor productivity shock (blue), trade cost shock for final goods (red), trade cost shock for intermediate inputs (yellow). Model calibrated at the estimated posterior mean parameters in Table A.3

Figure 13: Decomposition of U.S. CPI and U.S. GDP Growth



Notes: The black solid lines correspond to four quarter changes in the U.S. Consumer Price Index (left panel) and on U.S. real GDP (right panel) in deviations from the sample average over 1999:Q1-2019:Q4. The bars represent the contribution of trade costs (blue), U.S. shocks (red), and foreign shocks (yellow). U.S. shocks correspond to TFP, consumption preferences, and monetary policy shocks. Foreign shocks are the counterpart but also include UIP shocks. All shocks are estimated with the Kalman smoother and with the model calibrated with the estimated posterior mean parameters in Table A.3.

this stage of the inflation surge.[49] Starting in the second half of 2022 and afterwards—in line with signs of trade fragmentation following the Russian invasion of Ukraine and tensions in the Middle East—increases in trade costs hindered the disinflation process, contributing approximately one percentage point to additional inflation in 2022 and driving much of the inflation persistence in 2023.

Trade shocks also had a notable contribution to economic activity. The right panel of Figure 13 shows the shock decomposition for U.S. GDP growth. Higher trade costs lowered U.S. GDP growth at the onset of the pandemic in 2020; their reversal boosted activity in 2021 and 2022, and higher trade costs became a drag for growth in 2023.

7 Conclusions

We provide evidence that the macroeconomic effects of higher import costs are akin to negative supply shocks, leading to higher CPI inflation and lower GDP growth. On impact, a 10 percentage point increase in a country's import costs relative to another country leads to a 1.2 percentage point

[49] We do not aim to decompose supply vs demand factors, Bianchi et al. (2023), Barro and Bianchi (2024), and Giannone and Primiceri (2024) emphasize the role of fiscal and other demand shocks, while Blanchard and Bernanke (2023) and Gagliardone and Gertler (2023) underline the role of supply shocks.

($\approx 0.65 + 0.58$) relative increase in CPI inflation. Interestingly, we also document that these effects depend on the type of good—either final or intermediate—affected by the increase in import costs, with higher trade costs for intermediate inputs leading to significantly more persistent increases in inflation relative to those for final goods. We are able to document these facts by considering shocks to a broad measure of trade costs that we construct by exploiting static Gravity and data from global input-output tables. We estimate bilateral trade costs that can be compared consistently across countries and time, and then aggregate them into country-specific import costs that capture variation in both policy—such as tariffs—and non-policy—such as shipping costs—induced changes in trade costs.

We develop a dynamic trade model of inflation by embedding intertemporal trade in final and intermediate goods into a multi-country open economy model of inflation. Our approach to incorporate inflation dynamics relies on the off-the-shelf elements of models with staggered price and wage adjustments, as in the New Keynesian literature. Even under relatively stringent assumptions about heterogeneity across countries in our calibration, the model can replicate the empirical impulse responses we estimate in relative terms. Most importantly, our model allows us to provide an estimate for the macroeconomic effects of higher import costs. For the U.S., we find that a 10 percentage point increase in import costs—for example, in the form of blanket tariffs with all its trading partners—leads to a contemporaneous rise in CPI inflation of approximately 0.8 percentage points and a decline in GDP of approximately 1.8 percent. More importantly, the inflationary effects are persistent, resulting from higher trade costs of intermediate goods. We also use our model to analyze the inflationary effect of the U.S.-China 2018-19 trade war and to quantify the role of trade costs during the post-pandemic inflation episode. Although non-trade-related factors affecting aggregate supply and demand explain the buildup of inflation in the post-pandemic recovery, higher trade costs contributed to sustaining inflation above the Federal Reserve's target, particularly in late 2022 and 2023.

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Appendix

A World Input-Output Data

Our baseline empirical analysis relies on data from the OECD Inter-Country Input-Output (ICIO) data. This data set provides global input-output tables, which map flows of production and expenditure within countries and flows of international trade between countries, broken down by economic activity and country, globally. The ICIO considers 77 countries, 76 individual countries and a rest of the world aggregate (ROW) from 1995 through 2020. We aggregate the ICIO data to cover the same countries as WIOD data (described below) and use rest of world to carry the adjustment. The ICIO considers 45 sectors or areas of activity. We define sectors 1-22 (codes A-C) as tradable and the remaining sectors as non-tradable. We aggregate sectors into tradable and non-tradable. We then construct total final expenditure (aggregating final demand categories) on tradable sectors across geographic origins and obtain $\{X^C_{ih,t}\}_{i,h}$ in every t. Similarly, we consider total expenditure by tradable sectors on tradable sectors across geographic origins and obtain $\{X^M_{ih,t}\}_{i,h}$ in every t. We use these flows to construct bilateral trade costs. We have considered alternative aggregation procedures and our main empirial results remian robust.

We also consider data from the World Input-Output Database (WIOD).We combine the 2013 and 2016 releases of WIOD data. The WIOD 2013 release considers input-output data for 41 countries (including ROW) and 35 sectors for the period 1995-2011. The WIOD 2016 release considers 44 countries (including ROW) and 56 sectors covering the period 2000-2014. We combine both releases to obtain a balanced panel of with 41 countries for the period 2005-2014. Table A.1 provides our industry mapping between the WIOD and ICIO databases.

We also consider WIOD's long-run database which has input-output table estimates for 25 countries and 23 sectors covering the period 1965-2000. We follow the same procedure as with the ICIO data and construct bilateral trade costs relying on tradable sectors only.

Appendix

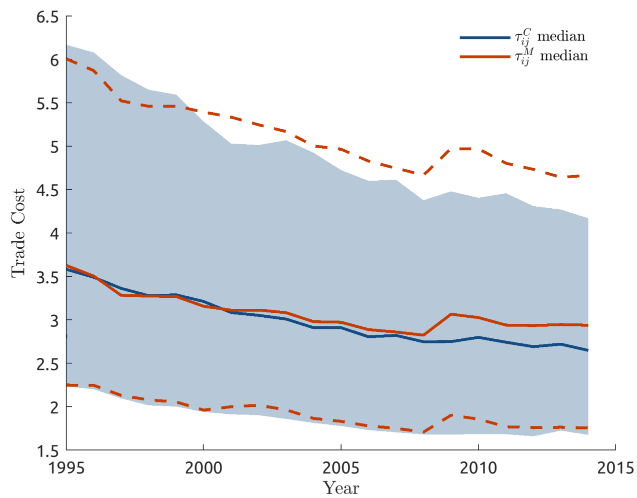
Table A.1: Manufacturing Sector Classification in WIOT and ICIO

Sector	WIOD 2016	ICIO 2023
1	Crop and animal production, hunting and related service activities	Agriculture, hunting, forestry
2	Forestry and logging	
3	Fishing and aquaculture	Fishing and aquaculture
4	Mining and quarrying	Mining and quarrying, non-energy producing products
		Mining support service activities
5	Manufacture of food products, beverages and tobacco products	Food products, beverages and tobacco
6	Manufacture of textiles, wearing apparel and leather products	
7	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Textiles, textile products, leather and footwear
8	Manufacture of paper and paper products	Wood and products of wood and cork
9	Printing and reproduction of recorded media	Paper products and printing
10	Manufacture of coke and refined petroleum products	Coke and refined petroleum products
11	Manufacture of chemicals and chemical products	Chemical and chemical products
12	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Pharmaceuticals, medicinal chemical and botanical products
13	Manufacture of rubber and plastic products	Rubber and plastics products
14	Manufacture of other non-metallic mineral products	Other non-metallic mineral products
15	Manufacture of basic metals	Basic metals
16	Manufacture of fabricated metal products, except machinery and equipment	Fabricated metal products
17	Manufacture of computer, electronic and optical products	Computer, electronic and optical equipment
18	Manufacture of electrical equipment	Electrical equipment
19	Manufacture of machinery and equipment n.e.c.	Machinery and equipment, nec
20	Manufacture of motor vehicles, trailers and semi-trailers	Motor vehicles, trailers and semi-trailers
21	Manufacture of other transport equipment	Other transport equipment
22	Manufacture of furniture; other manufacturing	Manufacturing nec; repair and installation of machinery and equipment
23	Repair and installation of machinery and equipment	

B Evolution of Bilateral Trade Costs

This Appendix considers alternative data sources to construct bilateral trade costs. Figure A.1 plots the evolution of the distribution of bilateral trade costs constructed using the WIOD data for the same set of countries that we consider using the ICIO data. Figure A.2 plots the evolution of the distribution of bilateral trade costs constructed using historical WIOD data. For the overlapping period 1995-2000, trade costs are lower in the historical WIOD data because of the difference in the sample of countries. The historical WIOD does not consider almost any low-income countries.

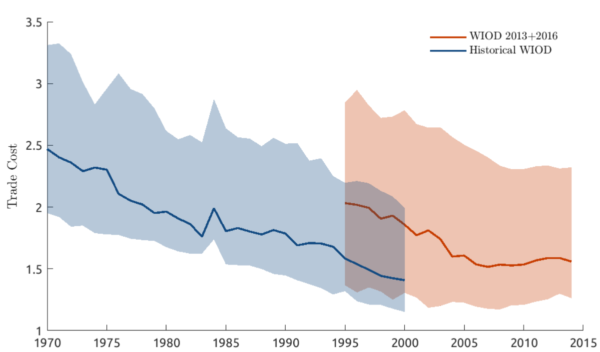
Figure A.1: Evolution of distribution of trade costs (all 41 countries): WIOD



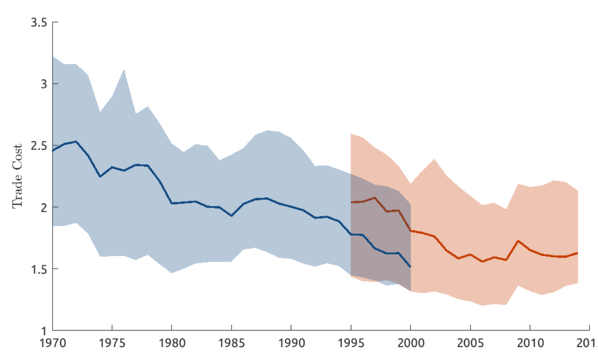
Note: Trade costs are expressed as a percentage of the sales price of the good. That is, the figure shows the evolution of $(\mathcal{T}_{ih,t}^{Q} - 1)$ for $Q \in \{C, M\}$.

Figure A.2: Historical Evolution of Global Trade Costs

(a) Median Trade Cost: Final Goods (C)



(b) Median Trade Cost: Intermediate Goods (M)

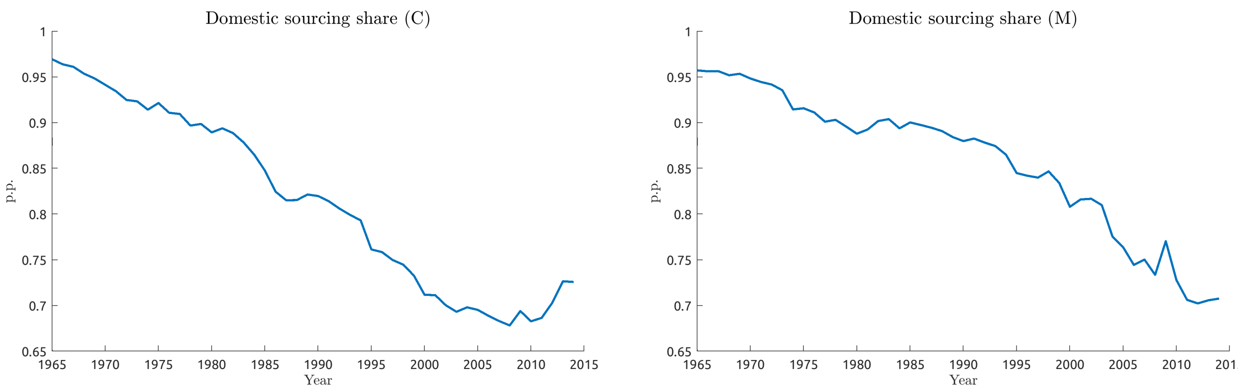


Note: Trade costs are expressed as a percentage of the sales price of the good, divided by 100. That is, the figure shows the evolution of $\mathcal{T}_{ih,t}^{Q} - 1$ for $Q \in \{C, M\}$. Shaded areas are bounded by the 20th and 80th percentiles.

Appendix

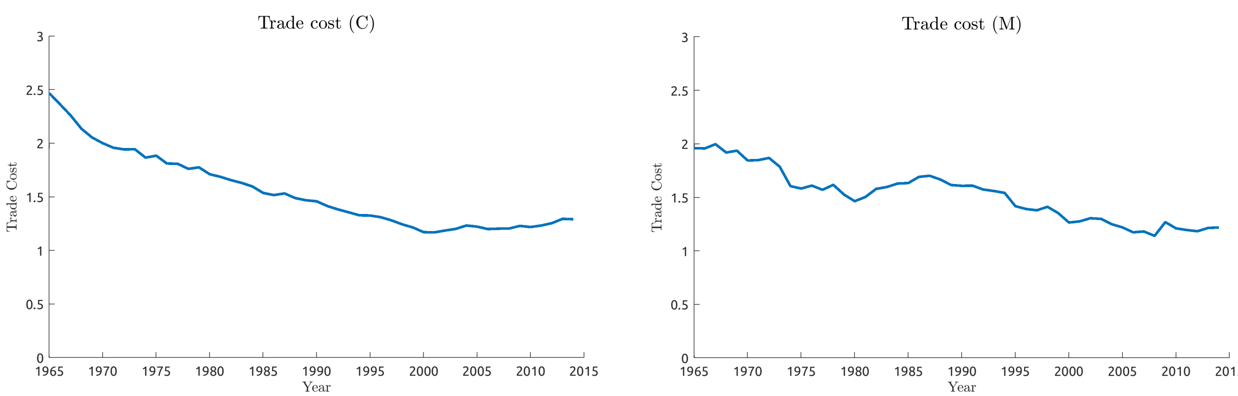
Figures A.3 and A.4 combine data from the historical WIOD and the 2013 and 2016 WIOD releases to construct and plot the historical evolution of the U.S. domestic sourcing share and U.S. import costs, respectively. These costs are constructed with $\eta^C = \eta^Q = 5$ and weighted using contemporaneous import weights.

Figure A.3: Evolution of United States domestic sourcing share



Note: data comes from WIOD database. The 2011-2014 numbers have been taken from the WIOD 2016 database and stitched to the WIOD 2013 numbers. The 1965-1999 come from the historical WIOD database

Figure A.4: Evolution of trade costs in the United States

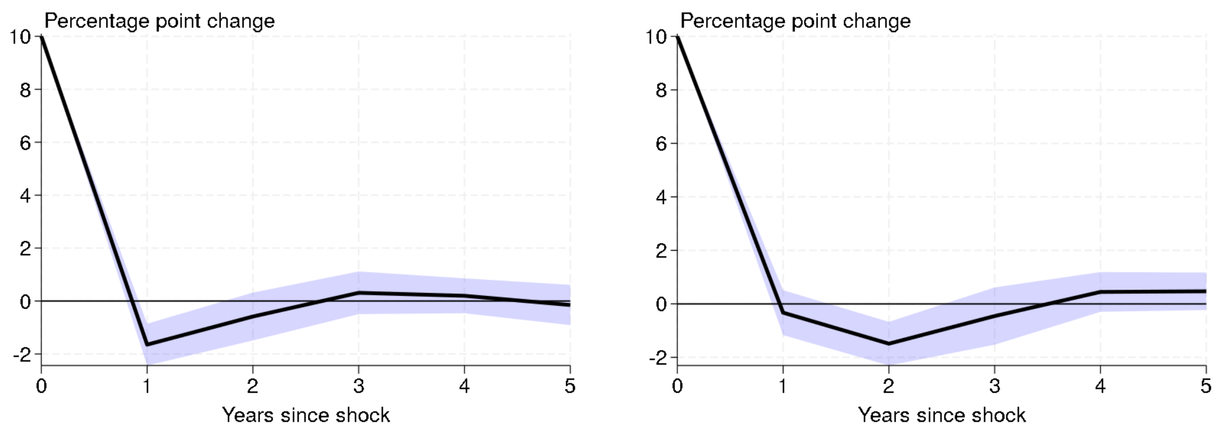


Note: Trade costs are expressed as a percentage of the sales price of the good, divided by 100. That is, the figure shows the evolution of $\tau_{i,t}^{Q} - 1$ for $Q \in \{C, M\}$. Data come from WIOD database. The 2011-2014 numbers have been taken from the WIOD 2016 database and stitched to the WIOD 2013 numbers. The 1965-1999 come from the historical WIOD database

C Additional Empirical Results

C.1 Response of Trade Costs

Figure A.5: Local projection of trade cost on itself



(a) Final trade cost (b) Intermediate trade cost

Note: Country fixed effects and year error clustering are included. The figure considers a 10 percentage point increase in import costs.

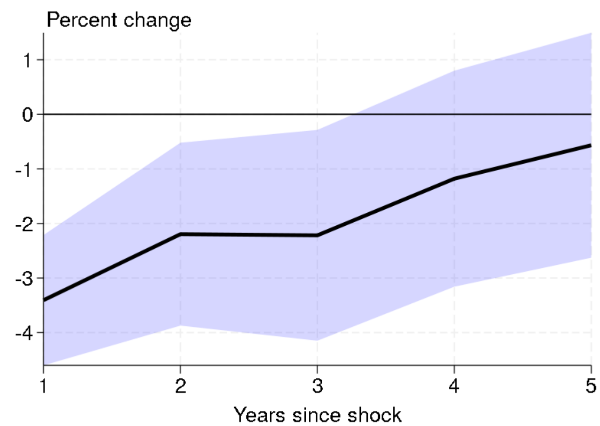
C.2 Additional Local Projection Estimates

Figures A.6 andA.7 plots the estimates of the local projection in Equation 11 for real exports, real imports, the real exchange rate and the trade-balance-to-GDP ratio.

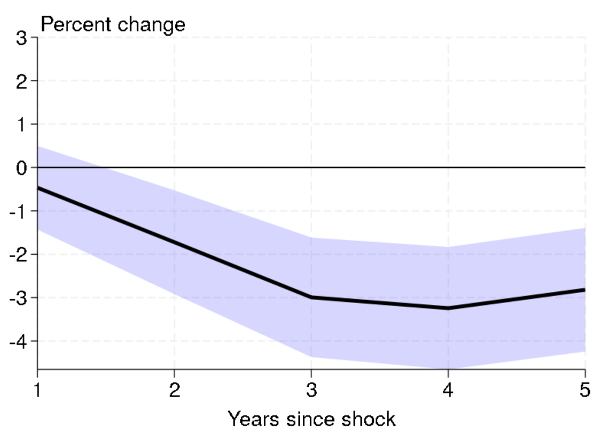
Figure A.6: Response to Final Trade Costs

(a) Real Exports

(b) Real Imports



(c) Real Exchange Rate



(d) TB/GDP

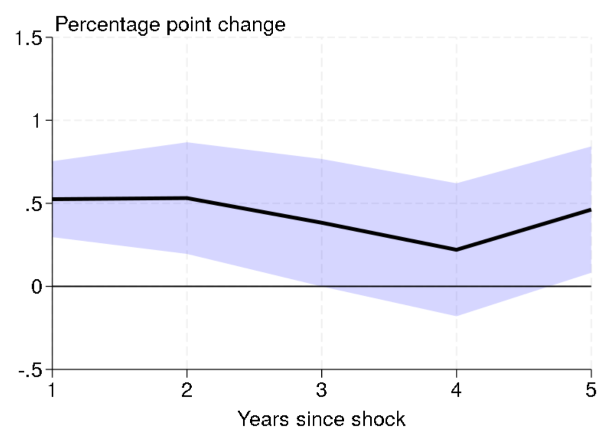
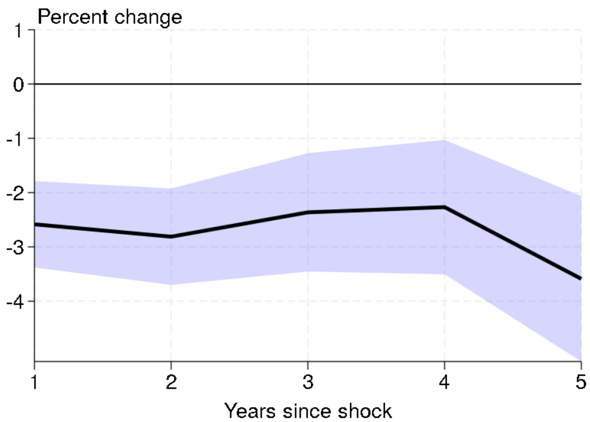
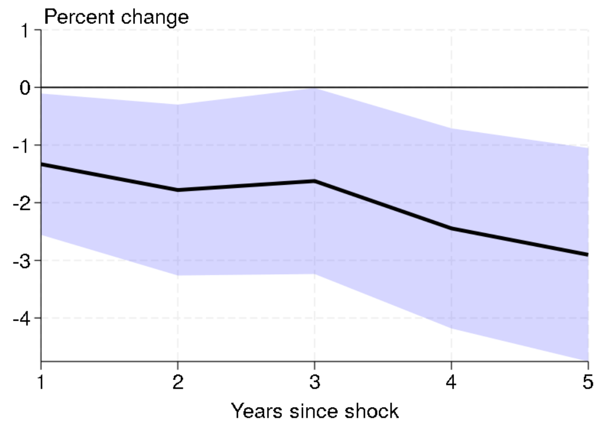


Figure A.7: Response to Intermediate Trade Costs

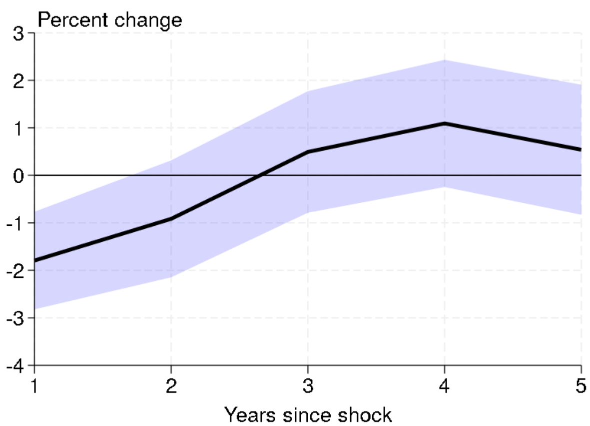
(a) Real Exports



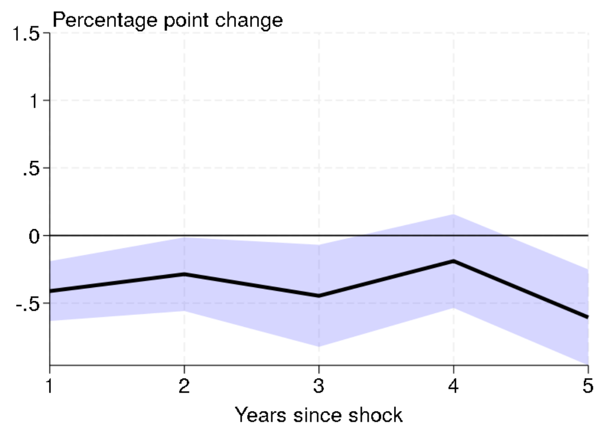
(b) Real Imports



(c) Real Exchange Rate



(d) TB/GDP



C.3 The Trade Elasticity

Our baseline estimate assumes a parameter of $\eta = \eta_M = 5$. However, there is a range of estimates for this parameter in the the literature (Boehm et al., 2023). We also construct bilateral trade costs as in (8) using different values of the trade elasticity, $\eta - 1 = \{2, 4, 6, 8\}$, and re-estimate our local projections in (11). Table A.2 shows how our estimates of β_h^Q for $h = 0, 1$ depend the value of the trade elasticity.

Given observed bilateral trade flows, a lower trade elasticity is consistent smaller bilateral trade costs and more muted variation in these costs across countries. Hence, for lower values of the trade elasticity, a given change in trade costs generates small changes in bilateral trade flows, and therefore small effects on both CPI inflation and GDP growth. The first two rows of each panel, $h = 0$ and $h = 1$, of Table A.2 show how our estimates of β_h^Q for $Q \in \{C, M\}$ become smaller for lower values of η. An alternative way to present our estimates is to normalize β_h^Q to reflect a change in trade flows consistent with a 1 percentage point increase in an importer's domestic sourcing share, $\omega_{ii,t}^Q$. This can be done by running the local projections specifications in (11) with country i's domestic sourcing share as the dependent variable. In results not shown in this appendix (available upon request), we show that normalized estimates are almost identical across different values of the trade elasticity.

Table A.2: Inflation and GDP growth regressions for different trade elasticities ($\theta = \eta - 1$)

(a) $h = 0$

	Year on year Inflation Rate ($h=0$)				Year on year GDP growth ($h=0$)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\eta-1=2$	$\eta-1=4$	$\eta-1=6$	$\eta-1=8$	$\eta-1=2$	$\eta-1=4$	$\eta-1=6$	$\eta-1=8$
%Δ Final trade cost	0.124	1.275	2.915	4.725	0.0131	0.0427	0.0798	0.125
	(0.0809)	(0.472)	(1.019)	(1.627)	(0.0458)	(0.310)	(0.677)	(1.086)
%Δ Interm. trade cost	0.159	0.747	1.463	2.234	-0.105	-0.719	-1.546	-2.454
	(0.114)	(0.680)	(1.387)	(2.146)	(0.0504)	(0.365)	(0.796)	(1.269)
CPI rate % (-1)	-0.207	-0.197	-0.195	-0.194				
	(0.223)	(0.227)	(0.228)	(0.229)				
GDP growth % (-1)					2.491	2.565	2.548	2.537
					(1.530)	(1.540)	(1.550)	(1.556)
Unemployment % (-1)	-0.0834	-0.0915	-0.0958	-0.0983	0.0924	0.0983	0.0997	0.100
	(0.0612)	(0.0625)	(0.0624)	(0.0624)	(0.0393)	(0.0401)	(0.0401)	(0.0401)
R-squared	0.857	0.852	0.851	0.850	0.652	0.646	0.645	0.644
Num. ind.	27	27	27	27	27	27	27	27
Num. obs.	542	542	542	542	542	542	542	542

(b) $h = 1$

	Year ahead Inflation Rate ($h=1$)				Year ahead GDP growth ($h=1$)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\eta-1=2$	$\eta-1=4$	$\eta-1=6$	$\eta-1=8$	$\eta-1=2$	$\eta-1=4$	$\eta-1=6$	$\eta-1=8$
%Δ Final trade cost	-0.0741	0.652	1.721	2.906	-0.0453	-0.379	-0.866	-1.406
	(0.125)	(0.392)	(0.895)	(1.464)	(0.0730)	(0.500)	(1.098)	(1.766)
%Δ Interm. trade cost	0.317	0.575	0.717	0.833	-0.119	-0.806	-1.688	-2.642
	(0.198)	(0.543)	(0.985)	(1.477)	(0.0652)	(0.486)	(1.067)	(1.711)
CPI rate % (-1)	0.0210	0.0458	0.0495	0.0508				
	(0.122)	(0.126)	(0.127)	(0.127)				
GDP growth % (-1)					2.098	2.261	2.272	2.273
					(2.090)	(2.112)	(2.134)	(2.144)
Unemployment % (-1)	-0.0850	-0.0730	-0.0724	-0.0726	0.285	0.295	0.297	0.298
	(0.0668)	(0.0677)	(0.0681)	(0.0682)	(0.0771)	(0.0782)	(0.0784)	(0.0785)
R-squared	0.634	0.609	0.606	0.605	0.668	0.661	0.660	0.659
Num. ind.	27	27	27	27	27	27	27	27
Num. obs.	542	542	542	542	542	542	542	542

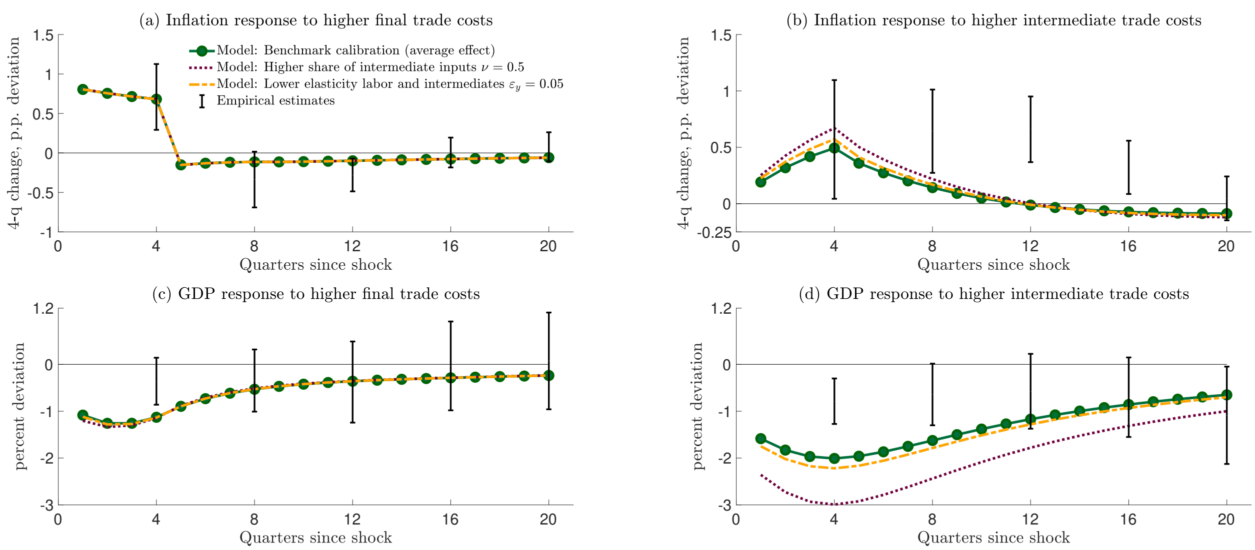
Note: Country fixed effects and year error clustering are included. Both sourcing share and CPI inflation tables respond to a 10% increase in trade costs.

D Robustness: Model vs Data

D.1 Technological Parameters.

We explore the role of two key technological parameters shaping the transmission of trade cost shocks: the share of intermediate inputs in firms' production (ν), and the elasticity of substitution between intermediate inputs and labor (ε_y). Figure A.8 contrasts the effects in our baseline calibration with $\nu = 0.4$ and $\varepsilon_y = 0.5$, with alternatives assuming higher and lower values for these parameters. A higher share of intermediate inputs implies a larger increase in inflation and a bigger decline in GDP. Similarly, a lower elasticity of substitution between intermediates and labor is also associated with amplified GDP and inflation effects of trade shocks. However, the impact of different values of the elasticity parameter is smaller relative to the effects induced by different shares of intermediate inputs.

Figure A.8: Model vs Data: Robustness Technological Parameters



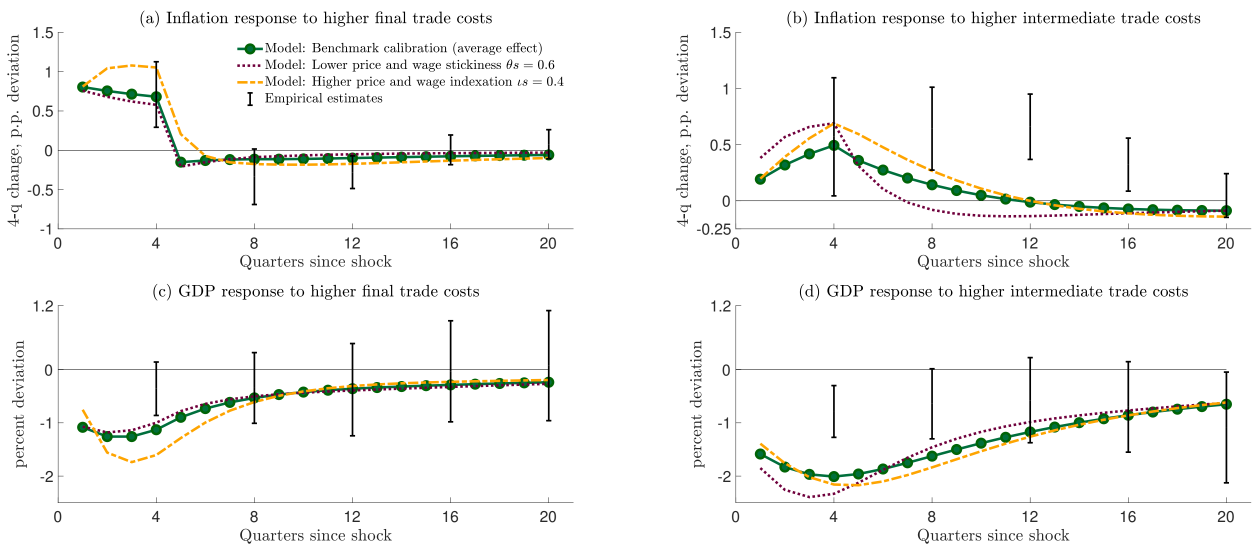
Note: Effects of a permanent 10 percentage point increase in the U.S.'s trade costs from all trading partners under alternative model calibrations.

D.2 Wage and Price Indexation

Because of the New Keynesian structure inflation dynamics in the model are influenced by the frequency of price and wage adjustment as well as the degree of price and wage indexation. So if prices and wages are more flexible we should expect to more inflation on impact. If price and wage setting are backward-looking due to indexation we should expect to see more persistence in the inflationary response. We study the transmission of trade shocks under two alternative configurations. One with less stickiness in prices and wages for which we set $\theta = \theta_w = 0.6$ which halves the duration of price and wage contracts relative to our baseline calibration. For the second experiment we extend the model to incorporate price and wage indexation. We assume that country's i differentiated firms unable to adjust prices follow the indexation rule $P_{i,t} = P_{t-1}\pi_{i,t-1}^{\iota}\pi^{1-\iota}$, with the parameter ι determining the degree of indexation with respect to past inflation $\pi_{i,t}$. Similarly, country-i's households unable to reset wage follow the indexation rule: $W_{i,t} = W_{i,t-1}\pi_{i,t-1}^{\iota_w}\pi^{1-\iota_w}$. Where ι_w determines the degree of wage indexation.

Figure A.9 contrasts the effects in our baseline calibration where $\theta = \theta_w = 0.8$ and no indexation, with one in which calibration in which prices and wages are more flexible $\theta = \theta_w = 0.6$ and another calibration in which prices and wages backward-looking with $\iota = \iota_w = 0.3$.

Figure A.9: Model vs Data: Robustness to Price and Wage Setting Parameters

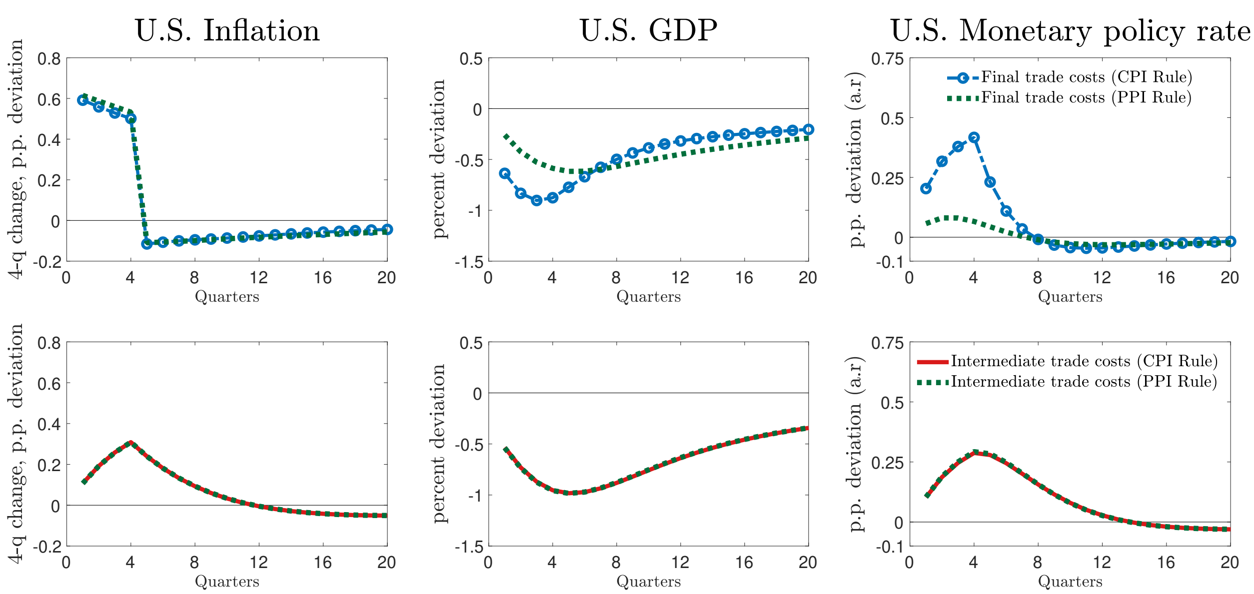


Note: Effects of a permanent 10 percentage point increase in the U.S.'s trade costs from all trading partners under alternative model calibrations.

E CPI vs PPI Rule: Transitory Increase in Trade Costs

Studying one-time permanent increases in trade costs is a useful benchmark. However, the changing nature of trade policy suggests that changes in trade costs are not permanent. The transitory nature of trade policies can have implications for the desirability of monetary stabilization. Figure A.10 illustrates this point by re-assessing the benefits of PPI targeting following a transitory 10 percentage point increase in bilateral trade costs between the U.S. and all trading partners.[50] In this case, PPI targeting does little to ameliorate the GDP, even in the case of final goods trade costs. As the price of imported goods falls due to the reversal of trade costs, the PPI-based rule generates persistent CPI deflation, increasing the real interest rate and reducing aggregate consumption.

Figure A.10: CPI vs. PPI Targeting with Transitory Increase in Trade Costs



Note: Effects of a transitory 10 percentage point increase in the U.S.'s trade costs from all trading partners under alternative monetary policy rules.

[50] For this experiment we assume tariffs follow the auto-regressive process in our baseline calibration.

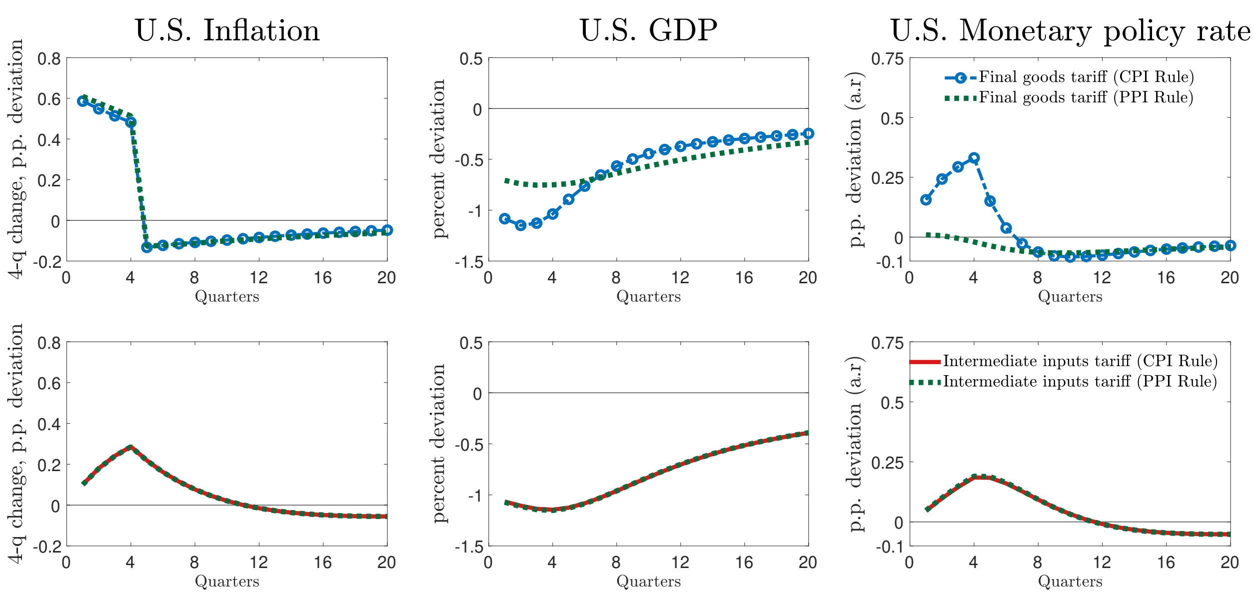
F Monetary Policy Response to Tariffs

We extend our analysis of alternative policy rules for the case of higher tariffs. In the model we use the shock $\kappa_{ih,t}$ to simulate the effect of tariffs imposed by country-i on imports from country-h. We use the shock $\kappa_{hi,t}$ to simulate the extent of retaliatory tariffs.

Figure A.11 analyzes the case in which the U.S. imposes a transitory 10 percent tariff on the imports from all its trading partners. We assume the persistence of new tariffs equals that of trade cost shocks under our baseline calibration in Table 1. Figure A.12 shows the same experiment for the case of a permanent increase in U.S. tariffs on imports from all its trading partners. In both experiments we assume that U.S.'s trading partners impose retaliatory tariffs of the same magnitude.

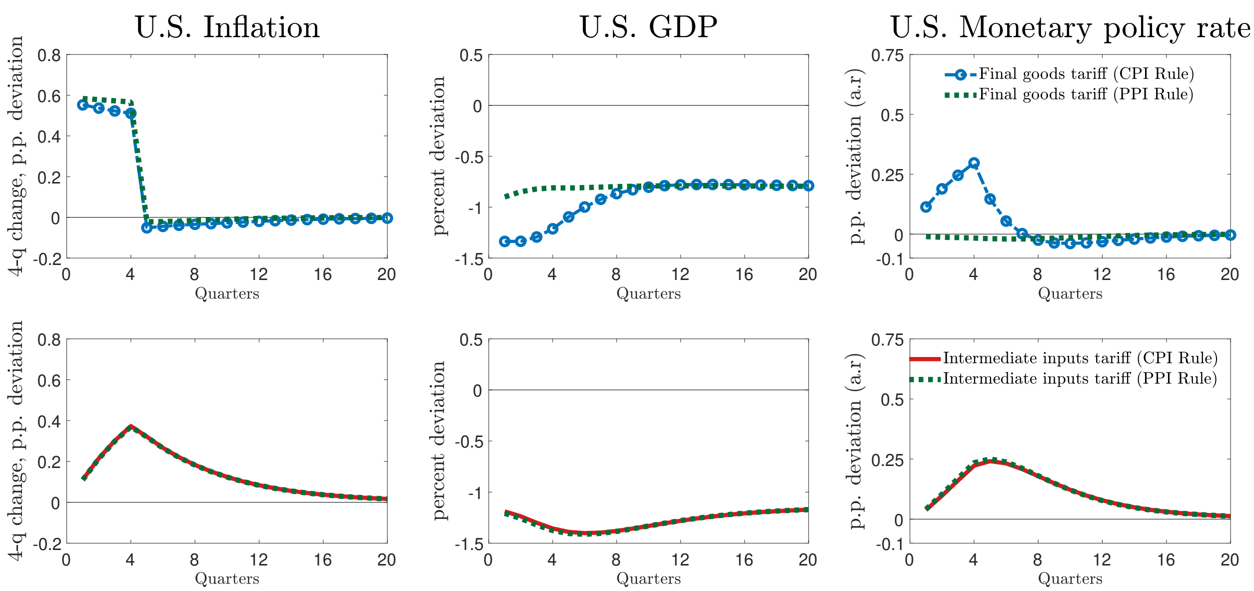
The top row shows the response to higher tariffs on final goods. The bottom row shows the response to higher tariffs on intermediate inputs. The results are very similar to those discussed in the main text. Importantly, when monetary policy follows a PPI rule, it can provide some relief to the contractionary effect of higher tariffs on final goods but this alternative policy rule does not improve the outcomes following an increase in tariffs for intermediate inputs.

Figure A.11: CPI vs. PPI Targeting with Transitory Increase in U.S. Tariffs



Note: Effects of a transitory 10 percentage point increase in the U.S. tariffs on all trading partners under alternative monetary policy rules. GDP measure is net of tariff revenues.

Figure A.12: CPI vs. PPI Targeting with Permanent Increase in U.S. Tariffs



Note: Effects of a permanent 10 percentage point increase in the U.S. import tariffs on all trading partners under alternative monetary policy rules. GDP measure is net of tariff revenues.

Appendix

G Post-Pandemic Inflation Analysis

G.1 Data Summary

United States. We collect the following data series for the U.S. for the period 1999:Q1-2023:Q4.

- Gross Domestic Product: we collect quarterly real GDP from the Bureau of Economic Analysis (BEA). We take the quarter-on-quarter log difference as our final measure.
- Consumer Price Inflation: we take the consumer price inflation index, which we then transform by taking the quarter-on-quarter log difference.
- Policy rate: we use the Wu-Xia shadow federal funds rate to measure the interest rate, to prevent from being stuck at the ZLB. The data is assembled by the Federal Reserve Bank of Atlanta.
- Real Exchange Rate: our measure of the real exchange rate is the "Real Broad Effective Exchange Rate" for United States obtained from FRED.
- U.S. Domestic Sourcing Shares for Final Goods: See Appendix G.2
- U.S. Domestic Sourcing Shares for Intermediate Inputs: See Appendix G.2

Rest-of-World Aggregate For the rest-of-world aggregate we combine country-level time series for country/blocs: Argentina, Australia, Brazil, Bulgaria, Canada, Colombia, Chile, China, Croatia, Czech Republic, Denmark, Euro Area, Hong Kong, Hungary, India, Indonesia, Israel, Japan, Malaysia, Mexico, New Zealand, Philippines, Poland, Romania, Russian Federation, Saudi Arabia, Singapore, South Africa, South Korea, Sweden, Taiwan, Thailand, Turkey, United Kingdom and the United States. Our sample of countries represents about 85% of PPP-adjusted world GDP in 2019. Unless otherwise note, all data is seasonally adjusted.

- Foreign GDP: trade-weighted average of real GDP growth measured as quarter-on-quarter log difference for each country.
- Foreign inflation: trade-weighted average of consumer price inflation, measured as quarter-on-quarter log difference of the CPI index of each country.
- Foreign policy rate: we proxy the foreign policy rates using the money market interest rate where available, otherwise we use the deposit rate. The foreign policy rate is aggregated using U.S. trade weights.

G.2 Quarterly Domestic Sourcing Shares

From the BEA input-output tables, we can construct the annual intermediate and final domestic sourcing shares as follows. We first filter the sectors of the "Use of Commodities by Industries" tables by selecting only tradable sectors.[51] We then aggregate all rows, and the industry columns to compose the intermediate goods, while aggregating the final end-use columns (both denoted as E_j, or expenditure, where $j \in \{intermediate, final\}$). We also collect the nominal dollar export expenditure (which cannot be split into intermediates and final goods due to being a single series) from the same table, denoted as X. We then collect imports for intermediates and final goods using the "Use of imported commodities by industry" tables in a similar aggregation process to our earlier tables (denoted as M_j where $j \in \{intermediate, final\}$). We use the import series to construct the domestic sourcing share, as:

$$\lambda_j = 1 - \frac{M_j}{E_j}$$

Where j represents the final and intermediate sourcing share. Our data runs annually from 1997 to 2023.

We then use the BEA International Trade in Goods, to interpolate our annual sourcing share series. We first collect total intermediate and final exports from this table, which we use to derive intermediate and final "shares". We then multiply our previously collected nominal exports series, X, into intermediate and final exports using these shares (resulting in X_j, where $X = X_{final} + X_{intermediate}$). We then obtain annual intermediate and final output using the expenditure series as:

$$O_j = E_j - M_j + X_j \tag{G.1}$$

Where once again $j \in \{intermediate, final\}$.

Therefore, we have annual output, imports, exports and expenditure split by intermediate and final goods. We then use quarterly industrial production from FRED (manufacturing and consumer final goods IP) to interpolate our new annual output series for intermediate and final goods respectively (we use PPI to deflate the series before interpolation, and reflate after interpolation). Then, we use the quarterly exports and imports by intermediate and final goods

[51] Tradable sectors are defined as sectors 1-5 and 8-26, in accordance with NICS classifications.

(from our International Trade in Goods database) to interpolate our annual numbers X_j and M_j. All quantities are nominal, so no deflation is necessary.

Thus, we obtain quarterly $O_j^Q, E_j^Q, M_j^Q, X_j^Q$ (by reversing equation (G.1) to obtain E_j^Q), which enables us to obtain quarterly domestic sourcing share as $\lambda_j^Q = 1 - \frac{M_j^Q}{E_j^Q}$. We also compose "Annualized Domestic Sourcing Share" λ_j^{QAnn}, still a quarterly series, by taking 4-quarter rolling sums of M_j^Q, E_j^Q and recomputing λ_j as previously. We now have quarterly domestic sourcing share ready for our Bayesian estimation exercise.

G.3 Mapping the Model to the Data

In each country-bloc, we observe the following variables: quarterly annualized output growth ($\Delta\tilde{y}_{i,t}^o$), quarterly annualized inflation measured ($\tilde{\pi}_{i,t}^o$), and quarterly annualized nominal interest rates ($\tilde{R}_{i,t}^o$), for $i = \{U.S., RoW\}$. The real exchange rate index between the U.S. and RoW, ($\hat{q}_t^o$), is measured in deviations from its long-run value of 100. For the U.S. only, we measure the domestic sourcing shares in final goods and intermediate inputs $\tilde{\lambda}_t^{C,o}$ and $\tilde{\lambda}_t^{M,o}$, respectively. Variables denoted with a tilde have been demeaned using their sample averages. We map the observed data series to the model counterparts through the following system of measurement equations:

$$
\begin{aligned}
\Delta\tilde{y}_{i,t}^o &= 100 \times \log\left(y_{i,t}/y_{i,t-1}\right), \quad i \in \{U.S., RoW\} \\
\tilde{\pi}_{i,t}^o &= 400 \times \log \pi_{i,t}, \quad i \in \{U.S., RoW\} \\
\tilde{R}_{i,t}^o &= 400 \times \log R_{i,t}, \quad i \in \{U.S., RoW\} \\
\hat{q}_t^o &= 100 \times \log\left(q_{12,t}/q_{12}\right), \\
\hat{\lambda}_{U.S.,t}^{C,o} &= 100 \times \left(\lambda_{11,t}^C - \omega_{11}^C\right), \\
\hat{\lambda}_{U.S.,t}^{M,o} &= 100 \times \left(\lambda_{11,t}^M - \omega_{11}^M\right),
\end{aligned}
$$

G.4 Priors, Posterior Sampler, and Estimation Results

Columns 2-4 in Table A.3 list prior distributions, along with prior means and standard deviations used to estimate the two-country model of Section 6.2. We assume the statistical independence of estimated parameters under the prior distribution, so we compute the joint prior density from the product of the marginal distributions.

Using standard perturbation techniques, we approximate the model solution around its non-stochastic steady state and evaluate the likelihood function using the Kalman filter. We use the

Appendix

Table A.3: Estimated Parameters: Two-Country Model

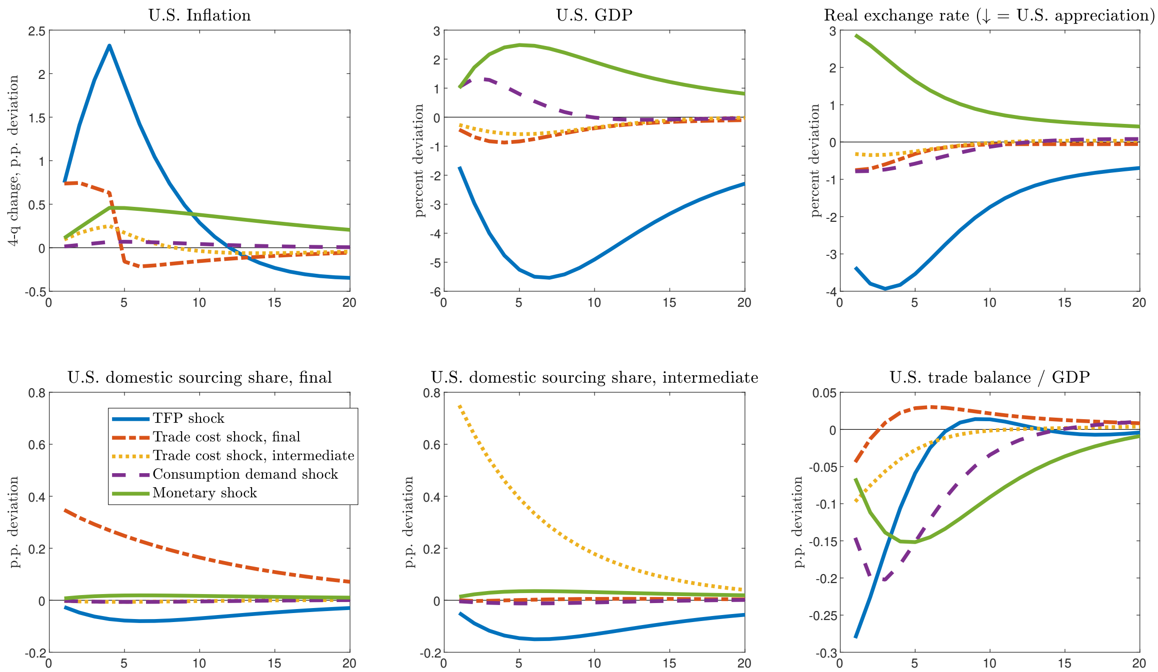
Parameter (1)	Description (2)	Prior (3)	Posterior Mean (4)	HPD Interval (5)
σ_1^A	Std dev. U.S. TFP shock	$\mathcal{IG}(0.01, 0.05)$	0.04	[0.04 0.05]
σ_1^r	Std dev. U.S. Monetary policy shock	$\mathcal{IG}(0.01, 0.05)$	0.01	[0.01 0.01]
σ_1^D	Std dev. U.S. Demand shock	$\mathcal{IG}(0.01, 0.05)$	0.02	[0.02 0.03]
σ_2^A	Std dev. RoW TFP shock	$\mathcal{IG}(0.01, 0.05)$	0.01	[0.01 0.02]
σ_2^r	Std dev. RoW Monetary policy shock	$\mathcal{IG}(0.01, 0.05)$	0.00	[0.00 0.00]
σ_2^D	Std dev. RoW Demand shock	$\mathcal{IG}(0.01, 0.05)$	0.01	[0.01 0.01]
σ_2^ψ	Std dev. RoW UIP shock	$\mathcal{IG}(0.01, 0.05)$	0.01	[0.00 0.01]
σ_{τ^C}	Std dev. Trade cost shock - C	$\mathcal{IG}(0.01, 0.05)$	0.04	[0.03 0.04]
σ_{τ^M}	Std dev. Trade cost shock - M	$\mathcal{IG}(0.01, 0.05)$	0.08	[0.08 0.10]
ρ_1^A	Persistence U.S. TFP shock	$\mathcal{B}(0.6, 0.125)$	0.98	[0.96 0.99]
ρ_1^r	Persistence U.S. Monetary policy response	$\mathcal{B}(0.6, 0.125)$	0.94	[0.92 0.96]
ρ_1^D	Persistence U.S. Demand shock	$\mathcal{B}(0.6, 0.125)$	0.56	[0.47 0.66]
ρ_2^A	Persistence RoW TFP shock	$\mathcal{B}(0.6, 0.125)$	0.89	[0.82 0.95]
ρ_2^r	Persistence RoW Monetary policy response	$\mathcal{B}(0.6, 0.125)$	0.77	[0.67 0.85]
ρ_2^D	Persistence RoW Demand shock	$\mathcal{B}(0.6, 0.125)$	0.79	[0.72 0.87]
ρ_2^ψ	Persistence RoW UIP shock	$\mathcal{B}(0.6, 0.125)$	0.83	[0.77 0.89]
ρ^{τ^C}	Persistence Trade cost shock - C	$\mathcal{B}(0.6, 0.125)$	0.93	[0.90 0.97]
ρ^{τ^M}	Persistence Trade cost shock - M	$\mathcal{B}(0.6, 0.125)$	0.88	[0.83 0.92]
$\rho(\epsilon_1^D, \epsilon_2^D)$	Correlation U.S. and Row demand shock	$\mathcal{U}(0, 0.5774)$	0.02	[-0.16 0.19]
$\rho(\epsilon_1^A, \epsilon_2^A)$	Correlation U.S. and Row TFP shock	$\mathcal{U}(0, 0.5774)$	0.15	[-0.00 0.30]

Notes: The estimation sample is 1991:Q1 - 2019:Q4. Column (3) reports the prior distributions. $\mathcal{B}$ is Beta distribution. $\mathcal{IG}$ is Inverse Gamma distribution. $\mathcal{U}$ is Uniform distribution. The numbers in parentheses denote the prior mean and standard deviation of each distribution. Column (4) report posterior meanss. Column (5) reports the Highest Probabality Density Interval in square brackets. All posterior statistics are based on the last 25,000 draws from a RWMH algorithm, after discarding the first 25,000 draws.

standard random walk Metropolis algorithm (RWM) described in An and Schorfheide (2007) to generate draws from the posterior distribution. The covariance matrix of the proposal distribution in the RWM algorithm to obtain an acceptance rate between 30% and 40%. We simulate 50,000 draws from the simulated posterior distribution and retain only the last 25,000 draws for posterior inference. Columns 5 and 6 in Table A.3 show key moments of the posterior distribution of the estimated parameters.

G.5 Additional Impulse Responses

Figure A.13: Identification of Demand and Supply Shocks



Notes: Impulse response to a one standard deviation to total factor productivity shock (blue), trade cost shock for final goods (red), trade cost shock for intermediate inputs (yellow). Consumption demand shock (purple). Monetary policy shock (green). Model calibrated at the estimated posterior mean parameters in Table A.3