Trade Costs and Inflation Dynamics[*]

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Abstract

We explore how shocks to trade costs affect inflation dynamics in the global economy. We exploit bilateral trade flows of final and intermediate goods together with the structure of static trade models that deliver gravity equations to identify exogenous changes in trade costs between countries. We then use a local projections approach to assess the effects of trade cost shocks on consumer price (CPI) inflation. Higher trade costs of final goods lead to large but short-lived increases in inflation, while increases in trade costs of intermediate goods generate small but persistent increases in inflation. We develop a multi-country New Keynesian model featuring trade in final and intermediate goods and show that it can replicate the inflation responses we identify in the data. We estimate the model using historical data and use it to explore the drivers of U.S. inflation in the aftermath of the COVID-19 pandemic. We find that trade costs account for one percentage point of additional inflation in 2022 and the bulk of inflationary pressures in 2023.

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1 Introduction

The global economy has become remarkably more integrated over the past half-century. Countries are now notably more interconnected than fifty years ago regarding the value of goods and services traded across borders: World exports as a share of world GDP almost doubled over this period, rising from 16 percent on average in the 1970s to 29 percent in the late 2010s.[1] Emerging economies, in particular, played a prominent role in driving this globalization process, as a notable rise in openness over this period accompanied their rapid growth.[2] China's example stands out: Its economy experienced extremely fast growth since the 1980s and increased its presence in global markets by joining the World Trade Organization (WTO) in 2001 and contributing to making the world economy more tightly interconnected than ever.

This interconnected global economic landscape suggests that disruptions to trade linkages can have important macroeconomic consequences. Recent changes in U.S. trade policies since 2017, the COVID-19 epidemic, and the subsequent global inflation surge underscore the inflationary risks of trade-related shocks. However, studies on the inflationary effects of (broadly defined) "trade cost shocks," remain scarce.[3] Some recent work has aimed at understanding how trade costs affect macroeconomic outcomes. This literature, however, has largely overlooked the effects of trade costs on inflation.[4] This omission may seem puzzling, given the critical relevance of inflation for monetary policy; it is partly explained by the focus of the existing trade literature on real outcomes, and by the differences between the modeling approaches taken in this literature and the ones adopted in the New Keynesian framework, which provides the workhorse approach to studying inflation dynamics.[5]

In this paper, we study how shocks to trade costs affect inflation dynamics in a global economy. Our study proceeds along four dimensions. The first two dimensions correspond to our empirical contribution, which consists in measuring bilateral trade costs and studying their effects on inflation using detailed input-output and macroeconomic data from 1995 to 2020 for a panel of 44 countries. The other two dimensions relate to our theoretical contribution, consisting

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[1] World Development Indicators, World Bank: `https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS`.

[2] Reyes-Heroles et al. (2020) document the rise of emerging market economies in trade since the mid-1990s.

[3] Empirical work has focused on the macroeconomic effects of tariffs (Furceri et al., 2018). However, most of the literature has focused on the global consequences of productivity (Backus et al., 1992; Heathcote and Perri, 2002) or demand shocks (Stockman and Tesar, 1995; Bai and Ríos-Rull, 2015).

[4] Fitzgerald (2012); Eaton et al. (2016b); Reyes-Heroles (2017); Alessandria and Choi (2021) are only a few of many examples focusing on outcomes other than inflation.

[5] Important recent exceptions to this divergence are Comin and Johnson (2020) and Barattieri et al. (2021). Di Giovanni et al. (2023) and Comin et al. (2024) also break this separation to study the implications of supply-chain bottlenecks for inflation.

in developing and analyzing a multi-country New Keynesian model augmented with trade in final goods and intermediate inputs. Our model quantifies the effects of the global impacts of the increase in U.S.-China trade tensions in 2018-2019 and estimates the role of trade costs in the worldwide inflation surge after 2021. We next turn to describing each of these dimensions in more detail.

First, we combine bilateral trade flow data on final goods and intermediate inputs—relying on detailed sectoral data from the OECD's Inter-Country Input-Output Tables—and the structure of static gravity-type trade models to estimate bilateral trade costs.[6] This approach offers one way to overcome the challenge of identifying exogenous variation in a broadly-defined notion of trade frictions.[7] Given data for bilateral trade flows and aggregate spending for final goods and intermediate inputs, we exploit the ratio-type estimation proposed by Head and Ries (2001), which measures bilateral trade frictions between any two countries. We document stylized facts about these bilateral costs from 1995-2020 for 44 countries. We also construct country-specific import costs by aggregating these bilateral frictions and show that import costs correlate positively with CPI inflation.[8]

Second, we study the causal relationship between changes in trade costs and inflation using local-projection methods as in Jordà (2005). We focus on the effects of trade costs aggregated at the country level on inflation. Our estimates show that increases in trade costs translate into higher inflation. There are, however, important differences in the resulting inflation dynamics depending on the type of goods affected by increased trade costs. Higher trade costs for final goods lead to large but short-lived increases in inflation. By contrast, higher trade costs for intermediate inputs generate initially smaller, but more persistent, increases in inflation. Thus, while higher trade costs in final goods are associated with inflationary impacts that persist for about one year, higher trade costs for intermediate inputs lead to inflationary pressures lasting up to five years after the shock. The impact effect also differs, with a rise of ten percentage points in the import costs of final goods leading to a contemporaneous increase in CPI inflation of 0.5 percentage points, compared to about half as much in the case of higher trade costs on intermediate inputs.

Third, we propose a multi-country New Keynesian model of the global economy featuring international trade in final goods and intermediate inputs. In our model, firms in each country

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[6] Head and Mayer (2014) provides an introduction and survey of the gravity equation in international trade.

[7] In our version of the Armington model, we have consumers and firms aggregating differentiated tradable goods across countries according to constant elasticity of substitution (CES) aggregators, and trade is subject to iceberg-type trade costs. This static model is the basis of the static trade bloc of the dynamic New Keynesian model that we develop later in the paper.

[8] Our aggregation of bilateral costs resembles the methodology by Frankel and Romer (1999) and Frankel and Rose (2002), who aggregate bilateral trade flows predicted by a country's geographic characteristics in gravity equations.

produce differentiated varieties using labor and intermediate inputs. A representative retailer firm buys these varieties and aggregates them into a single good that is differentiated across countries. These goods are traded across borders and are subject to trade costs. The goods can be used for final consumption or as an intermediate production input. Our dynamic framework embeds the static Armington model of trade used in the empirical section. We assume that trade costs are different for final goods and intermediate inputs and can vary in a stochastic fashion over time. These features of our model imply that, at any given point in time, trade across countries is described by gravity-type equations consistent with the empirical strategy we use to identify trade costs in the data. We also assume that firms adjust prices infrequently, as in standard New Keynesian models, implying sluggish price movements. Moreover, we consider nominal wage rigidities in labor markets. Households earn labor income, exchange one-period bonds issued domestically in their currency, and trade an international bond denominated in U.S. dollars—hence, households face incomplete financial markets.

To align our theoretical analysis with the cross-country evidence, we calibrate our model to observed trade linkages in final and intermediate goods across five regions: the U.S., China, advanced non-U.S. economies, Asian emerging market economies (EMEs) excluding China, and other EMEs. We use the calibrated model to explore the transmission mechanisms of changes in trade costs. We find that the model implies inflation effects of final and intermediate trade cost shocks that are qualitatively consistent with the empirical responses, with rises in intermediate good trade costs leading to smaller but more persistent inflation effects. This higher persistence arises due to a persistent increase in domestic firms' marginal costs resulting from more costly imported inputs, which are passed through only slowly to domestic prices due to nominal rigidities.

The fourth and final dimension in our analysis uses the model to provide quantitative estimates of the global economic impact of the increase in U.S.-China trade barriers in 2018-19 and the role of trade costs in explaining the worldwide inflation surge after 2021. In the first experiment, we find that an increase in trade barriers between the U.S. and China of similar magnitude to that observed in 2018-19 triggers an increase in U.S. inflation of up to 0.5 percentage points, with a small but persistent component lasting about three years. The increase in trade barriers also leads to a decline in U.S. GDP of around 0.5 percent at the trough. We also show that simple calculations of the effect of higher import prices, as in simple pass-through regressions, understate the contribution of trade costs to inflation because they cannot capture the inflation persistence arising from the increase in the import costs of intermediate inputs.

In the second experiment, we use Bayesian methods to estimate a two-country version of the model focusing on the U.S. and the Rest of the World (ROW). We use the estimated model to examine the role of trade costs in driving the post-pandemic surge in inflation in the U.S. in the aftermath of the COVID-19 pandemic. Our newly constructed quarterly series on gross output and domestic sourcing shares for final goods and intermediate inputs are central to our estimation. These series, which span the period 1999:Q1 to 2023:Q4, allow us to identify the role of trade costs between the U.S. and the ROW and to distinguish their contribution from that of other supply and demand shocks that have been emphasized in recent literature as key drivers of the post-COVID inflation surge. Our model, combined with the novel data on domestic sourcing shares we use in estimation, reveal that absent shocks to trade costs, inflation in the U.S. would have been about one percentage point lower in 2022 and essentially returned to target by early 2023. Hence, we find a significant role for trade costs in explaining the persistence of the global inflation surge experienced after the COVID-19 pandemic.

Relation to the Literature. Our work is most closely related to Comin and Johnson (2020), who explore the role of globalization in driving the long-run trend in U.S. inflation. Relative to this work, our contribution is twofold. First, we exploit panel data to document how trade costs affect inflation and provide novel evidence about the magnitude and persistence of the inflationary effects of these shocks. Hence, we also contribute to empirical work estimating the macroeconomic effects of tariffs (Furceri et al., 2018; Caldara et al., 2020). Second, we develop and estimate a multi-country general equilibrium New Keynesian model to explore mechanisms that may explain our estimated effects. We also relate to multiple strands of the literature on international macroeconomics and trade. Motivated by the work of Obstfeld and Rogoff (2000)—who examine how costs to trade in goods can explain several international macroeconomic puzzles—we explore the macroeconomic consequences of global trade costs. Thus we contribute to recent quantitative papers investigating how trade costs are related to international risk sharing, trade imbalances, and business cycles, among others (Eaton et al., 2016a; Fitzgerald, 2012; Reyes-Heroles, 2017; Alessandria and Choi, 2021; Eaton et al., 2016b).[9]

Our work is also related to the literature studying the role of trade openness in shaping business cycles and inflation through the lens of open economy New-Keynesian models (Ho et al., 2022; Erceg et al., 2023; Amiti et al., 2024).[10] Most closely related to our work are those that consider the

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[9] Alessandria and Mix (2021) and Alessandria et al. (2023) are additional works focusing on how trade policy and supply chains can have aggregate effects.

[10] Other work like Hottman and Reyes-Heroles (2023) exploit regional U.S. data and follow a less model-dependent

macroeconomic impact of protectionist policies (Barattieri et al., 2021) and the inflationary effects of supply-chain bottlenecks and import constraints (Comin et al., 2024; Di Giovanni et al., 2023). We contribute to this literature by considering the inflationary effects emanating from shocks to broadly defined trade barriers—reflecting both protectionist policies or supply-chain disruptions—consistent with the structure of gravity models of international trade. Moreover, and in line with our empirical approach, our multi-country framework with trade in final goods and intermediate inputs allows us to consider the effects of trade diversion following trade cost shocks.[11] In addition, 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 on international trade that uses static gravity models of trade to estimate trade costs. Head and Mayer (2014) review various approaches to estimate trade costs. Fitzgerald (2012); Eaton et al. (2016b,a); Reyes-Heroles (2017) all exploit the fact that dynamic models can deliver static gravity conditional on aggregate data to identify trade costs given an estimate of the trade elasticity. We contribute to this literature by isolating exogenous changes in import costs, exploring the correlation between measured trade costs with inflation and other macroeconomic variables, and documenting causal relationships.[12]

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. Sections 4 and 5 present the model and its calibration. Sections 6 and 7 conduct model experiments and present the quantification of the contribution of trade shocks to the recent surge in inflation. Section 8 concludes.

2 Trade Costs Across Time and Space

2.1 Measuring Trade Costs: Static Armington Model and Structural Gravity

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 calculate these costs, we follow the literature in international trade that estimates trade costs

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approach to estimate the effects of openness on inflation dynamics and the slope of the Phillips curve in the U.S.

[11] Our focus on the transmission of trade cost shocks through the intermediate inputs channel is consistent with the evidence in Flaaen and Pierce (2019), who show that through this channel, the 2018-19 U.S.-China trade war had significant effects on U.S. manufacturing prices and employment.

[12] Our approach is related to that followed 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.

based on the structure of static trade models that deliver gravity equations (Head and Mayer, 2014). Relying on a structural framework rather than just on observable measures of trade costs will also allow us to compare trade costs across countries and over time.

We consider an Armington model of trade determining bilateral trade flows across countries at any given point in time that is consistent with static gravity.[13] In section 4, we embed the exact structure of this static model into a dynamic stochastic general equilibrium model that we will use to analyze the mechanisms through which shocks to trade costs affect inflation. The equilibrium of the static bloc of the model delivers predictions for bilateral trade flows for different types of goods conditional on aggregate spending on such goods at a point in time.[14] We rely on the equilibrium conditions of the static bloc of the model to recover bilateral trade from observables.

Consider a world comprised of multiple countries indexed by $i, h \in \mathcal{I} = \{1, \dots, N\}$ in any given period t. Each country produces a unique tradable good that is available to all countries—that is, there is *national product differentiation*. Goods produced in a country can be bought by households for final consumption or by firms as intermediate inputs in all countries. We assume households and firms in country i aggregate goods across sources into a single nontradable composite consumption good, $C_{i,t}$, or intermediate input, $M_{i,t}$. 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 consumption 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 in h in terms of country i's currency is $P_{ih,t} \equiv \mathcal{E}_{ih,t} P_{h,t}$.

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 shipped at time t. That is, $\tau^{Q}_{ih,t} - 1$ units of the good disappear when it is shipped internationally

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

[14] In the dynamic model, aggregate expenditures on various types of goods are endogenously determined.

from country h to country i.[15] We normalize domestic trade costs such that $\tau^Q_{ii,t} = 1$ for every i and $Q \in \{C, M\}$. Therefore, the price in local currency units that country i has to pay to acquire one unit of the good of type $Q \in \{C, M\}$ produced in country h is given by

$$P^Q_{ih,t} \equiv \tau^Q_{ih,t} P_{ih,t}. \tag{2}$$

Households and firms in country i seek to minimize expenditure on final goods and intermediate inputs, 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 $\lambda^Q_{ih,t}$ denote the share of expenditure by country i on goods of type Q produced in country h, $\lambda^Q_{ih,t} \equiv \frac{P^Q_{ih,t} Q_{ih,t}}{P^Q_{i,t} Q_{i,t}}$. Equation (3) implies that these shares are given by

$$\lambda^Q_{ih,t} = \left(\frac{\tau^Q_{ih,t} P_{ih,t}}{P^Q_{i,t}} \right)^{-(\eta_Q - 1)}, \tag{5}$$

where the trade elasticity in this model is given by $\eta_Q - 1$. Note that (5) 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. Gravity models constitute the workhorse framework in international trade to estimate bilateral trade flows and their determinants (Head and Mayer, 2014). In what follows, we describe our approach to infer bilateral trade costs relying on (5) and using only data on bilateral trade flows.

Note from (5) that we can use a country's domestic sourcing share given by $\lambda_{ii,t}$, to control for

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

the price of the goods produced in the exporting country denominated in local currency units. More specifically, given (5) for importer i and exporter h, we can express bilateral trade costs between these countries as a function of their bilateral trade share, the exporter's domestic sourcing share, and prices as follows:

$$\tau_{ih,t}^{Q} = \left(\frac{\lambda_{ih,t}^{Q}}{\lambda_{hh,t}^{Q}} \right)^{-\frac{1}{\eta_Q - 1}} \frac{P_{i,t}^{Q}}{\mathcal{E}_{ih,t} P_{h,t}^{Q}}. \tag{6}$$

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 $\eta_Q > 1$.[16]

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. However, we can further manipulate the model to obtain a measure of bilateral trade frictions that only depends on data on bilateral trade flows. By switching the roles of the importing and exporting countries in (6) to control for relative price differences, we obtain a measure of trade frictions between individual country pairs given by

$$HR_{ih,t}^{Q} \equiv (\tau_{ih,t}^{Q} \tau_{hi,t}^{Q})^{\frac{1}{2}} = \left(\frac{\lambda_{ih,t}}{\lambda_{hh,t}} \frac{\lambda_{hi,t}}{\lambda_{ii,t}} \right)^{-\frac{1}{2(\eta_Q - 1)}}, \tag{7}$$

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 $\tau_{ih,t}^{j}$ for any pair of countries. Note that $HR_{ii,t} = 1$, 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 its trading partners, which we will use in section 2.5 to construct a measure of import costs at the country level.

Note that our procedure to measure bilateral trade frictions controls for both importer and exporter characteristics. Hence, variation in our measured frictions is driven exclusively by bilateral factors—for example, geographical characteristics like distance between two countries, typically

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

considered in gravity models—and controls for country-wide factors, such as inflation, that could be driving trade flows. In that sense, we identify variation in bilateral costs that is exogenous to aggregate supply or demand shocks.[17] Thus, by aggregating bilateral costs we can obtain exogenous shocks to trade costs and therefore identify the the causal effect of these shocks on inflation, as we do in section 3.

Before turning to the description of the data that we use to construct HR indices, note that we require each country's "domestic" trade flows or domestic sourcing to construct bilateral trade frictions. This requirement represents an important challenge in terms of data availability. To be more precise, let $X^Q_{ih,t} \equiv P^Q_{ih,t} Q_{ih,t}$ for $Q \in \{C, M\}$ denote expenditure by country i on goods produced in h of type Q. Then, $X^Q_{i,t} \equiv \sum_{h=1}^{N} X^Q_{ih,t}$ defines total expenditure by country i on type Q goods, which is such that $X^Q_{i,t} = P^Q_{i,t} Q_{i,t}$. While data for $X^Q_{ih,t}$ for $h \neq i$ is readily available in multiple datasets for bilateral trade flows, data for $X^Q_{ii,t}$ is not. However, we can obtain $X^Q_{ii,t}$ if we have data for $X^Q_{i,t}$ consistent with trade flows. In the following section, we describe the datasets that allow us to construct bilateral and domestic trade flows for many countries over three decades.

2.2 Data

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.

We consider multiple data sources for our analysis. Our primary and main data source is the Inter-Country Input-Output Tables (ICIO) published by the OECD. The ICIO provides global input-output tables, that is, it maps flows of production and expenditure within countries and flows of international trade between countries, broken down by economic activity and by country, globally. The regular ICIO considers 76 countries and a rest of the world aggregate (ROW) from 1995 through 2020. In addition to the ICIO, we source data from the World Input-Output Database (WIOD) (Timmer et al., 2015), which provides world input-output tables for a set of countries and periods that differ from the ICIO. There are two data releases of the WIOD. The WIOD 2013 Release considers 41 countries and a ROW aggregate for 1995-2011, and the WIOD 2016 release considers 43 countries and a ROW aggregate for 2000-2014.

We rely on the HR indices that we construct using the ICIO data to derive our main empirical

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

results because of the longer period covered by these data. However, we also use HR indices recovered from WIOD data for comparison and robustness. To that end, we aggregate both the ICIO and WIOD releases to 41 countries—40 countries and a ROW aggregate—and “stitch” together the two WIOD releases to obtain series for 2000-2014. We consider trade flows for tradable sectors—basically, non-service sectors in the data—and differentiate between goods used as intermediate inputs, $Q = M$, and those used as final goods for consumption or investment, $Q = C$.[18]

For each country i, we obtain from our data the expenditure for final or intermediate goods, $Q \in \{C, M\}$, on goods produced by each of i's trading partners, including itself, $X^Q_{ih,t}$ for $i = 1, \ldots, N$. We then use $X^Q_{ih,t}$ construct expenditure shares, $\lambda^Q_{ih,t}$, that we use to construct HR indices according to (7), conditional on a value of the trade elasticity parameterized by η_Q. For our baseline empirical exercises and calibration (see section 5), we will consider equal parameters across types of goods, $\eta \equiv \eta_C = \eta_M$, and a value of $\eta = 5$ which implies a trade elasticity equal to four. Given the estimates of Simonovska and Waugh (2014) and the more recent estimates by Boehm et al. (2023) for the long-run trade elasticity, we consider this value a reasonable choice. We explore the robustness of our main results to different values of this parameter in Appendix C.2.

2.3 Trade Costs Across Time

How do global bilateral trade costs evolve? The first fact we document deals with low-frequency changes in median bilateral trade costs.

Fact T1: 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 1 plot the median HR index—which we call bilateral trade costs from now on—for final (blue line) and intermediate (red 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, divided by 100—in terms of our definition in (7), the figure shows $HR^Q_{ih,t} - 1$ for $Q \in \{C, M\}$. According to our ICIO estimates in panel (a), median bilateral trade costs across countries for both final and intermediate goods fell approximately 80 percentage points from 1995 to 2008. This is a significant decline given that these costs in 1995 were approximately 380 and 420 percent for final and intermediate goods,

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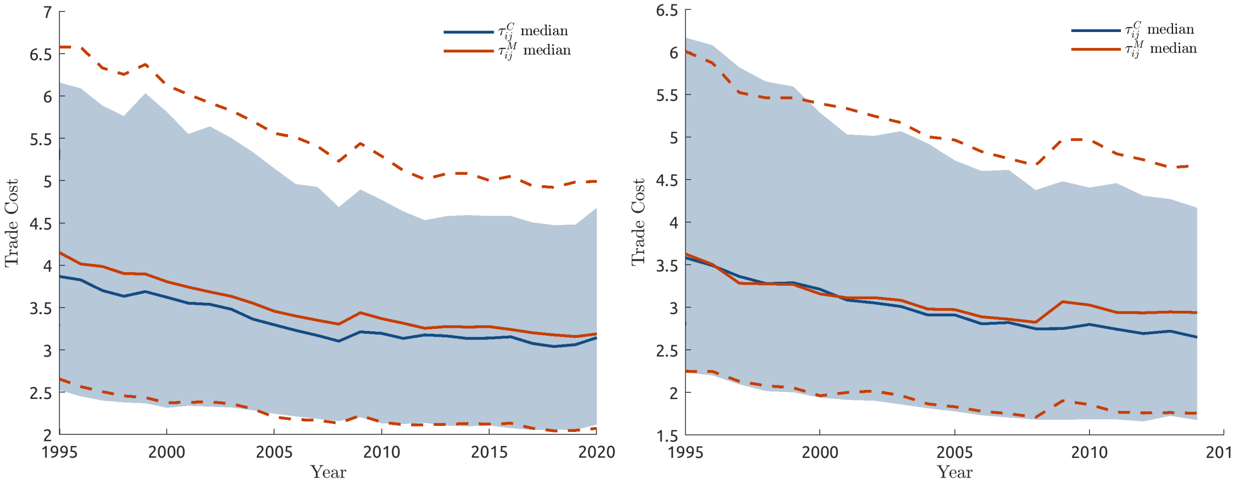
[18] See Appendix A for further details on data cleaning and manipulation.

respectively.[19] The plot also shows that, since 2008, median trade costs have remained pretty much unchanged. From 2008 to 2020, median trade costs for final goods and intermediate inputs hovered around 310 and 350 percent, respectively. Hence, the long-run evolution of global trade costs is consistent with a long period of globalization that has stalled since 2010.[20]

Fact T1 is not exclusive to data from the ICIO. Panel (b) of figure 1 considers the case of the evolution of the distribution of bilateral trade costs for WIOD data. These data show similar patterns to those stated in Fact T1 for the ICIO data.

Figure 1: Evolution of global bilateral trade costs


(a) ICIO Database

(b) WIOD Database

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 $HR^Q_{ih,t} - 1$ for $Q \in \{C, M\}$.

The second fact we document is related to the long-run evolution of the dispersion in bilateral trade costs at a given time.

Fact T2: The dispersion in bilateral trade costs across country pairs remained relatively stable from 1995 to 2020.

Figure 1 also plots the evolution of the dispersion of trade costs over time. The charts plot the 20-80 percentile bands for final consumption (boundaries of blued shaded region) and intermediate inputs (dashed red lines). Panel (a) shows that the dispersion in trade costs decreased minimally

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[19] 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 country.

[20] Appendix B provides more details on the evolution of trade costs before 1995 using the historical WIOD data.

until 2010 and has remained completely stable since then. Hence, it seems that differences in costs across space have remained relatively stable.

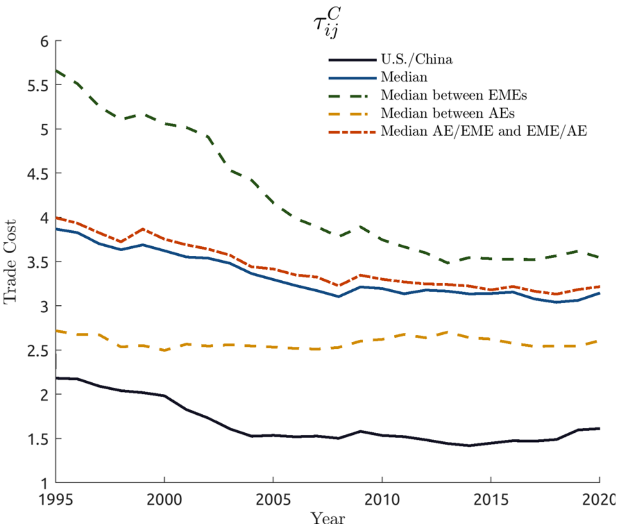
2.4 Trade Costs Across Space

How do global bilateral trade costs vary across space? Even though Fact T2 already provides insights into the variation of trade costs across space, we formalize and detail one fact in this section about the cross-sectional dispersion in bilateral trade costs.

Fact S1: There is substantial variation in trade costs across countries.

Figure 1 shows that variation in bilateral trade costs is substantial at any given time. Moreover, this variation remains sizable over the years considered. 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.

Figure 2: Median Trade Costs for Selected Regions



(a) Final Goods

(b) Intermediate Goods

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 $HR_{ih,t}^{Q} - 1$ for $Q \in \{C, M\}$.

What types of country-pairs drive the differences in bilateral trade costs? Figure 2 plots the evolution of median bilateral trade costs conditional on specific types of country pairs. If we split our sample of countries into Advanced Economies (AE) and Emerging Market Economies (EME), then we can classify trade flows between any two counties as between AEs, between EMEs, or between different types of countries (AE/EME of EME/AE). The figure shows that trade between EMEs and between countries of different types of countries (AE/EME or EME/AE) faces the highest costs. However, these costs also decline the most from 1995 to 2020. These trends align with the fact that trade between these countries has grown the most over the last 25 years (Reyes-Heroles et al., 2020). Interestingly, trade costs across AEs remained relatively stable, reflecting that trade between these countries did not increase substantially over 1995-2020.

Does our measure of bilateral trade frictions capture changes in tariffs? Figure 2 also plots bilateral trade costs between the U.S. and China (black solid line). These costs followed a path similar to median costs until the onset of recent trade tensions. During the 2018–19 period, U.S.–China trade costs increased 20 percentage points and 11 percentage points for intermediate and final goods, 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 evidence showing that these increases were tilted toward intermediate goods (Bown, 2021). Hence, our measure of costs captures changes in tariffs remarkably well.

2.5 Import Costs and Inflation

To estimate the effects of changes in trade cost on inflation, we exploit variation in trade costs across time and space in section 2. Thus, the facts we document motivate our approach of using panel data local projections (Jordà, 2005) to estimate these effects. However, to follow this approach, we must first construct country-specific measures of trade costs that capture the variation arising from bilateral—or country-pair-specific —trade frictions. Hence, we construct country-specific import costs $\tau_{i,t}^{Q}$ for $Q \in \{C, M\}$ by aggregating bilateral trade costs using lagged import weights in our baseline specification.[21] More specifically, our import costs are given by

$$\tau_{i,t}^{Q} = \sum_{h=1}^{N} \left(\frac{X_{ih,t-1}^{Q}}{\sum_{k \neq i} X_{ik,t-1}^{Q}} \right) HR_{ih,t}^{Q}, \tag{8}$$

for $Q \in \{C, M\}$. We consider lagged import weights to better isolate changes in import costs driven by contemporaneous changes in $HR_{ih,t}^{Q}$ rather than by changes in weights driven by trade cost changes.[22]

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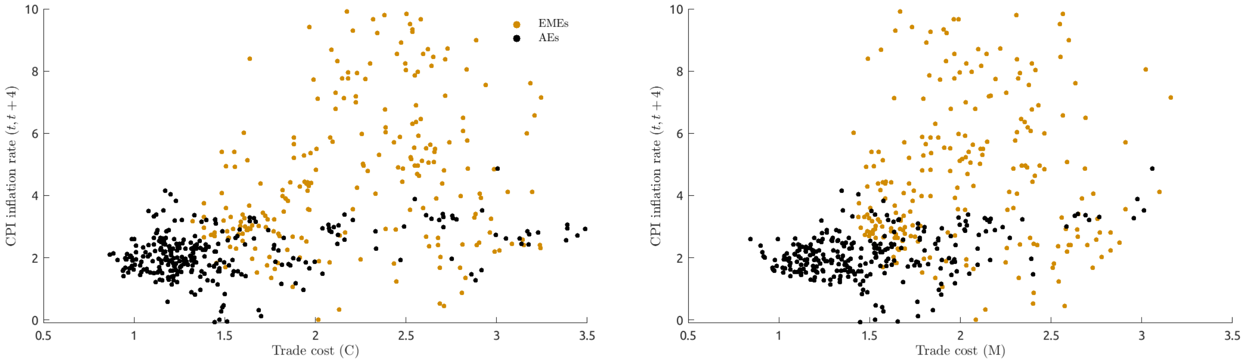
[21] It is not key to consider import weights—Frankel and Romer (1999), for instance, consider equal weights across trade partners—and we could consider weighting costs in different manners.

[22] Alternatively, we could fix weights so that they do not vary over time.

Figure 3 shows a scatter plot of our import costs and CPI inflation. More specifically, each dot in the figure corresponds to a country-year observation where we relate the trade costs in year t, $\tau^{Q}_{i,t}$, with the average CPI inflation observed in the subsequent four years, up to $t+4$.[23] We show inflation measured as the year-on-year change in the Consumer Price Index (CPI) for each country, which we collected from the World Development Indicators (WDI) database.[24] The left panel (right) shows the relation between trade costs in final (intermediate) goods and inflation.

Figure 3: Trade Costs and Inflation



(a) Trade costs in consumption and inflation

(b) Trade costs in intermediates and inflation

Note: Trade costs in year t, $\tau^{Q}_{i,t}$, plotted against average CPI inflation in the subsequent four years, up to $t+4$. Trade cost data from ICIO database, inflation data from the WDI database.

Visual inspection suggests a positive correlation between higher import costs and future CPI inflation. The scatter plot also reveals substantial dispersion in the inflation rate, particularly for country-year observations where trade costs are above 100 percent. Uncovering the causal effect and the magnitude of higher trade costs on inflation requires controlling for unobserved factors driving the positive correlation in this simple scatter plot. We turn to this analysis in the next section.

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[23] The relation between contemporaneous inflation and trade costs is similar, but it is instructive to show future average inflation to abstract from variation in inflation that may be unrelated to current trade costs.

[24] Because the period we consider includes some high inflation episodes driven by factors unrelated to trade costs, such as currency crises or macroeconomic turmoil due to pro-market reforms in Eastern Europe, we restrict attention to country-year observations where the inflation is below 10 percent.

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:

$$y_{i,t+h} = \alpha_i + \gamma_t + \beta_h^Q \tau_{i,t}^Q + A_h Z_{i,t} + \varepsilon_{i,t+h} \qquad \text{for } h \geq 0, \tag{9}$$

where $y_{i,t+h}$ is the dependent variable of interest for country i in period $t+h$. We will focus here on the case where CPI inflation is the dependent variable and leave the analysis of other macroeconomic outcomes to Appendix C. Thus, we have that $y_{i,t} = \pi_{i,t}$.

Our coefficient of interest in equation (9) is β_h^Q, which captures the average effect of trade costs on CPI inflation h periods ahead. To isolate the dynamic impact of trade costs, $\tau_{i,t}^Q$, on inflation, we control for unobserved sources of variation that are time-invariant but specific to each country. We capture these factors through the country-fixed effect term α_i in (9). We also include a time-fixed effect γ_t to control for time-varying factors that influence all countries equally. The vector $Z_{i,t}$ controls for other observable characteristics of country i. In our baseline specification, the vector $Z_{i,t}$ includes the first lag of the dependent variable, the first lag of the unemployment rate, the first lag of GDP growth, the first lag of the level of GDP, and the lag of the trade cost, $\tau_{i,t-1}^Q$. Note that including the lag of the trade cost implies that we are estimating the effects of innovations in these costs.

Finally, to account for outliers related to macroeconomic events, such as currency or banking crises that may lead to inflation surges but are unrelated to changes in trade costs, we include country-year dummy observations related to inflationary episodes from the Global Crises Data database.[25]

Given that our measure of import costs is expressed as a percent of the final sale price, the coefficient β_h^Q measures the effect of a 1 percentage point increase in trade costs. We scale the response coefficients such that total import costs of final and intermediate goods increase by 10 percentage points.

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[25] See https://www.hbs.edu/behavioral-finance-and-financial-stability/data/Pages/global.aspx

3.2 Inflationary Effects

Our estimates for $h = 0, 1, ..., 5$, presented in figure 4, show that an increase in trade costs of either final (left panel) or intermediate (right panel) goods leads to a contemporaneous statistically significant rise in CPI inflation.[26] According to our estimates, a 10 percentage point increase in a country's trade costs of final goods from all its trading partners leads to a 0.5 percentage point increase in CPI inflation within the first year. An equally sized rise in trade costs of intermediate goods leads to a 0.3 percentage point increase in CPI inflation. Hence, the magnitude of the immediate impact on CPI inflation varies depending on the type of trade cost shock. The fact that the effect of an increase in import costs of final goods is almost twice as large as that of an increase in the costs of intermediate inputs is in line with the intuition that an increase in the costs of imported final consumption goods affects the CPI directly. Meanwhile, higher import costs of intermediate inputs first affect production costs, which in turn affects producers' prices and, ultimately, consumer prices.

An interesting and novel result is that the persistence of the effects differs depending on the type of trade cost shock. Higher costs for trade of final goods—say, due to tariffs imposed on goods like washing machines—lead to a larger but more short-lived effect on CPI inflation. Higher costs of intermediate goods trade—say, due to a shortage in semiconductors or tariffs imposed on imported Chinese battery cells or boat motors—have somewhat more persistent effects on CPI inflation. Thus, a combination of an increase in trade costs for intermediate and final goods leads to a 0.8 percentage point increase in inflation on impact that takes several years to peter out.

Overall, differences in the magnitude and persistence of the effects on inflation across types of trade costs shocks imply that the effects on the CPI price level after three years of the shock are larger for an increase in the trade cost of final goods. For the case of final goods, the CPI level is 0.9 percentage point higher after three years, 0.1 percentage point more than for the case of intermediate inputs.

Given our main empirical results, we develop a dynamic model in section 4 to compare its predictions to our empirical estimates. We will show that our calibrated model does a good job in replicating the impulse response functions estimated in this section. Moreover, we show that by affecting firms' marginal costs, changes in trade costs of intermediate inputs lead to smaller, but more persistent responses in inflation, in line with our empirical results.

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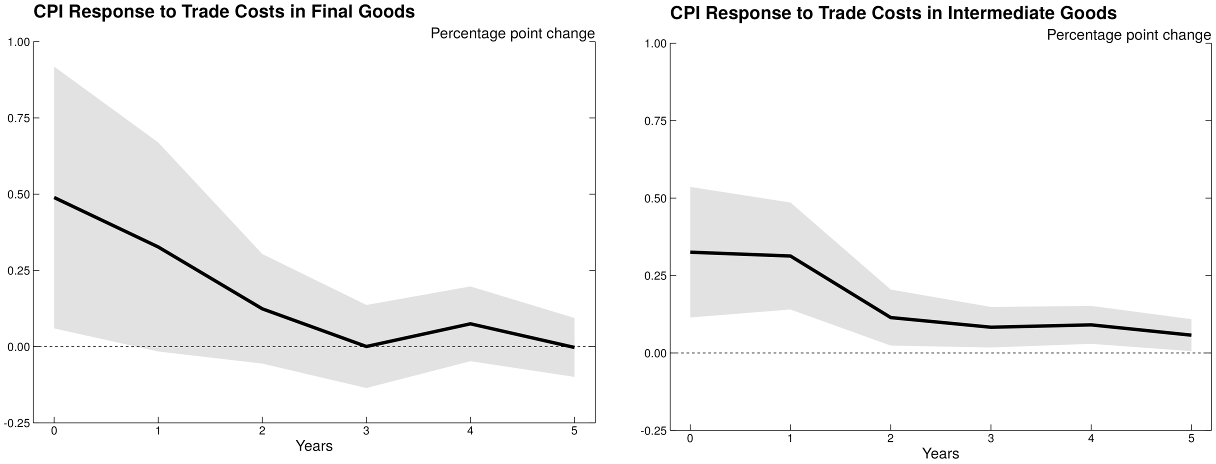
[26] We estimate our panel specification using the approach suggested in Correia (2016), and consider heteroskedasticity-robust standard errors.

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


CPI Response to Trade Costs in Final Goods

CPI Response to Trade Costs in Intermediate Goods

Note: Note: The figure shows the consumer price index (CPI) response to a 10 percentage point increase in trade costs. Solid lines show the, average response across countries. Shaded areas show the 70 percent confidence intervals.

4 The Model

We next develop a dynamic model to better understand some key mechanisms through which changes in trade costs can affect inflation and macroeconomic outcomes. We will conduct a series of experiments using the model to examine these mechanisms and their quantitative relevance. In addition, the model will allow us to quantify the relevance of trade cost shocks during the surge in inflation observed in 2021 and its subsequent decline.

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 2.1—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 2.1 into a dynamic framework. Time is discrete and indexed by $t = 1, 2, \ldots$. To recap, we consider a world 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 2.1—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 household ℓ in country i is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[U_i(C_{i,t}) - V_i(L^{\ell}_{i,t}) \right], \tag{10}$$

where $C_{i,t}$ is as in (1) for $Q = C$.[27] 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 (10), $L^{\ell}_{i,t}$ denotes labor services (hours) provided by household ℓ in country i.

Household ℓ in country i seeks to maximize (10) subject to the budget constraint

$$\sum_{h=1}^{N} \tau^C_{ih,t} P_{ih,t} C_{ih,t} + B_{ii,t} + \frac{B_{i1,t}}{\mathcal{E}_{1i,t}} \leq W^{\ell}_{i,t} L^{\ell}_{i,t} + R_{i,t-1} B_{ii,t-1} + R_{1,t-1} \Psi_{i,t-1} \frac{B_{i1,t-1}}{\mathcal{E}_{1i,t}} + T_{i,t} \tag{11}$$

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 2.1—and $T_{i,t}$ are transfers to households in country i.[28] We allow for risk premia to vary across countries by means of the term $\Psi_{1,t-1}$ in (11). 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

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[27] 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 $C_{i,t}$.

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

that for $i \neq 1$, $\Psi_{i,t}$ is given by

$$\Psi_{i,t} \equiv (1 - \psi \frac{b_{i1,t}}{\mathcal{Q}_{1i,t} Y_{i,t}}) \varepsilon^{\psi}_{i,t}, \tag{12}$$

where $b_{i1,t} \equiv \frac{B_{i1,t}}{P^C_{1,t}}$ denotes country i's borrowing in units of country 1's good, $Y_{i,t}$ denotes total tradable output in country i, $\varepsilon^{\psi}_{i,t}$ 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

$$\mathcal{Q}_{ih,t} \equiv \frac{\mathcal{E}_{ih,t} P^C_{h,t}}{P^C_{i,t}}, \tag{13}$$

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

Note that in (11), we express prices paid for final consumption goods i, $P^C_{ih,t}$, explicitly in terms of the trade costs for final consumption goods, $\tau^C_{ih,t}$—as defined in section 2.1—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, have a direct impact on their behavior and welfare. We now impose additional structure on these trade costs and assume that they are comprised of exogenous iceberg trade costs, $d^C_{ih,t} \geq 1$, and exogenous add-valorem tariffs, $\kappa^C_{ih,t} \geq 0$, such that total trade costs are given by $\tau^C_{ih,t} = d^C_{ih,t}(1 + \kappa^C_{ih,t})$.

Note that, conditional on $C_{i,t}$, equation (3) for $Q = C$ determines demand for consumption goods across country sources, where $P^C_{i,t}$ is given by (4) for $Q = C$. Hence, conditional on aggregate expenditure, all bilateral trade flows are fully determined by equation (5). Aggregate expenditure, in turn, is determined by the household's intertemporal optimality condition with respect to bonds denominated in domestic currency. This condition is characterized by the Euler equation

$$U'_i(C_{i,t}) = \beta R_{i,t} \mathbb{E}_t \left[\frac{U'_i(C_{i,t+1})}{\pi_{i,t+1}} \right], \tag{14}$$

where $\pi_{i,t} \equiv \frac{P^C_{i,t}}{P^C_{i,t-1}}$ 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, household's optimal portfolio choice is characterized by an uncovered interest parity (UIP) condition, which in real terms is given by

$$R_{i,t}\mathbb{E}_t\left[\frac{U_i'(C_{i,t+1})/U_i'(C_{i,t})}{\pi_{i,t+1}}\right] = R_{1,t}\Psi_{i,t}\mathbb{E}_t\left[\frac{U_i'(C_{i,t+1})/U_i'(C_{i,t})}{\pi_{1,t+1}\frac{\mathcal{Q}_{1i,t+1}}{\mathcal{Q}_{1i,t}}}\right]. \tag{15}$$

Hence, given our assumption about $\Psi_{i,t}$ in (12), 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

$$L_{i,t} = \left(\int_0^1 {L_{i,t}^{\ell}}^{\frac{\epsilon_w - 1}{\epsilon_w}} d\ell\right)^{\frac{\epsilon_w}{\epsilon_w - 1}}, \tag{16}$$

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

$$L_{i,t}^{\ell} = \left(\frac{W_{i,t}^{\ell}}{W_{i,t}}\right)^{-\epsilon_w} L_{i,t}, \tag{17}$$

where

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

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, $W_{i,t}^{\ell}$, with probability $1 - \theta_w$, and that with probability θ_w, household ℓ's nominal wages 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

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta_w^k \left(U_i(C_{i,t}) - V_i(L^{\ell}_{i,t+k|t}) \right), \tag{19}$$

where

$$L^{\ell}_{i,t+k|t} = \left(\frac{\overline{W}_{i,t}}{W_{i,t+k}} \right)^{-\epsilon_w} L_{i,t+k} \tag{20}$$

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:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta_w^k L^{\ell}_{i,t+k|t} U_i'(C_{i,t+k}) \left(\frac{\overline{W}_{i,t}}{P^C_{i,t+k}} - \frac{\epsilon_w}{\epsilon_w - 1} \frac{V_i'(L^{\ell}_{i,t+k|t})}{U_i'(C_{i,t+k})} \right) = 0. \tag{21}$$

Note that in the case in which workers can adjust wages in every period, $\theta_w^k = 0$, then we obtain the usual optimally 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

$$Y_{i,t}^{v} = A_{i,t}\left[(1-\nu)^{\frac{1}{\varepsilon_y}} L_{i,t}^{v\,\frac{\varepsilon_y-1}{\varepsilon_y}} + \nu^{\frac{1}{\varepsilon_y}} M_{i,t}^{v\,\frac{\varepsilon_y-1}{\varepsilon_y}}\right]^{\frac{\varepsilon_y}{\varepsilon_y-1}}, \tag{22}$$

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.[29] The intermediate input, in turn, consists of an aggregate of goods produced in all countries according to 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,

$$\sum_{h=1}^{N} \tau_{ih,t}^{M} P_{ih,t} M_{ih,t}, \tag{23}$$

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 add-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 $Q = M$.

Differentiated firms choose the amount of labor and the intermediate input bundle to minimize total production costs given by

$$W_{i,t}L_{i,t} + P_{i,t}^{M} M_{i,t}, \tag{24}$$

subject to (22). Given nominal wages and the price of the intermediate input bundle in country i, $P_{i,t}^{M}$, the solution to the cost minimization problem delivers the marginal cost faced by retail firms,

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[29] 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).

which is the same across firms and given by

$$MC_{i,t} = \frac{1}{A_{i,t}} \left[(1-\nu){W_{i,t}}^{1-\varepsilon_y} + \nu (P^M_{i,t})^{1-\varepsilon_y} \right]^{\frac{1}{1-\varepsilon_y}} . \tag{25}$$

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 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

$$Y_{i,t} = \left(\int_0^1 {Y^v_{i,t}}^{\frac{\epsilon-1}{\epsilon}} dv \right)^{\frac{\epsilon}{\epsilon-1}} , \tag{26}$$

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 (26). The solution to this maximization problem delivers the demand for variety v in country i:

$$Y^v_{i,t} = \left(\frac{P^v_{i,t}}{P_{i,t}} \right)^{-\epsilon} Y_{i,t}, \tag{27}$$

where

$$P_{i,t} = \left[\int_0^1 {P^v_{i,t}}^{1-\epsilon} dv \right]^{\frac{1}{1-\epsilon}} \tag{28}$$

defines the nominal price of a unit of the homogeneous good produced in country i in terms of its own currency, and $P^v_{i,t}$ denotes the nominal price charged by firm v in country i, also in terms of local currency units. As stated in section 2.1, excluding trade costs, the price of country i's imports from any country h is given by price country h producers set domestically, adjusted for the exchange rate between the two countries. Accordingly,

$$P_{ih,t} = \mathcal{E}_{ih,t} P_{h,t}. \tag{29}$$

Given the conditional demands for differentiated varieties in (27), we now turn to how retails firms set prices.

4.2.3 Price Setting by Differentiated Firms

Differentiated firms in country i set prices to sell their goods to retailers.[30] 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 it price in period t. Such a firm in country i will set this price to maximize

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta^k \frac{U'_{i,t}(C_{i,t})}{P^C_{i,t+k}} \left(\overline{P}_{i,t} - MC_{i,t+k}\right) \left(\frac{\overline{P}_{i,t}}{P_{i,t+k}}\right)^{-\epsilon} Y_{i,t+k}, \tag{30}$$

where the marginal cost is as specified in (25). The optimal price set by those firms able to adjust prices must be such that the following optimality condition holds:

$$\mathbb{E}_t \sum_{k=0}^{\infty} \beta^k \theta^k \frac{U'_{i,t}(C_{i,t})}{P^C_{i,t+j}} P^{\epsilon}_{i,t+k} Y_{i,t+k} \left[\overline{P}_{i,t} - \frac{\epsilon}{\epsilon-1} MC_{i,t+k}\right] = 0. \tag{31}$$

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 (28) we obtain that $P_{i,t}$ satisfies the law of motion $P^{1-\epsilon}_{i,t} = \theta P^{1-\epsilon}_{i,t-1} + (1-\theta)\overline{P}^{1-\epsilon}_{i,t}$.

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

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[30] 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.

the inertial policy rule given by

$$R_{i,t} = (R_{i,t-1})^{\phi_r} \left(\frac{1}{\beta} (\pi_{i,t})^{\phi_\pi} \left(\frac{GDP_{i,t}}{GDP_{i,0}} \right)^{\phi_y} \varepsilon^r_{i,t} \right)^{1-\phi_r}, \tag{32}$$

where $GDP_{i,t}$ denotes real value added in country i.[31] In (32), $\phi^r > 0$ is a parameter that determines the inertia in monetary policy, $\phi^\pi > 0$ and $\phi^y > 0$ parameterize the elasticities of the policy rate with respect to changes in inflation and GDP deviations, respectively, and $\varepsilon^r_{i,t}$ 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

$$\xi_i Y_{i,t} = \sum_{h=1}^{N} \xi_h (d^C_{hi,t} C_{hi,t} + d^M_{hi,t} M_{hi,t}) \tag{33}$$

for $i = 1, ...N$, where the population terms ξ_i reflect the fact that all variables are expressed in per-capita terms. Note that (33) accounts for the goods that are lost when traded across countries because of the iceberg-type trade costs $d^Q_{hi,t} \geq 1$ 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 these countries' holdings of the dollar-denominated international bond. To do so, we aggregate domestic budget constraints and obtain

$$\sum_{h=1}^{N} \tau^C_{ih,t} P_{ih,t} C_{ih,t} + \frac{B_{i1,t}}{\mathcal{E}_{1i,t}} = W_{i,t} L_{i,t} + R_{1,t-1} \Psi_{i,t-1} \frac{B_{i1,t-1}}{\mathcal{E}_{1i,t}} + T_{i,t}, \tag{34}$$

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

$$\mathcal{K}_{i,t} = \sum_{h=1}^{N} \left(\kappa^C_{ih,t} \frac{\tau^C_{ih,t} P_{ih,t} C_{ih,t}}{1 + \kappa^C_{ih,t}} + \kappa^M_{ih,t} \frac{\tau^M_{ih,t} P_{ih,t} M_{ih,t}}{1 + \kappa^M_{ih,t}} \right), \tag{35}$$

and firms profits, $\Pi_{i,t}$, such that $T_{i,t} = \mathcal{K}_{i,t} + \Pi_{i,t}$. Given that profits are given by $\Pi_{i,t} = P_{i,t} Y_{i,t} -$

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

$W_{i,t}L_{i,t} - \sum_{h=1}^{N} \tau_{ih,t}^{M} P_{ih,t} M_{ih,t}$, (34) can be rewritten as

$$\sum_{h=1}^{N} d_{ih,t}^{C} P_{ih,t} C_{ih,t} + \frac{B_{i1,t}}{\mathcal{E}_{1i,t}} = P_{i,t} Y_{i,t} - \sum_{h=1}^{N} d_{ih,t}^{M} P_{ih,t} M_{ih,t} + R_{1,t-1} \Psi_{i,t-1} \frac{B_{i1,t-1}}{\mathcal{E}_{1i,t}}, \tag{36}$$

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

$$B_{i1,t} - B_{i1,t-1} = \mathcal{E}_{1i,t} \left(EX_{i,t} - IM_{i,t} \right) + \left(R_{1,t-1} \Psi_{i,t-1} - 1 \right) B_{i1,t-1}, \tag{37}$$

where $EX_{i,t} = P_{i,t} Y_{i,t} - P_{i,t} C_{ii,t} - P_{ii,t} M_{ii,t}$ and $IM_{i,t} = \sum_{h \neq i} d_{ih,t}^{C} P_{ih,t} C_{ih,t} + \sum_{h \neq i} d_{ih,t}^{M} P_{ih,t} M_{ih,t}$, denote exports and imports. Condition (37) simply states that country i's current account is equal to its trade balance plus its net foreign investment income.

5 Calibration

To illustrate how changes in trade costs affect inflation dynamics in our model, we calibrate it and then use it conduct a series of numerical experiments in section 6. We consider five countries, $N = 5$, 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 emerging market economies, respectively. The population parameters, ξ_i, are set to replicate the weights of these five regions in world GDP.

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

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

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

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

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

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 $\tau_{ih,t}^{Q} = \left(\omega_{ih}^{Q}\right)^{\frac{1}{1-\eta_Q}} \varepsilon_{ih,t}^{Q}$, where ω_{ih}^{Q} are time-invariant parameters such that $\sum_{h=1}^{N} \omega_{ih}^{Q} = 1$ for all i, and $\varepsilon_{ih,t}^{Q}$ are stationary shocks to trade costs for $Q \in \{C, M\}$. Note that, by equation (5), this assumption implies that ω_{ih}^{Q} parameterizes the trade shares in a steady state of the model in which all relative prices are unity.[32] Given our assumption that trade is balanced in steady state, we can only calibrate half of the openness parameters for final consumption goods, ω_{ih}^{C}, and intermediate inputs, ω_{ih}^{M}, with the rest being determined by the restriction that trade must be balanced.[33]

We proceed to choose the parameters of the model by relying on previous literature or by using certain moments in the data. Table 1 lists the parameter values for our calibration. Starting with our choice for values of preference parameters, these are standard and similar to those in existing literature. For instance, our values for the 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 trade of final goods, we follow Comin and Johnson (2020) and choose η_C equal to 3. This value is lower than the value we used to construct bilateral trade costs in section 2. However, choosing a lower value is consistent with calibrating a the model at a quarterly frequency, while our estimates in our empirical exercises are for annual data.

For the case of technological parameters, our choices are also standard and similar to those in the literature. In terms of 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), our values are standard (Bodenstein et al., 2023). We also allow for wage indexation to past inflation parameterized by ι_w. To calibrate the technologies of differentiated firms, we follow Comin and Johnson (2020) to choose the value of the steady-state share of intermediates in production, ν, the elasticity of substitution across labor and intermediate inputs, ϵ_y, and the trade

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

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

and $\tau_{ih,t}^{Q} = \varepsilon_{ih,t}^{Q}$ for $Q \in \{C, M\}$.

[33] It can be shown that ω's can be chose recursively such that a steady state of the model with balanced trade and unity prices exists.

elasticity for trade in intermediate inputs, η_M. 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 rule, we assume in our baseline calibration that the policy rate does not responds to output deviations. In addition, our baseline calibration does not consider deviations in the UIP conditions.

For the parameters determining the trade shares, we set four of these parameters for the U.S., three for China, and so on, and let the rest be determined by the trade balance condition in steady state. We choose the values of these parameters based on data from the WIOD. These values are shown at the bottom of table 1.

Table 1: Calibrated Parameters

Parameter	Description	Value
β	Discount factor	0.99
σ	Inverse IES	0.5
h	Habit	0.75
η_C	Elasticity of substitution for final consumption	3
φ	Inverse labor supply elasticity	2
ϵ	Elasticity of substitution across retailers	6
ϵ_w	Elasticity of substitution across labor varieties	6
θ	Price rigidity	0.80
θ_w	Wage rigidity	0.80
ι_w	Wage indexation to past inflation	0.05
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	3
ϕ_π	Taylor rule inflation coefficient	1.5
ϕ_y	Taylor rule output coefficient	0
ϕ_r	Taylor rule inertia	0.75
ψ	Risk premium elasticity to NFA	0
ρ_τ	Trade cost shock autocorrelation	0.95
$[\xi_1, \xi_2, \xi_3, \xi_4, \xi_5]$	Region populations	[.20,.19,.19,.27,.14]
$[\omega_{11}^C, \omega_{12}^C, \omega_{13}^C, \omega_{14}^C]$	Consumption trade weights, country 1	[.94,.012,.004,.021]
$[\omega_{11}^M, \omega_{12}^M, \omega_{13}^M, \omega_{14}^M]$	Intermediates trade weights, country 1	[.88,.025,.007,.04]
$[\omega_{22}^C, \omega_{23}^C, \omega_{24}^C]$	Consumption trade weights, country 2	[.95,.009,.02]
$[\omega_{22}^M, \omega_{23}^M, \omega_{24}^M]$	Intermediates trade weights, country 2	[.94,.01,.014]
$[\omega_{33}^C, \omega_{34}^C]$	Consumption trade weights, country 3	[.94,.014]
$[\omega_{33}^M, \omega_{34}^M]$	Intermediates trade weights, country 3	[.81,.045]
ω_{44}^C	Consumption trade weights, country 4	.94
ω_{44}^M	Intermediates trade weights, country 4	.89

6 Model Experiments

We next perform a series of experiments highlighting the model's predictions about the effects of disruptions in trade. We first examine the effects of an increase in trade costs in the model, mimicking the empirical analysis described earlier. We next discuss the role of key model parameters in the transmission of trade cost shocks. Finally, we consider the effects of an increase in bilateral trade costs between the U.S. and China.

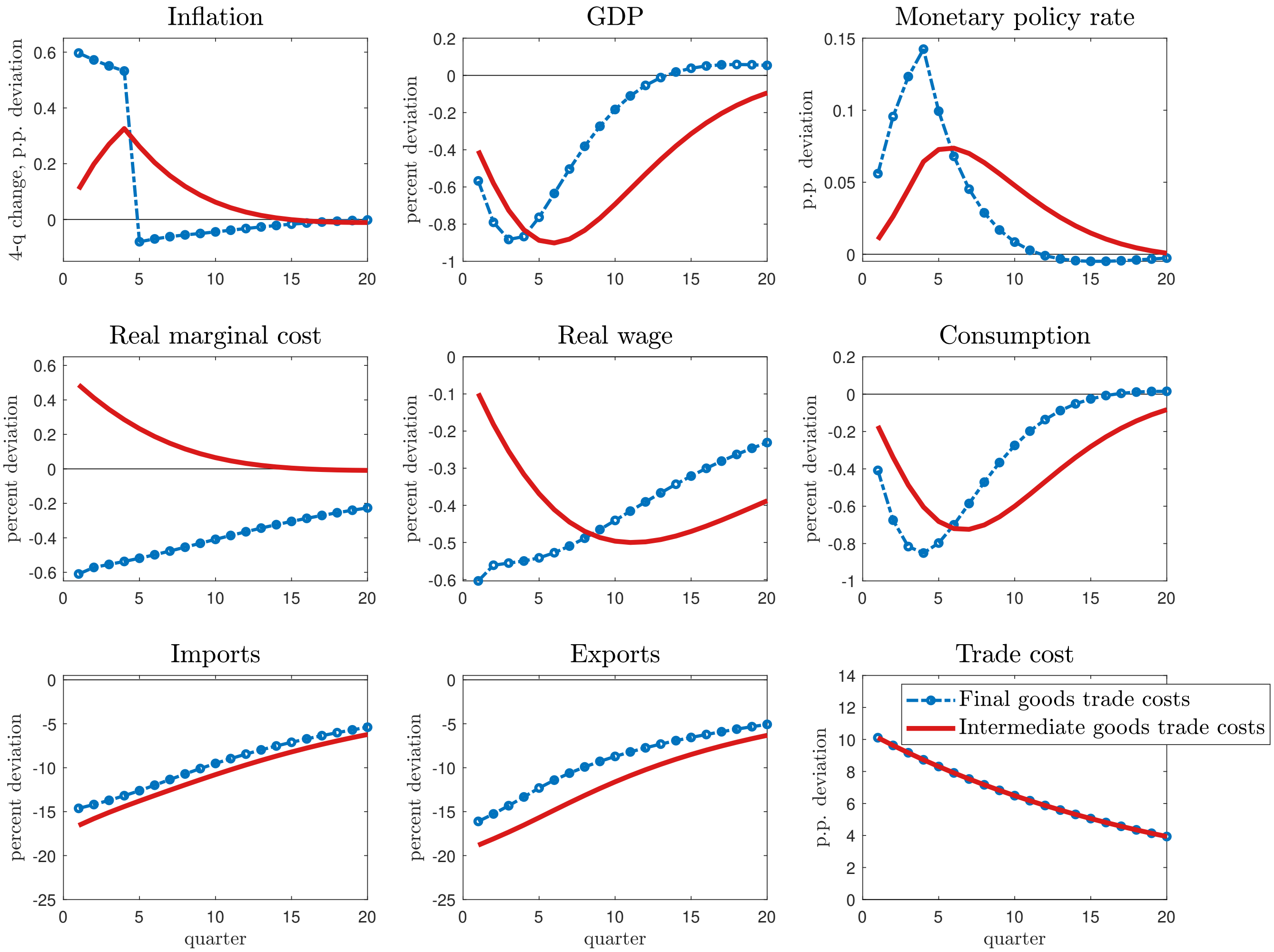
6.1 Effects of increases in trade costs

Focusing on the United States (country 1 in our model), we begin by considering a 10 percentage point increase in trade costs against all trading partners, mimicking the experiment in the empirical analysis of section 3. Consistent with that empirical analysis, we assume here a symmetric increase in the costs that foreigners pay for U.S. imports, that is, we set $\tau^{Q}_{ih,t} = \tau^{Q}_{hi,t}$ for $Q \in \{C, M\}$. As in the data, we perform this experiment separately for trade costs affecting final consumption and intermediate goods.

Figure 5 shows the dynamic effects of the shock when it affects only final consumption goods (blue circled line) and when it affects only intermediates (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, very close to our empirical local projections; but that the effects are very short lived, with 4-quarter inflation falling slightly below 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 that 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—also in line with the empirical estimates.

The more persistent inflation response reflects that an increase in import costs raises the marginal costs of domestic producers. In addition to the direct effect of higher prices of imported inputs, there are "second-round" effects due to the input-output nature of production: More expensive domestic goods raise costs for firms (both at home and abroad) who use those goods as inputs. As such, the effects of an increase in intermediate goods' trade costs resemble an exogenous fall in aggregate total factor productivity: Even though firms can substitute more expensive foreign inputs for domestic inputs (including labor), these other inputs are imperfect substitutes, and therefore inefficiencies arise. Consequently, real marginal cost rises—in stark

Figure 5: Effects on the U.S. of an increase in trade costs

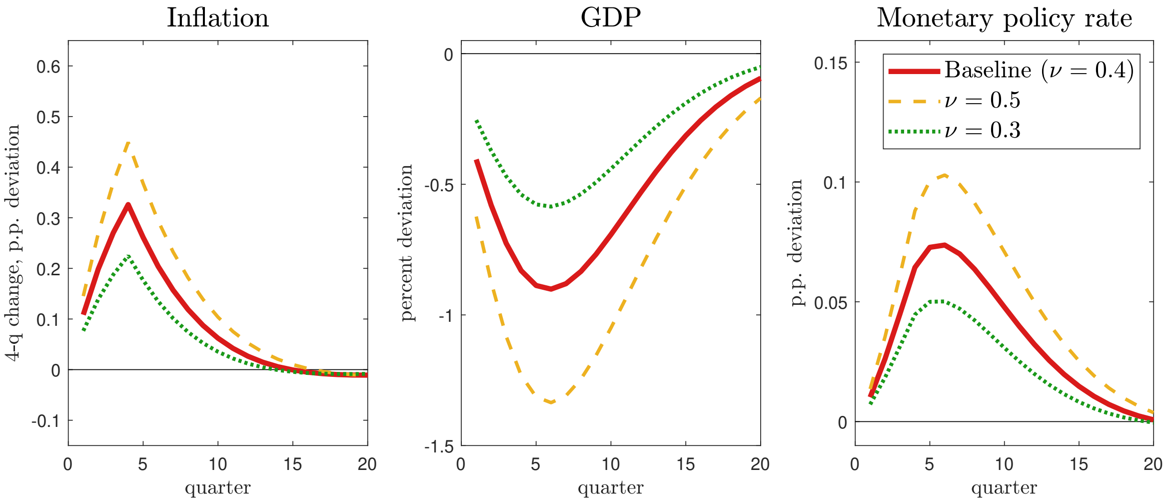


Note: Effects of a 10 percentage point increase in the U.S.'s trade costs from all trading partners on final consumption goods (blue circled line) and intermediate inputs (red solid line).

contrast to the consumption goods case, in which marginal cost falls due to lower domestic real wages. A persistent rise in real marginal cost then translates into persistent inflation, driven by firms adjusting prices sluggishly. GDP falls in both cases, reflecting a drag from tighter monetary policy and lower export demand, but the decline is much more persistent in the intermediate goods case. Imports and exports fall sharply and roughly the same amount in both cases. However, in each case, the decline is concentrated in the type of good (final consumption or intermediate) affected by the higher trade costs.

Hence, in line with our empirical results, increases in trade costs of intermediate inputs lead to smaller increases in inflation in the short run compared with an increase in inflation caused by

Figure 6: Effects on the U.S. of an increase in intermediates trade costs, role of ν



Note: Effects of a 10 percentage point increase in the U.S.'s trade costs from all trading partners on intermediate inputs, baseline calibration with weight of intermediates in production $\nu = 0.4$ (red solid), $\nu = 0.5$ (yellow dashed), and $\nu = 0.3$ (green dotted).

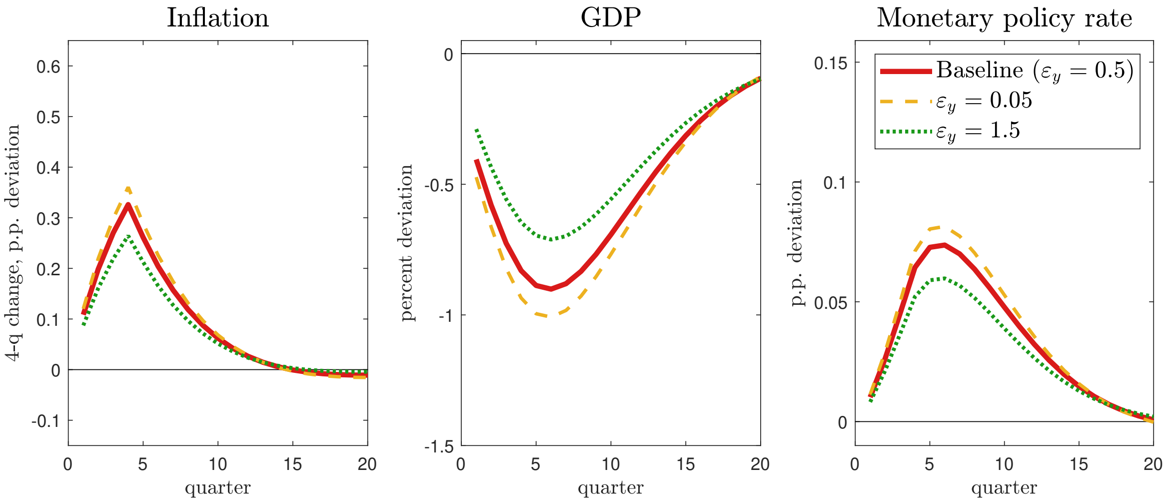
higher import costs of final consumption goods, but are associated with more persistent increases in inflation. This result has notable policy implications, as shocks leading to more-persistent inflation may create larger risks of partially de-anchoring longer-run inflation expectations.

6.2 The role of the share of intermediates and the substitution between labor and intermediate inputs

Given the important role that increases in trade costs of intermediates play in shaping firms' marginal costs and, therefore, inflation dynamics, we explore in this section the role of two key technological parameters shaping these effects. First, we consider how the share of intermediates in firms' production, governed by the parameter ν, affects the response of inflation to shocks. We are particularly interested in this parameter because it determines the relevance of intermediate inputs in production. For instance, if intermediates were not used in production—as in most existing literature on open economy New Keynesian models—then firms' marginal costs would not be affected by changes in intermediate trade costs. Second, we consider how the value of the elasticity of substitution between intermediate inputs and labor—governed by the parameter ε_y—affects inflation dynamics. This parameter determines how easy it is to substitute away from intermediate inputs, given an increase in the costs of this bundle.

Figure 7 contrasts the effects in our baseline calibration with $\nu = 0.4$, with the impact assuming

Figure 7: Effects on the U.S. of an increase in intermediates trade costs, role of ε_y



Note: Effects of a 10 percentage point increase in the U.S.'s trade costs from all trading partners on intermediate inputs, baseline calibration with intermediates-labor substitution elasticity $\varepsilon_y = 0.5$ (red solid), $\varepsilon_y = 0.05$ (yellow dashed), and $\varepsilon_y = 1.5$ (green dotted).

a higher (0.5) and lower (0.3) value for this parameter. As the figure shows, higher values of ν imply a larger increase in inflation and a bigger decline in GDP. The magnitude of the difference is considerable: The rise in inflation roughly doubles, and the decrease in GDP more than doubles when ν increases from 0.3 to 0.5. Hence, the more dependent an economy is on intermediate inputs, the greater the inflationary risks posed by increases in intermediate trade costs. Similarly, figure 7 shows that lower elasticities of substitution between intermediates and labor are also associated with amplified GDP and inflation effects of trade shocks. However, the range of effects spanned by different values of the elasticity parameter is smaller. The results indicate that economies with higher ν—which could be interpreted as a greater prevalence of supply chains—and lower substitutability between intermediate inputs and labor would feature worsened monetary policy trade-offs when hit by disruptions affecting intermediate goods trade. This issue represents a key concern for policymakers.

6.3 Increase in trade costs between the U.S. and China

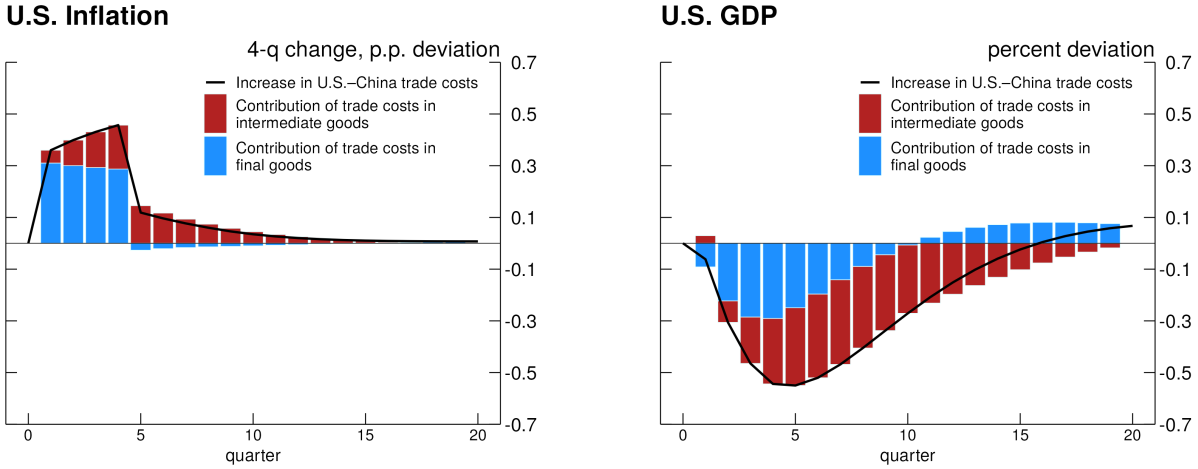
A major recent development in the global economy has been an increase in trade barriers between the U.S. and China: In 2018 and 2019, the two countries imposed tariffs and other trade barriers on each other before reaching an agreement in 2020. As of this writing, the U.S. imposed additional tariffs on China in early 2025, to which China partially retaliated. In this section, we use our multi-country model to gauge the implications of increased trade barriers between these countries.

Thus, we construct a scenario where trade costs between the U.S. and China increase for final and intermediate goods. Specifically, we assume that U.S. trade costs for all Chinese imports increase by 20 percentage points—capturing the imposition of U.S. tariffs on Chinese imports, to which China partially retaliates by raising tariffs on U.S. goods by 10 percentage points. This magnitude somewhat overstates the tariffs the U.S. imposed in 2018-19 (which amounted to a 20 percentage point increase on roughly two-thirds of goods imported from China) but understates the total increase in trade barriers to date, once accounting for the 10 percentage point increase in tariffs in early 2025. The assumption that China retaliates only partially also aligns with the evidence. The increase in trade costs is expected to be highly persistent, consistent with the persistence of our trade costs measure.

In the scenario, U.S. inflation rises, and U.S. GDP growth slows (figure 8). The effect on inflation is significant: The increase in trade costs drives U.S. inflation up by 0.5 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. As before, a hike in trade costs on final goods largely leads to a one-time step-up in the price level without a persistent increase in the inflation rate Note that the figure shows four-quarter inflation rates. Therefore, a one-time rise in the price level occurring in the initial quarter shows through as an increase in four-quarter inflation for four quarters. By contrast, the contribution 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, translating into higher inflation for longer. The associated higher policy rates contribute to a persistent drag on GDP growth relative to the baseline (right panel).

Figure 9 shows the effects on inflation and GDP in China (top row) and in the rest of non-U.S. regions (bottom row). China experienced a larger hit to GDP than the U.S. did and a smaller increase in inflation, reflecting that China's retaliation was only partial. GDP in the non-China foreign regions experiences a bump, as U.S. and Chinese firms and households partly divert trade flows toward imports from these countries—with the non-U.S. advanced foreign economies, which have the U.S. as an important trading partner, and the rest of the world experiencing larger activity increases than the non-China Asian economies. In turn, inflation rises in the foreign economies—

Figure 8: Increase in U.S.-China trade costs, effects on U.S.



Note: The figure shows the effects of a 20 percentage point increase in trade costs between the U.S. and China. The blue bars show the contributions of final goods trade costs, and the red bars show the contributions of intermediate goods trade costs.

reflecting both higher input costs and some depreciation of their currencies against the dollar—but the increase is very modest.

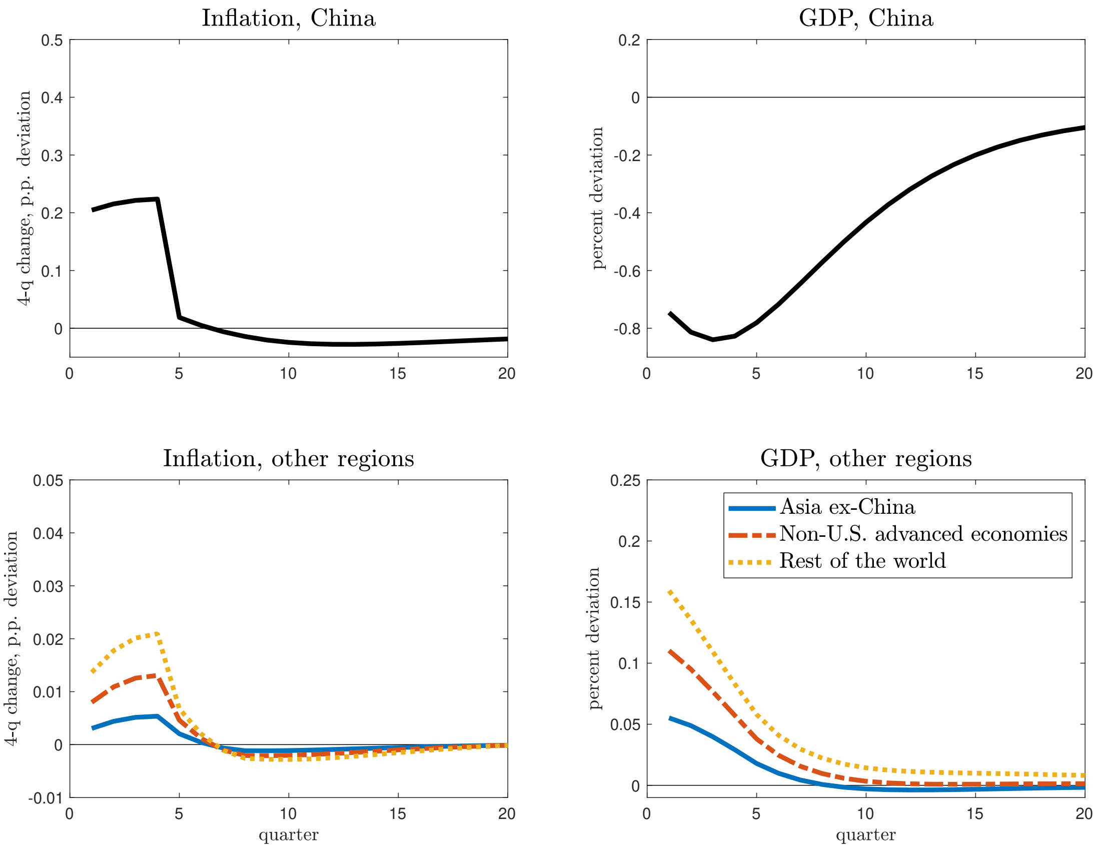
7 Post-Pandemic Trade Costs

In this section, we explore the contribution of trade cost shocks during the most recent surge in inflation in the U.S. during 2021-2022, in the aftermath of the COVID-19 pandemic. This period is a natural laboratory for exploring the role of disruptions to trade flows resulting from several factors, but most prominently those related to supply chain disruptions, bottlenecks, and higher shipping costs. We capture all these factors using the iceberg trade costs in our model and compare them with other supply and demand forces at play during this period. We focus our analysis on a two-country version of the model presented in Section 6. We associate country one with the United States and country two with a Rest-of-World (RoW) aggregate.

7.1 Data

Relative to our analysis in Section 2, we assemble an additional dataset that includes 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 frequency are generally unavailable. We follow a procedure similar to Eaton et al. (2016b)

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

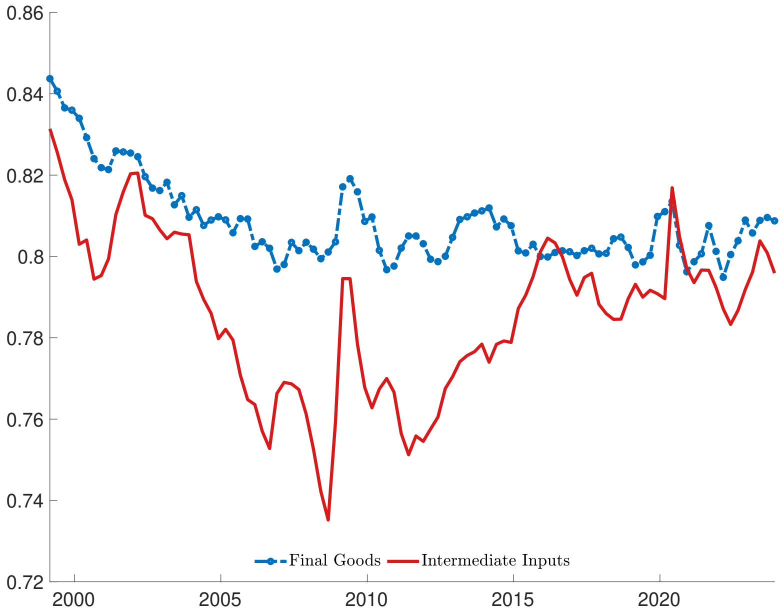


Note: The figure shows the effects of a 20 percentage point increase in trade costs between U.S. and China. The impulse responses show the response of inflation and GDP for China in black, Asian economies excluding China in blue, advanced economies excluding the U.S. in red, and the rest of the world in yellow.

to overcome this challenge. We construct quarterly gross output interpolating annual figures from the BEA's input-output tables using industrial production as a reference series and ensuring our quarterly interpolated values aggregate to the annual values. We combine our gross output estimates with quarterly trade flows of the U.S. with the rest of the world to obtain our measures of domestic sourcing shares. Additional details are provided in Appendix F.2.

Figure 10 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. We focus only on manufacturing industries for consistency with the empirical findings of Section 2. We observe two main features of this measure. Domestic sourcing shares declined through 2008, consistent with the continuing expansion of global trade. Thereafter, the sourcing share for final goods moved sideways, whereas the domestic sourcing share in intermediate

Figure 10: U.S. Quarterly Domestic Sourcing Shares



Notes: U.S. sourcing shares interpolated from BEA inpunt-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 correspond to tradable sectors in accordance to standard NICS classification. See Appendix F for details.

inputs trended upwards, in line with the slowdown in globalization. Both patterns are consistent with the facts documented in Comin and Johnson (2020) using annual data for the U.S. Still, our measure has the advantage of capturing higher frequency movements in sourcing shares associated, for example, with the onset of the COVID-19 lockdowns.[34]

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. 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. We measure the RoW aggregate as a trade-weighted average of the major U.S. trading partners as in Bodenstein et al. (2023). Appendix F provides additional details and data sources.

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[34] Because we focus on manufacturing industries, the sourcing shares are lower relative to the whole U.S. economy. We use demeaned sourcing shares as observable variables when linking the data to the model. See Appendix F for details.

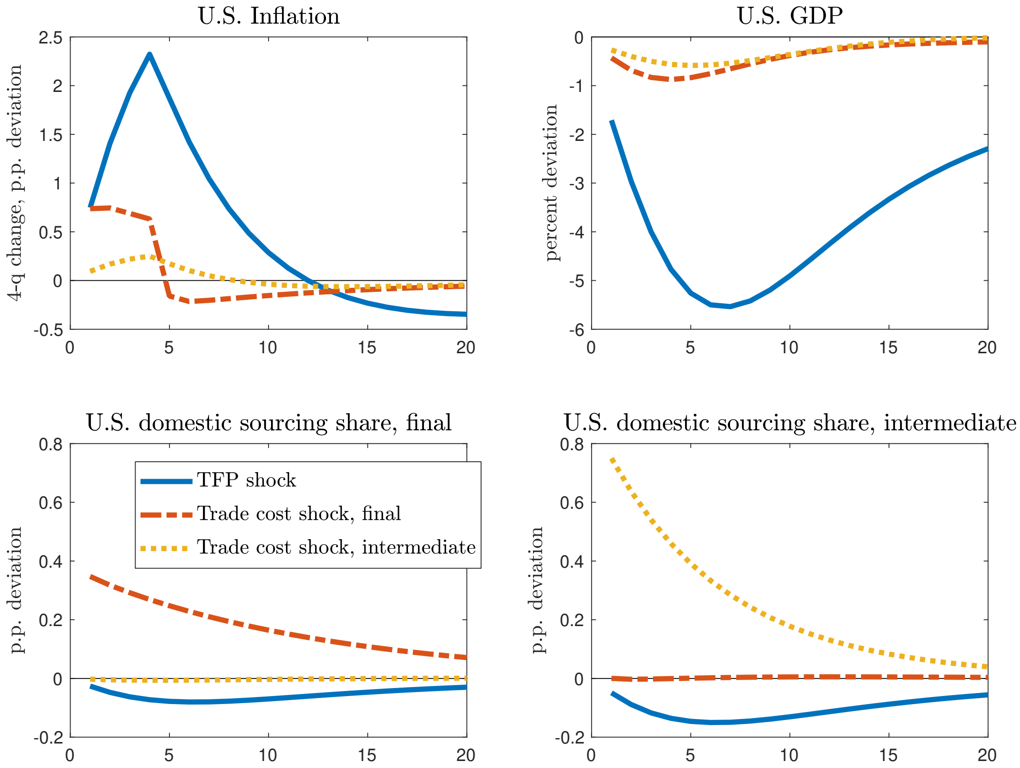
7.2 Calibration and Shock Inference

We use the values reported in Table 1 for structural parameters, assuming symmetric values in each country-bloc. In addition to trade cost shocks, we turn on three additional shocks in each country-bloc: technology $A_{i,t}$, domestic demand $D_{i,t}$, and monetary policy shocks, $\varepsilon^r_{i,t}$. The exogenous variables follow auto-regressive process of the form $x_{i,t} = \rho^x_i x_{i,t-1} + \epsilon^x_{i,t}$ for $x = \{A, D, \tau^C, \tau^M\}$ and where $\varepsilon^x_{i,t} \sim N(0, \sigma^x_i)$ for $x = \{A, D, \tau^C, \tau^M, r\}$. We use Bayesian inference to estimate the parameters ρ^x_i and σ^x_i and recover the unobserved shocks. Our procedure has two steps to avoid contaminating parameter estimates with large shocks due to COVID-19-related lockdowns. First, we restrict the estimation sample from 1999:Q1 to 2019:Q4. Conditional on the estimated shock process parameters, we extend our sample to 1999:Q1 to 2023:Q4 to recover the smoothed shocks $\epsilon^x_{i,t}$. Appendix F details our estimation procedure and the estimated parameters for the shock processes.

Figure 11 illustrates the relevance of using domestic sourcing shares time series to identify trade cost shocks and differentiate 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). We show responses to a one-standard-deviation shock based on the estimates obtained for 1999:Q1-2019:Q4. This allows us to illustrate the quantitative importance of each shock in accounting for movements in the observed data.

Our main source of identification comes from the correlation between inflation and domestic sourcing shares and the correlation between GDP and domestic sourcing shares. As shown in the top panels of figure 11, 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

Figure 11: 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.4

shocks. These observations help understand how the model identifies the historical contributions of these shocks to inflation, discussed next.[35]

7.3 Trade Costs and Pandemic Inflation

Having illustrated how data on domestic sourcing shares permits distinguishing the effects of total factor productivity shocks and trade cost shocks, we next turn to exploring the drivers of inflation observed between 2018:Q1-2023Q4 using our estimated model, shown in figure 12. We consider the following shock groupings. First, *supply shocks* encapsulate the contributions of shocks to total factor productivity. We interpret these shocks more broadly as capturing various factors restricting domestic supply, including lower productivity but also shifts in labor supply or other factors explaining the prolonged tightness in the U.S. labor market during this episode. As discussed

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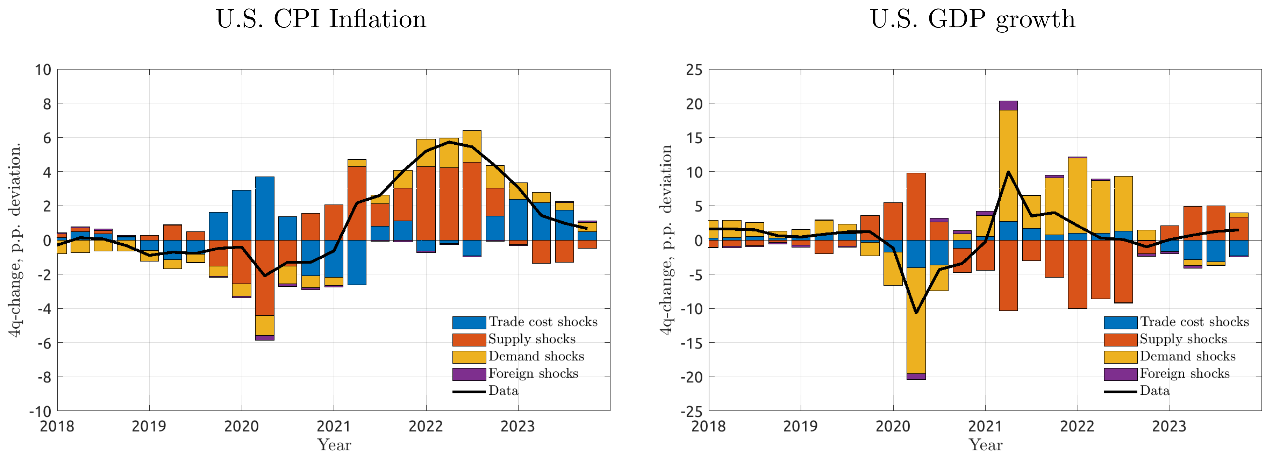
[35] Appendix A.8 shows impulse responses to demand-side shocks in the estimated model.

Figure 12: Decomposition of U.S. CPI and U.S. GDP Growth


U.S. CPI Inflation

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. supply shocks (red), U.S. demand shocks (yellow), and foreign shocks (purple). U.S. supply shocks correspond to TFP shocks, U.S. demand shocks correspond to preference and monetary policy shocks. Foreign shocks include foreign TFP shocks, preference and monetary policy shocks, as well as UIP shocks. All shocks are estimated with the Kalman smoother and with the model calibrated with the estimated posterior mean parameters in Table A.4.

earlier, the characteristic that identifies the role of these shocks is that they move inflation and GDP in opposite directions, with limited effect on the other variables used in estimation. We also group under the label *demand shocks* the shocks that induce a positive correlation between inflation and GDP, which correspond to the consumption demand and monetary policy shocks in our settings. We collect all shocks originating in the foreign economy, including shocks to the UIP condition, in a separate category, labeled “foreign shocks.”

Our estimation exercise reveals that trade costs played a meaningful role in driving inflation at certain points during the pandemic period. For example, in the initial quarters of the pandemic, trade costs offset the demand contraction and the price reduction. This partly explains why the U.S. economy did not experience a more pronounced period of deflation, given the size of the economic shock. Turning to the post-pandemic period in 2022 and 2023, we find that trade costs significantly contributed to sustaining inflation above the Federal Reserve’s target. In particular, trade costs explained about one percentage point of additional inflation in 2022 and contributed to the bulk of inflationary pressures in 2023.

Interestingly, the model assigns a relatively minor role to demand shocks in driving the inflation surge, with supply-side shocks playing a more dominant role. This finding contrasts with other recent papers analyzing the drivers of the post-pandemic inflation surge.[36] As seen in the right panel, demand shocks alone would have implied much faster GDP growth in 2022 than was observed, leading the model to lean on supply shocks.

8 Conclusions

We construct a broad measure of trade costs from sectoral bilateral flow data consistent with the "gravity" framework. Empirically, we find that, on average, increases in trade costs are inflationary. A 10 percentage point increase in trade costs, for example, in the form of blanket tariffs with all trading partners of a country, leads to a contemporaneous rise in CPI inflation of approximately 0.8 percentage points. Moreover, the inflationary effects are persistent, resulting from higher trade costs of intermediate goods.

We build a New Keynesian model with trade in final goods and intermediate inputs that replicates the empirical responses of macro variables to trade cost shocks and use it to analyze the inflationary effect of the rise in U.S.-China trade tensions. We also quantify the role of trade costs during post-pandemic inflation. Although non-trade-related factors affecting aggregate supply and aggregate demand conditions explain the buildup of inflation in the post-pandemic recovery, the effects of higher trade costs contributed to sustaining inflation above the Federal Reserve's target, particularly in late 2022 and 2023.

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[36] Bianchi et al. (2023), Barro and Bianchi (2024), and Giannone and Primiceri (2024) emphasize the role of fiscal and other demand-side factors in driving the inflation surge. On the other hand, Blanchard and Bernanke (2023) and Gagliardone and Gertler (2023) also find important roles for supply-side factors such as oil prices.

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Appendix

A World Input-Output Data

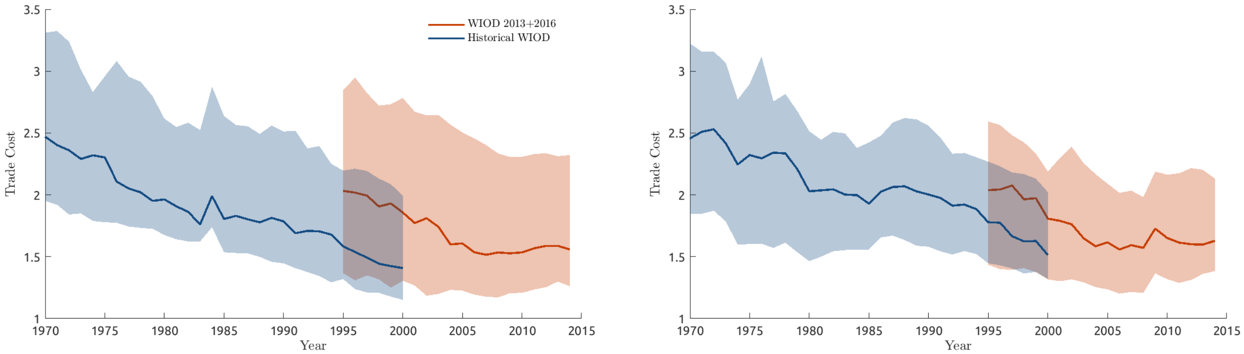
The bulk of our analysis is based on expenditure shares in final goods and intermediate inputs derived from the World Input-Output Tables (WIOT) and the OECD Inter-Country Input-Output (ICIO). For the WIOT we combine editions 2013 and 2016 which contain input-output data for 44 countries and 56 industries covering the period 1995-2014. For the ICIO we use the 2023 release which contains input-output tables for 77 countries and 45 industries, covering the period 1995-2020. In both databases one of the countries is rest of the world. We aggregate the ICIO data to cover the same countries in WIOT and use rest of world to carry the adjustment. For some of our analysis regarding trade costs we use WIOT's long-run database which has input-output table estimates for 25 countries and 23 sectors covering the period 1965-2000. When calculating trade costs we focus on manufacturing sectors only. Table A.1 shows how we map industry/sectors across ICIO and WIOT databases.

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

Sector	WIOT 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 Trade Costs Around the World

Figure A.1: Historical Evolution of Global Trade Costs

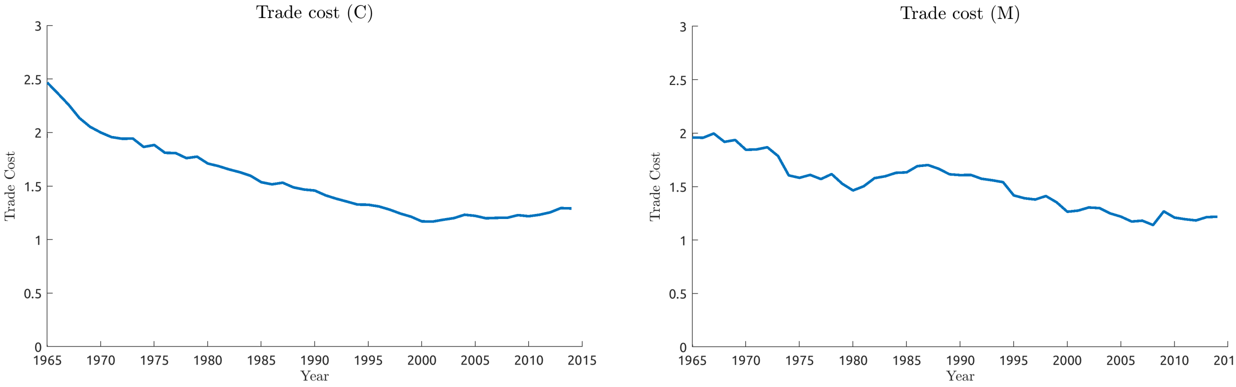


(a) Median Trade Cost: Final Goods (C)

(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 $HR^{Q}_{ih,t} - 1$ for $Q \in \{C, M\}$. Shaded areas are bounded by the 20th and 80th percentiles.

Figure A.2: **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 $HR^{Q}_{ih,t} - 1$ 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

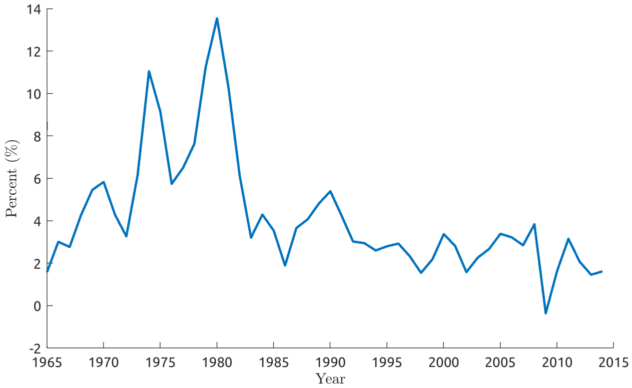
C Additional Empirical Results

C.1 Trade Costs and the Macroeconomy

Having estimated the impact of trade costs on inflation, we now explore the transmission of trade costs to other macroeconomic variables. We amend our regression specification such that, given

Appendix

Figure A.3: **Evolution of United States inflation, 1965-2014**



Note: core PCE inflation from WDI database - World Development Indicators. Washington D.C. : The World Bank. We end our inflation data in 2014 to coincide with the end of the WIOD database in 2014.

$y_{i,t}$, we estimate:

$$\log y_{i,t+h} - \log y_{i,t-1} = \alpha_i + \beta_h^Q \tau_{i,t}^Q + A_h Z_{i,t} + \varepsilon_{i,t+h} \qquad \text{for } h \geq 0 \tag{C.1}$$

where $y_{i,t}$ is our chosen real macroeconomic variable, and $Z_{i,t}$ is a vector of controls including lagged unemployment, GDP year-on-year growth, CPI inflation rate, and $y_{i,t-1}$, or a lag of the macroeconomic variable of interest.

Figure A.4 plots the response of four macroeconomic aggregates: real GDP, real exports, real imports, and the real exchange rate. The top panels trace out the responses of these four variables to an increase in final trade costs. The bottom panels trace out the responses to intermediate trade costs. We scale the response of all the macroeconomic aggregates to a 1 p.p. increase in the corresponding sourcing share.

Our main result is that higher trade costs that increase the domestic sourcing share by 1 percentage point generate a persistent contraction in economic activity, a decline in real exports, a decline in real imports, and an appreciation of the real exchange rate. The real GDP response is weak on impact, but it progressively increases over time, bottoming out at around -1% after five years. The economic recovery is slow, with the level of real GDP recovering its losses only after 10 years. The response of GDP with respect to final and intermediate trade costs is broadly similar.

Turning to the response of trade variables, an increase in trade costs leads to a contraction in real exports and real imports. The muted short-run response of trade variables is consistent with a low-trade elasticity due to fixed costs in exporting and importing decisions (Alessandria and

Choi, 2021). However, real exports decline by about -3% to -4%, while real imports decline slightly less, implying a deterioration of the real trade balance Once again, the effects of higher trade costs on trade flows are persistent, with imports and exports taking nearly a decade to recover. The reduction in trade flows and the increase in the domestic sourcing shares translates into an appreciation of the real exchange rate of about -1.5% to -2.5% by year five. The appreciation induced by higher trade costs reverts slowly.

C.2 Robustness

The Trade Elasticity

To compute our measure of trade costs we had to assume a value for the trade elasticity. Despite its central importance, there is a wide range of estimates for the value of η in the literature, with long-run estimates ranging from $\eta = 3$ to $\eta = 9$, see Boehm et al. (2023). We explore how the trade elasticity affects our main result. We first recompute the Head-Ries indices in (7) using four different values of the trade elasticity $\eta - 1 = \{2, 4, 6, 8\}$. We then re-estimate our local projection in Equation 9 to obtain the impact response of inflation ($h = 0$).

Table A.2b shows the results. The top panel presents estimation results of the impact response of inflation to final trade costs. The bottom panels shows the impact responses of inflation to higher trade costs of intermediate inputs. Across all specifications we normalize the estimated response coefficient to obtain a 1 percentage point increase in the domestic sourcing shares.

Our results are consistent across different specifications of the trade elasticity, with inflation increasing between 0.6 and 1.2 percentage points in response to higher trade costs. Note, however, that the trade elasticity matters to determine the size of the shock. In each panel, the memo line shows the associated increase in the Head-Ries index necessary to achieve a 1 percentage point increase in the domestic sourcing shares. We note that the required change in trade costs to induce a 1 percentage point increase in the sourcing share is decreasing in the value of the trade elasticity.

C.3 Sectoral Trade Costs

In our baseline results we investigated the effect of aggregate trade costs on inflation. We now briefly investigate if the inflation response is more sensitive to particular sectors in the economy. We use the granularity of the Input-Output tables to construct sector specific trade costs. In particular we map 16 non-service WIOD sectors for the 2000-2011 period and 23 non-service WIOD sectors for the 2012-2014 period, into four broad categories: (a) agricultural and mining, (b) low-tech manufacturing, (c) mid-tech manufacturing, and (d) high-tech manufacturing. We then run a local projection of the following form:

$$y_{i,t+h} = \alpha_i + \beta^{Q}_{h,s}\tau^{Q}_{i,s,t} + A_{h,s}Z_{i,t} + \varepsilon_{i,s,t+h} \qquad \text{for } h \geq 0,, \tag{C.2}$$

where the coefficient $\beta^{Q}_{h,s}$ now traces the response of inflation to an increase in trade costs in sector $s = \{a, b, c, d\}$ for goods of type $Q = \{C, M\}$, after h years following the shock. For comparison, we scale the aggregate inflation response such that the sectoral trade costs lead to an increase in sectoral domestic sourcing shares of 1 percentage point.

Figure A.5 shows the inflation responses to sectoral trade costs. For illustration, we focus on final trade costs in each sector. The peak inflation response, typically observed one year after the shock, ranges from 0.5 to 3 percentage points. The magnitudes are consistent with the average effects of higher trade costs in the aggregate. Heterogeneity in inflation responses is consistent with the different importance and substitutability of domestic and foreign goods across different sectors. For example, inflation increase modestly in response to higher trade costs in low-tech manufacturing sectors. In contrast, inflation is more sensitive to increases in trade costs in the high-tech manufacturing sector.

C.4 Tables and Figures

Table A.2: Inflation regressions on different elasticities ($\eta - 1$) of trade cost

(a) Final trade cost, scaled to 1% increase in final sourcing share

	YoY Inflation Rate			
	(1)	(2)	(3)	(4)
	$\eta - 1 = 2$	$\eta - 1 = 4$	$\eta - 1 = 6$	$\eta - 1 = 8$
τ_C	1.2651**	0.9439**	0.8487**	0.8038**
	(0.4426)	(0.3384)	(0.3044)	(0.2883)
Memo				
Implied $\Delta\tau_C$ *(p.p.)*	92.97	9.98	4.31	2.64
R-squared	0.4872	0.4808	0.4769	0.4749
Number of individuals	37	37	37	37
Number of observations	681	681	681	681

(b) Intermediate trade cost, scaled to 1% increase in intermediate sourcing share

	YoY Inflation Rate			
	(1)	(2)	(3)	(4)
	$\eta - 1 = 2$	$\eta - 1 = 4$	$\eta - 1 = 6$	$\eta - 1 = 8$
τ_M	0.8352**	0.7028**	0.6546**	0.6302**
	(0.3589)	(0.3019)	(0.2820)	(0.2720)
Memo				
Implied $\Delta\tau_M$ *(p.p.)*	73.84	9.11	4.07	2.52
R-squared	0.4682	0.4655	0.4636	0.4627
Number of individuals	37	37	37	37
Number of observations	681	681	681	681

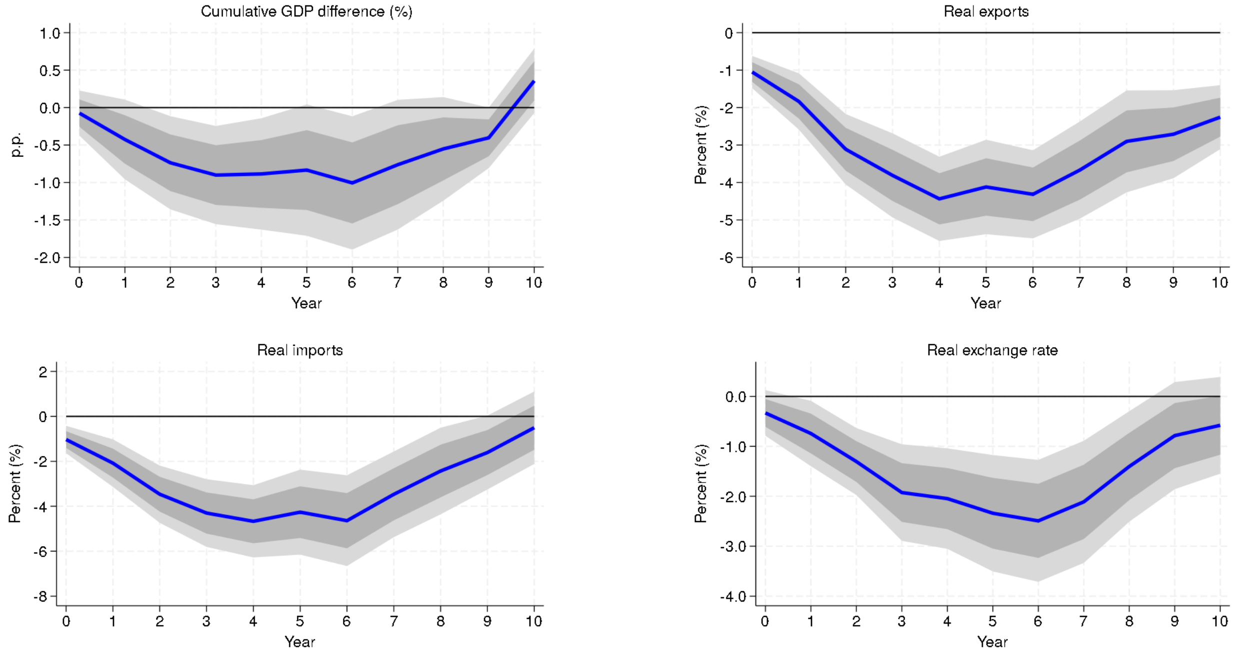
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Note: Country fixed effects and year error clustering are included. The magnitudes reflect the increase in τ that correspond to a 1 p.p. increase in the corresponding domestic sourcing share. Controls not shown includes one lag of the inflation rate, lag of GDP growth, and lag of unemployment.

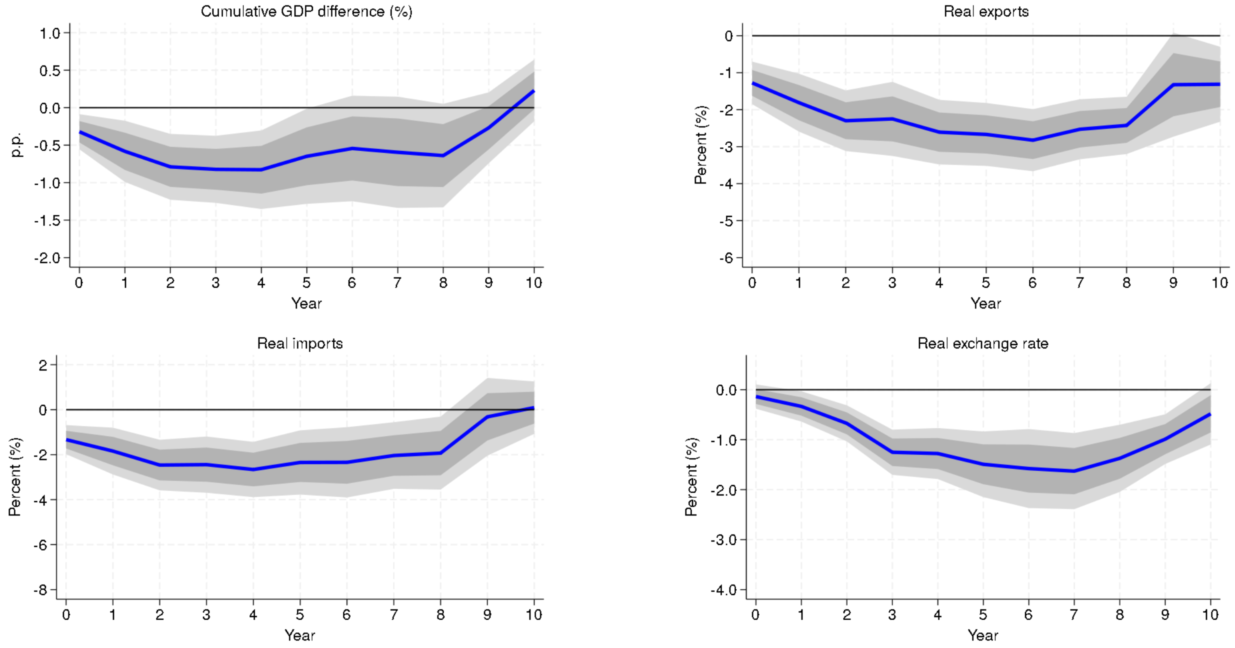
Appendix

Figure A.4: Macroeconomic Response to Higher Trade Costs

Response to Final Trade Costs



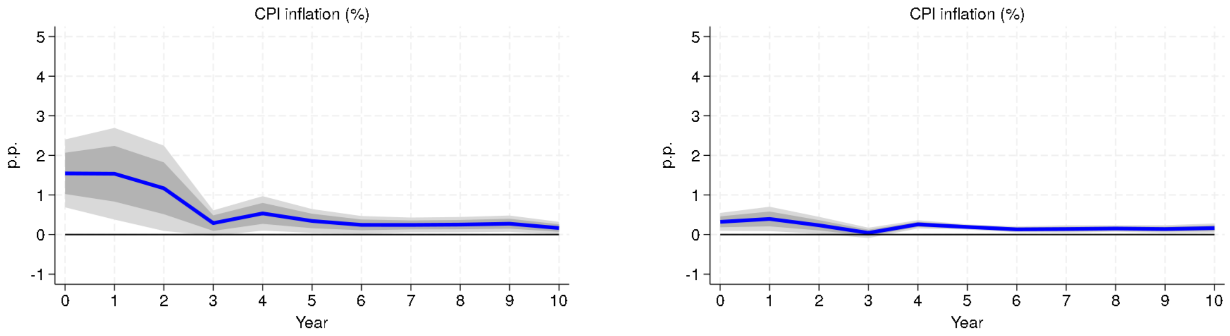
Response to Intermediate Trade Costs



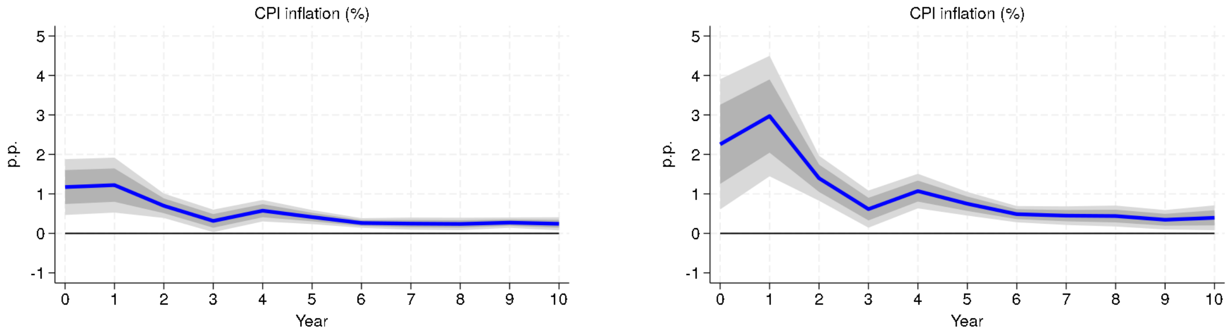
Note: country fixed effects and year error clustering are included. We multiply the trade cost by the same coefficient as in Figure 4 so as to correspond to a 1% increase in the sourcing share. This gives us the same numbers in Year 0 as we computed, namely 4.3% and 4% for final and intermediate trade costs, respectively.

Appendix

Figure A.5: Inflation Response to Sectoral Trade Costs


(a) Agriculture and mining

(b) Low-tech manufacturing


(c) Mid-tech manufacturing

(d) High-tech manufacturing

Note: country fixed effects and year error clustering are included. Controls are one lag of CPI inflation, Unemployment and GDP growth. The size of the trade cost shock is scaled to 1% for all, and the sourcing share is the corresponding sub-sector sourcing share.

D Additional Regression Results

Table A.3: Inflation and sourcing share regressions on different elasticities (θ) of trade cost

(a) Final sourcing share and trade cost

	YoY Inflation Rate				Sourcing share			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\eta - 1 = 2$	$\eta - 1 = 4$	$\eta - 1 = 6$	$\eta - 1 = 8$	$\eta - 1 = 2$	$\eta - 1 = 4$	$\eta - 1 = 6$	$\eta - 1 = 8$
Tau	0.0138**	0.0946**	0.1967**	0.3050**	0.0109***	0.1002***	0.2318***	0.3795***
	(0.0048)	(0.0339)	(0.0706)	(0.1094)	(0.0022)	(0.0194)	(0.0454)	(0.0748)
CPI rate % (-1)	0.2561***	0.2673***	0.2735***	0.2767***				
	(0.0515)	(0.0545)	(0.0561)	(0.0570)				
Sourcing share (-1)					0.6462***	0.6009***	0.5920***	0.5886***
					(0.0559)	(0.0613)	(0.0628)	(0.0634)
GDP growth % (-1)	0.0118	0.0256	0.0319	0.0352	-0.0366	-0.0235	-0.0218	-0.0215
	(0.0896)	(0.0887)	(0.0883)	(0.0881)	(0.0385)	(0.0380)	(0.0376)	(0.0373)
Unemployment % (-1)	-0.1026	-0.0981	-0.0946	-0.0926	-0.0495	-0.0467	-0.0471	-0.0475
	(0.1027)	(0.0981)	(0.0970)	(0.0965)	(0.0668)	(0.0629)	(0.0615)	(0.0608)
R-squared	0.4872	0.4808	0.4769	0.4749	0.9835	0.9849	0.9853	0.9855
Num. ind.	37	37	37	37	37	37	37	37
Num. obs.	681	681	681	681	681	681	681	681

(b) Intermediate sourcing share and trade cost

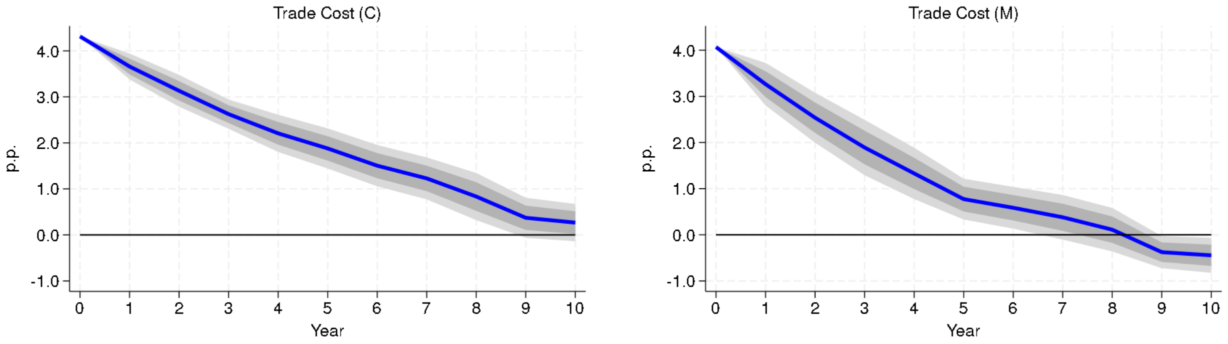
	YoY Inflation Rate				Sourcing share			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	$\eta - 1 = 2$	$\eta - 1 = 4$	$\eta - 1 = 6$	$\eta - 1 = 8$	$\eta - 1 = 2$	$\eta - 1 = 4$	$\eta - 1 = 6$	$\eta - 1 = 8$
Tau	0.0113**	0.0771**	0.1608**	0.2503**	0.0135***	0.1097***	0.2457***	0.3973***
	(0.0049)	(0.0331)	(0.0693)	(0.1081)	(0.0029)	(0.0216)	(0.0470)	(0.0750)
CPI rate % (-1)	0.2868***	0.2906***	0.2934***	0.2948***				
	(0.0595)	(0.0605)	(0.0613)	(0.0618)				
Sourcing share (-1)					0.6314***	0.6059***	0.6007***	0.5981***
					(0.0695)	(0.0699)	(0.0695)	(0.0693)
GDP growth % (-1)	0.1108	0.1172	0.1176	0.1176	0.0064	0.0203	0.0220	0.0226
	(0.0912)	(0.0920)	(0.0920)	(0.0920)	(0.0613)	(0.0575)	(0.0568)	(0.0564)
Unemployment % (-1)	-0.0998	-0.1040	-0.1015	-0.0999	-0.0899	-0.1001	-0.1015	-0.1020
	(0.1060)	(0.1054)	(0.1049)	(0.1046)	(0.1014)	(0.0974)	(0.0963)	(0.0958)
R-squared	0.4682	0.4655	0.4636	0.4627	0.9810	0.9819	0.9821	0.9821
Num. ind.	37	37	37	37	37	37	37	37
Num. obs.	681	681	681	681	681	681	681	681

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Note: Country fixed effects and year error clustering are included. Both sourcing share and CPI inflation tables respond to a 1% increase in trade costs. We compare different theta values for the Head-Ries index, which is $\eta - 1 = 6$ for our analysis.

E Additional Local Projection Responses

Figure A.6: **Local projection of trade cost on itself**

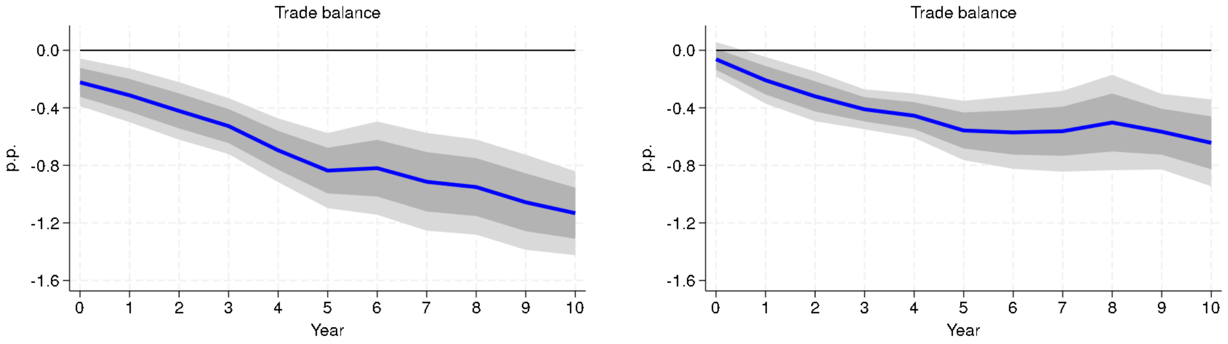


(a) Final trade cost

(b) Intermediate trade cost

Note: Country fixed effects and year error clustering are included. We multiply the trade cost by the same coefficient as in Figure 4 so so as to correspond to a 1 p.p. increase in the sourcing share.

Figure A.7: **Local projection of trade cost on Trade Balance (% GDP)**



(a) Final trade cost

(b) Intermediate trade cost

Note: Country fixed effects and year error clustering are included. We multiply the trade cost by the same coefficient as in Figure 4 so as to correspond to a 1 p.p. increase in the sourcing share.

Appendix

F Post-Pandemic Inflation Analysis

F.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 F.2
- U.S. Domestic Sourcing Shares for Intermediate Inputs: See Appendix F.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.

F.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.[37] 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:

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

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

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[37] 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 (F.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.

F.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:

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

F.4 Priors, Posterior Sampler, and Estimation Results

Columns 2-4 in Table A.4 list prior distributions, along with prior means and standard deviations used to estimate the two-country model of Section 7. 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

Table A.4: Estimated Parameters: Two-Country Model

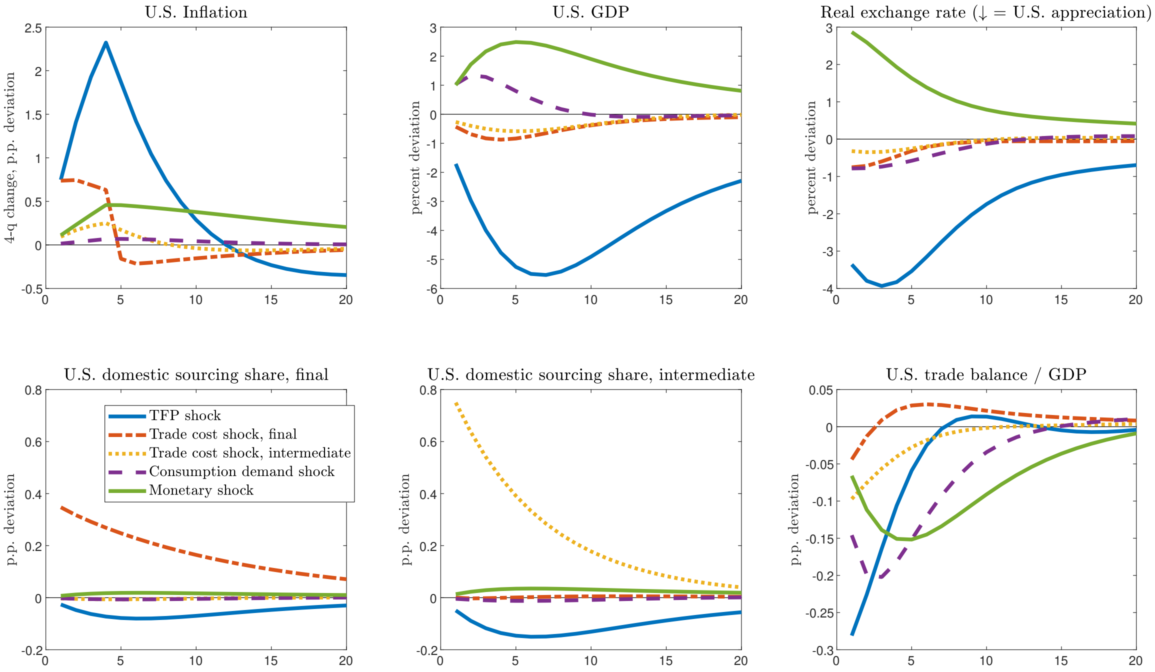
Parameter (1)	Description (2)	Prior (3)	Posterior Mean (4)	HPD Interval (5)
σ_1^A	Std dev. U.S. TFP shock	$\mathcal{IG}(0.01, 0.05)$	0.04	[0.04 0.05]
σ_1^r	Std dev. U.S. Monetary policy shock	$\mathcal{IG}(0.01, 0.05)$	0.01	[0.01 0.01]
σ_1^D	Std dev. U.S. Demand shock	$\mathcal{IG}(0.01, 0.05)$	0.02	[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.4 show key moments of the posterior distribution of the estimated parameters.

F.5 Additional Impulse Responses

Figure A.8: 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.4