

Multilateral Comovement in a New Keynesian World: A Little Trade Goes a Long Way*

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Abstract

We develop a model in which trade plays a key role in shaping the joint dynamics of inflation and output growth across multiple large economies. Absent trade, average cross-country correlations fall markedly, by 80 percent for output growth, 25 percent for inflation, and 45 percent for the cross-country comovement between inflation and output growth. These sizable effects arise because disturbances propagate across countries both directly through pairwise relationships and indirectly through knock-on network effects from expenditure switching. The analysis highlights the role of demand shocks and how knock-on effects from trade depend on nominal rigidities, the presence of more than two countries, and financial integration. The model also helps resolve the Backus-Kehoe-Kydland puzzle, producing lower cross-country correlations in consumption than output.

Keywords: International Comovement, Multilateral Trade, Nominal Rigidities

JEL Codes: E31, E32, F41, F44

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1 Introduction

Inflation and output growth exhibit substantial comovement between countries. Moreover, the correlation between inflation and output growth at business cycle frequencies, a hallmark moment for the New Keynesian (NK) framework, is at times more pronounced *across* countries than it is *within* countries. However, large economies, including the U.S. and the European Union (E.U.), purchase goods and services mostly from themselves, with shares of domestic purchases exceeding 75 percent of total purchases, so that the quantitative study of output and inflation dynamics has largely proceeded with closed-economy models. Is it then the case that international trade linkages have only a small role in explaining comovement across countries, with global shocks the main drivers of common variations in output growth or inflation? In this paper, we develop a structural framework featuring multiple large open economies with nominal rigidities that suggests otherwise.

Our framework introduces the nominal rigidities of NK models (e.g., Justiniano, Primiceri, and Tambalotti, 2010; Herbst and Schorfheide, 2015; Bianchi and Melosi, 2017) into a dynamic model featuring multiple regions (e.g., Devereux, Gente, and Yu, 2023; Kleinman, Liu, and Redding, 2023; Huo, Levchenko, and Pandalai-Nayar, 2024). The model additionally allows for trade in both intermediate and final goods. In this setting, the network structure of trade generates knock-on effects from foreign demand shocks, increasing cross-country comovement relative to previous international real business cycle (IRBC) (e.g., Kose and Yi, 2006; Corsetti, Dedola, and Leduc, 2008; Bai and Ríos-Rull, 2015; Uribe and Schmitt-Grohé, 2017) and NK open economy (NKOE) (e.g., Corsetti and Pesenti, 2001; Devereux and Engel, 2002) models.

Network effects in our framework arise by way of both *backward* and *forward* trade linkages, summarizing a country’s import and export network, respectively. The backward linkages operate through marginal costs, which now depend on foreign input costs and exchange rates of all trading partner countries. The forward linkages arise because these input costs in part reflect demand conditions abroad. Thus, not only do disturbances in one country spill over directly to multiple countries, but the resulting responses also propagate through the trade network to generate knock-on effects. Consequently, despite relatively low observed trade shares across countries, country-specific shocks generate sizable cross-country comovement in output growth, in inflation, and between output growth and inflation.

The knock-on effects of country-specific shocks arise through expenditure switching. Four features are central to the mechanism. First, demand shocks play a key role in generating cross-country spillovers. In contrast, local total factor productivity (TFP) shocks raise both domestic demand and supply, generating comparatively little need for additional international supply adjustments. Second, our model allows for international financial flows. With sufficiently well-functioning financial markets, countries can respond to demand shocks via trade deficits, which stimulate trade partners’ economies. Third, we allow for multiple (more than two) large countries. This allows the model to incorporate country-specific shocks that do not get subsumed into a broad ‘rest of

the world’ aggregation. Lastly, consistent with empirical findings in [Devereux and Yetman \(2010\)](#), consumer prices in our model are sticky, implying imperfect pass-through of imported goods prices to local prices. Consequently, in response to a local demand expansion, local wages rise relative to foreign wages and terms of trade can improve despite real exchange rate depreciation. This generates incentives to switch expenditures away from home and towards foreign countries, leading output in foreign countries to respond disproportionately relative to their trade shares. The increase in demand for goods from foreign countries leads to further rounds of terms-of-trade adjustments that propagate the effects of demand shocks internationally, creating global comovement. These features further help resolve the [Backus, Kehoe, and Kydland \(1992\)](#) puzzle and produce cross-country output correlations that exceed those of consumption, unlike standard IRBC models.

We use our structural model to quantify the role of both international linkages (e.g., [Imbs, 2006](#); [Boeckelmann, Imbs, and Pauwels, 2024](#)) and global factors (e.g., [Mumtaz, Simonelli, and Surico, 2011](#)) for cross-country comovement in output growth, in inflation, and between output growth and inflation. Our findings derive from a full-information Bayesian estimation of almost all structural parameters (e.g., [Justiniano and Primiceri, 2008](#); [Schmitt-Grohé and Uribe, 2012](#)). This allows us to estimate the cross-country effects of shocks while accounting for the network effects of trade and other general equilibrium channels. Our data cover five world regions—the U.S., China, the E.U., Japan, and Canada. We allow for heterogeneous structural parameters, such as the degree of nominal rigidities across countries. Despite the model being substantially larger than typical medium-scale NK models (e.g., [Smets and Wouters, 2007](#)) and having relatively computationally involved steady-state computations, we are able to estimate it on a laptop using a state-of-the-art sequential Monte Carlo algorithm ([Cai, Del Negro, Herbst, Matlin, Sarfati, and Schorfheide, 2021](#)).

Our estimation reveals that despite trade shares generally being less than 25 percent of national purchases, multilateral trade plays a key role in explaining international comovement in output growth, in inflation, as well as between output growth and inflation. Absent trade, the average cross-country correlation of output growth falls by 80 percent, that of inflation by 25 percent, and that between output growth and inflation by 45 percent. While these results reflect parameter estimates informed by the data, we describe analytically how key elasticities determine the size of spillovers by influencing the extent of trade substitution in response to shocks. In addition, while we show analytically that ‘beggar-thy-neighbor’ effects can generate negative cross-country spillovers with large frictions in global financial markets, our estimation finds that these frictions are relatively small.

Our analysis highlights why the prior literature, dating back to [Backus et al. \(1992\)](#) in flexible price environments, struggled to generate endogenous comovement between countries from country-specific shocks. In work with nominal rigidities, [Galí and Monacelli \(2005\)](#) miss indirect trade effects because all countries are infinitesimally small, preventing country-specific disturbances from having meaningful global implications. Knock-on effects are also absent in [Justiniano and Preston \(2010\)](#) because in their two-country setting, only one country is large and disturbances propagate in only

one direction. The setting of [Clarida, Gali, and Gertler \(2002\)](#) with two large countries is an example of a model with producer currency pricing (PCP) only. It thus possesses perfect pass-through from imported goods prices to consumer prices, which precludes the knock-on effects of trade. More recently, [Huo et al. \(2024\)](#) consider a model with multiple countries but that features perfect pass-through, financial autarky and an emphasis on supply shocks, all of which mitigate the importance of country-specific shocks for global comovement. In short, with the right set of ingredients—sticky consumer prices, multilateral trade, and well-functioning financial markets—knock-on effects from trade emerge that have a sizable role in generating empirically observed cross-country spillovers.

This paper is organized as follows. Section 2 provides motivating empirical findings. Section 3 presents the economic environment. Section 4 discusses the model solution in linearized form. Section 5 explores the mechanisms underlying global spillovers from country-specific shocks. Section 6 describes our quantitative findings. Section 7 concludes. The [Online Appendix](#) contains derivations of all results, a comprehensive description of the data and statistical methods, discussions of departures from our benchmark assumptions, and additional figures and tables.

2 GDP Growth and Inflation Across Countries

We begin by documenting comovement and evidence of spillovers across a large panel of countries.

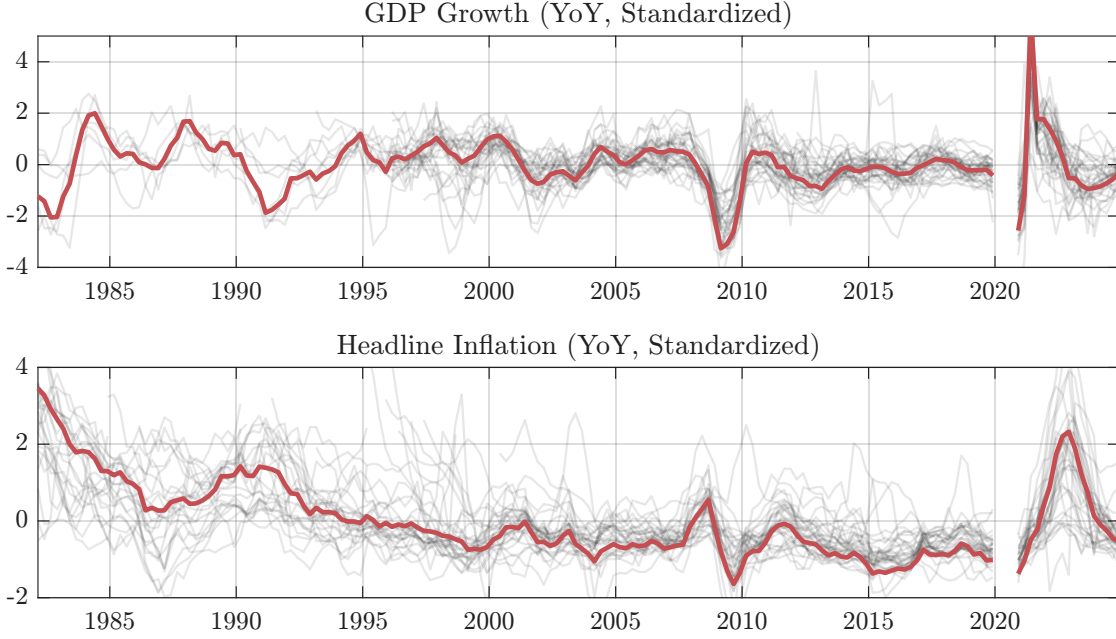
2.1 Global Comovement

We first document raw correlations in GDP growth and inflation across 33 countries over the sample period 1982Q1 through 2024Q4. These regions cover roughly 85 percent of world GDP over the sample period. The panel is unbalanced given data limitations; sample start and end dates for each country are listed in Section A of the [Online Appendix](#). We drop inflation observations larger than 25 percent to remove hyperinflationary periods and exclude the peak of the COVID-19 pandemic from 2020Q1 through 2020Q3.

Figure 1 plots the data along with its first principal component. The figure depicts year-over-year GDP growth and headline inflation, standardized for each country to have mean zero and unit standard deviation. We see substantial comovement across countries, with a clear common component. The comovement is particularly prominent over the second half of the sample, coinciding with an increase in global trade.

We quantify the comovement in Figure 2 using histograms of pairwise cross-country correlations computed from quarter-over-quarter data to be consistent with the estimation carried out in Section 6. The top two panels show that GDP growth and headline inflation are positively correlated across countries, with 94 percent and 93 percent of country pairs having positive correlations of GDP growth and headline inflation, respectively. In the bottom left panel, the positive cross-country inflation correlations hold even focusing on core inflation, with 84 percent of country pairs having

Figure 1: Standardized GDP Growth and Inflation



Notes: Gray lines correspond to individual countries; red lines correspond to the first principal component.

positive correlations after removing the effect of global food and energy prices. Similar correlations have been documented in the literature for various sets of countries and sample periods.¹

While the observations in the top panels have been documented in other work for a wide range of countries and time periods, the bottom right panel shows a less well-known fact—inflation and output comove more *across* countries than *within* countries. The cross-country mean pairwise correlation of 0.05 is statistically significant, with around 2/3 being positive and 1/3 exceeding 0.1, whereas the within-country mean of 0.02 is not. A positive Phillips curve-type slope is normally apparent when inflation dynamics are dominated by output-gap fluctuations.² As such, the difference is indicative of demand shocks playing a more important role in driving comovement across countries than within countries, an observation that we aim to address explicitly in this paper.³

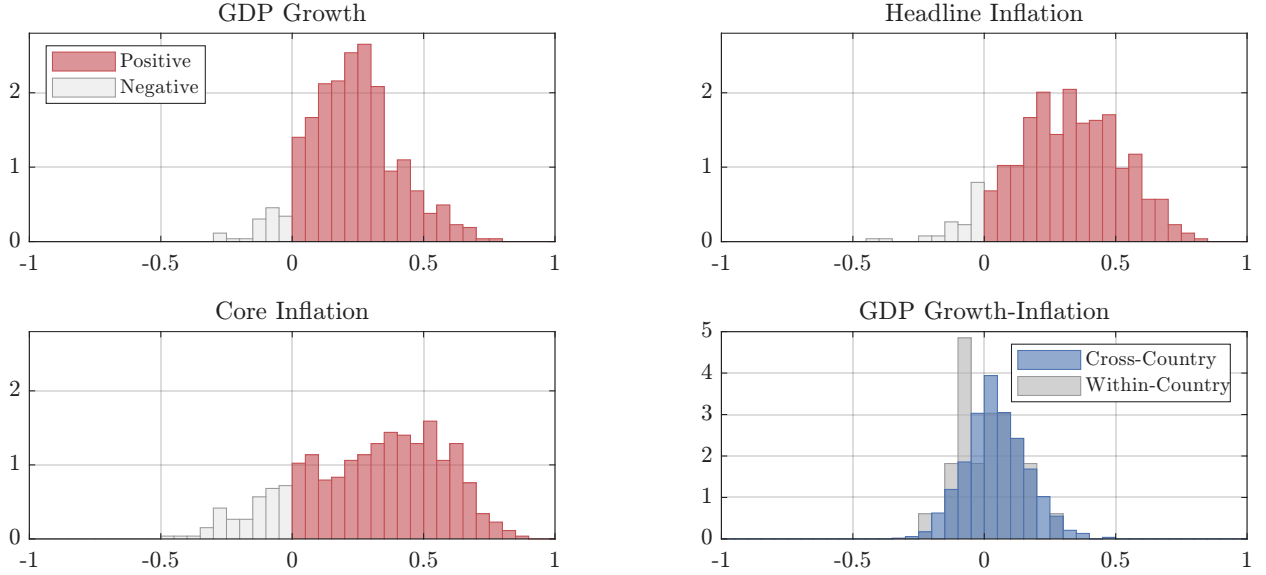
In Section A of the [Online Appendix](#), we document that these patterns are robust across a range of different specifications: i) excluding the Great Recession, ii) including the COVID-19 period observations, iii) aggregating across the European monetary union, and iv) focusing on the 2004Q3 through 2019Q4 period as in the estimation in Section 6. We then show that the correlations

¹For real variables, [Kose, Otrok, and Whiteman \(2003\)](#) study a 60-country sample from 1960 through 1990, [Stock and Watson \(2005\)](#) focus on G7 countries between 1960 and 2002, [Del Negro and Otrok \(2008\)](#) consider 19 developed countries from 1970 through 2005, and [Ferroni and Klaus \(2015\)](#) analyze the Euro Area between 1998 and 2012. For inflation, [Ciccarelli and Mojon \(2010\)](#) analyze 22 OECD countries from 1971 through 2004 and [Mumtaz and Surico \(2012\)](#) study 13 countries from 1961 through 2004.

²See [Borio and Filardo \(2007\)](#), [Eickmeier and Pijnenburg \(2013\)](#), and [Bianchi and Civelli \(2015\)](#) for empirical work relating domestic inflation to foreign activity.

³[McLeay and Tenreyro \(2020\)](#) explain the low within-country Phillips-curve slope as a natural consequence of a monetary policy that acts by countervailing the effects of domestic demand shocks.

Figure 2: Distribution of Cross-Country Correlations



Notes: For GDP Growth, Headline Inflation, and Core Inflation panels, gray bars correspond to negative correlations and red bars correspond to positive correlations. In the GDP Growth-Inflation panel, gray bars correspond to within-country correlations and blue bars correspond to cross-country correlations. All vertical axes scaled so that bars integrate to 1.

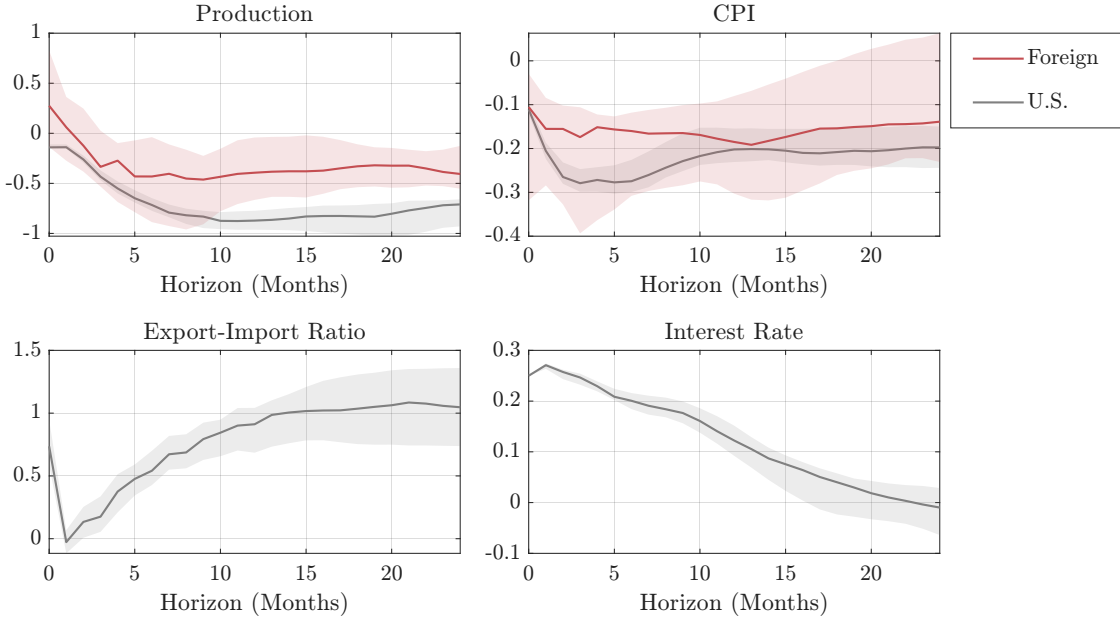
increase substantially when using year-over-year data, consistent with early work on international comovement by [Kose, Otrok, and Whiteman \(2003\)](#), suggesting that some of the country-specific variation arises from high-frequency variation or measurement error.

2.2 Impulse Responses to Monetary Policy Shocks

The correlations we just highlighted can arise from global shocks affecting multiple countries simultaneously or country-specific shocks spilling across borders. To provide causal evidence for the latter, we estimate the effects of an identified U.S. monetary policy shock on foreign countries. Specifically, we run a series of country-specific vector autoregressions (VARs) using monthly U.S. data for industrial production, the consumer price index, one-year Treasury yields, and an excess bond premium, following [Gertler and Karadi \(2015\)](#). In addition, each VAR includes data on industrial production and prices in one other country to measure spillovers of U.S. monetary policy to that country. Finally, we include the ratio of U.S. exports to imports from the rest of the world, providing a measure of the trade response that we later compare to that implied by our quantitative model. We estimate these VARs using the panel of countries that we consider in [Figures 1 and 2](#).

Our maximum sample period runs from January 1982 through December 2019, but the foreign data restrict sample lengths for a number of countries. To ensure the likelihood is sufficiently informative, we restrict estimation to countries with at least 25 years of data, which reduces the sample of foreign countries from 32 to 19. Each VAR includes 12 lags and is estimated using Bayesian

Figure 3: Responses to U.S. Monetary Policy Shock



Notes: Distribution of posterior medians for impulse response to 25 basis point U.S. monetary policy shock. Solid line denotes median across countries, shaded regions denote interquartile range.

methods with a Minnesota prior with tightness chosen to maximize the marginal likelihood.

To identify the U.S. monetary policy shock, we use the high-frequency instrument from [Bauer and Swanson \(2023\)](#). The instrument measures monetary policy shocks using changes in Eurodollar futures in a narrow window around monetary policy announcements, which include FOMC announcements and speeches by the Federal Reserve Chair. The narrow window ensures that these shocks are plausibly exogenous with respect to other shocks both in the U.S. and abroad.

Figure 3 plots the interquartile range (across countries) of the posterior medians for the impulse responses, following [Camara, Christiano, and Dalgic \(2024\)](#). In response to a 25 basis point contractionary monetary policy shock, foreign production and prices fall about half as much as their U.S. counterparts.⁴ The export-import ratio spikes on impact and subsequently increases gradually. The initial spike arises in part from exchange rates responding at a higher frequency than production and prices. This relative trade-balance improvement, which reflects the U.S. demanding relatively fewer goods and services from abroad, drives spillovers in our model.

Section A of the [Online Appendix](#) shows that these results hold across a series of robustness checks: i) replacing the one-year Treasury yield with the shadow rate from [Wu and Xia \(2016\)](#), ii) using an alternative monetary policy shock instrument from [Miranda-Agrippino and Ricco \(2021\)](#), iii) including commodity prices or foreign interest rates in the VAR, iv) lowering the minimum sample length to 20 years (thus including 6 additional countries), v) extending the sample back

⁴Other papers have also documented foreign spillovers of U.S. monetary policy shocks (e.g., [Dedola et al., 2017](#); [Miranda-Agrippino and Rey, 2020](#); [Degaspero et al., 2026](#); [Camara et al., 2024](#)) with various samples and specifications.

to January 1973 (where possible), and vi) plotting the posterior credible intervals for the ‘median’ country (following [Degasperis et al. \(2026\)](#); see the [Online Appendix](#) for details) instead of the interquartile range of posterior medians.

3 A New Keynesian Global Economy

To address these empirical observations, we present an NK world economy where multilateral trade allows country-specific disturbances in one country to spill over to other countries both directly, through pairwise trade, and indirectly, through network knock-on effects. We describe the problems faced by each agent and the key equations implied by these problems. Sections B and C of the [Online Appendix](#) provide details of the equilibrium conditions and model solution.

The world is composed of N countries (or regions encompassing different countries) indexed by $n = 1, \dots, N$. As in the prototypical NK closed economy, each country has three types of agents: firms that produce various types of outputs, households that consume final goods aggregated from these outputs, and a monetary authority that sets interest rates. Unlike the prototypical NK closed economy, we address the interplay between sticky prices and multilateral trade by having two layers of intermediate varieties rather than one: one layer consists of internationally traded varieties and a second layer is subject to sticky prices.

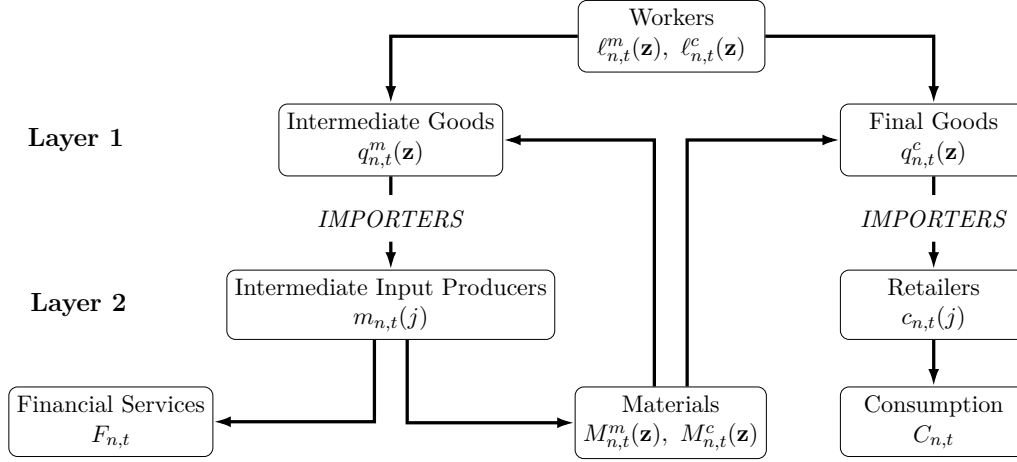
Figure 4 summarizes how these layers fit within the economic environment of each country. Layer 1, which we refer to as *tradable goods*, is produced in competitive markets and traded internationally. It consists of final and intermediate goods. Layer 2, which we refer to as *sticky-price goods*, assembles goods from Layer 1 and is subject to nominal rigidities as in [Calvo \(1983\)](#). In this layer, bundles of final goods are sold by differentiated domestic retailers for final consumption, while bundles of intermediate goods are sold by differentiated intermediate input producers as materials.

The introduction of retailers with sticky prices builds on previous work, in particular by [Monacelli \(2005\)](#) and [Justiniano and Preston \(2010\)](#). These papers allow for imperfect pass-through of exchange rate shocks (and, more broadly, imported goods prices) to domestic consumer prices, a feature documented and underscored, for example, by [Devereux and Yetman \(2010\)](#). Imperfect pass-through implies dynamics and effects from monetary policy that differ significantly from typical NKOE models with full pass-through (e.g., [Clarida et al., 2002](#); [Galí and Monacelli, 2005](#)).

Households can not only purchase and sell bonds domestically but also trade state-contingent assets internationally. Frictions in global financial markets determine how much countries can run trade deficits or surpluses, thereby influencing the behavior of exchange rates and the way shocks spill over across countries. Securities traded in global financial markets are subject to these transaction costs that, in equilibrium, introduce deviations from uncovered interest parity (UIP).

Finally, the monetary authority in each country sets policy according to a country-specific Taylor rule.

Figure 4: Economic Environment in Each Country



3.1 Tradable Intermediate and Final Goods

We first describe the two types of tradable goods in Layer 1 of Figure 4—final (right-hand side) and intermediate (left-hand side). The modeling of both follows [Eaton and Kortum \(2002\)](#) and the subsequent trade literature. Given this similarity, we describe the production structure of final and intermediate goods in parallel before highlighting their key differences. We use the superscript $k \in \{c, m\}$ to distinguish between final and intermediate goods. The superscript ‘ c ’ denotes final goods, underscoring that they are used for final consumption, and the superscript ‘ m ’ denotes intermediate goods, which are used for materials.⁵

Final and intermediate tradable goods are produced in different varieties. The quantity of goods variety $\mathbf{z}$ produced in country n at date t is denoted by $q_{n,t}^k(\mathbf{z})$, where $k \in \{c, m\}$. Variety $\mathbf{z} = \{z_1, \dots, z_N\}$ captures a vector of country-specific parameters where each element, z_n , reflects the productivity of firms producing that variety in country n . Goods in sector k are then produced according to the technology,

$$q_{n,t}^k(\mathbf{z}) = z_n \left(\ell_{n,t}^k(\mathbf{z}) \right)^\gamma \left(M_{n,t}^k(\mathbf{z}) \right)^{1-\gamma}, \quad \gamma \in (0, 1) \text{ and } k \in \{c, m\}, \quad (1)$$

where $\ell_{n,t}^k(\mathbf{z})$ and $M_{n,t}^k(\mathbf{z})$ denote, respectively, labor and material inputs in sector k , and $\gamma \in (0, 1)$ is the labor share in the production of tradable goods. The use of materials for production implies a roundabout production structure that captures input-output relationships as in [Basu \(1995\)](#).

The elements of $\mathbf{z}$ are jointly drawn from a multivariate Fréchet distribution with shape parameter φ^k , $\Phi^k(\mathbf{z}) = \exp \left\{ - \sum_n (z_n)^{-\varphi^k} \right\}$, $k \in \{c, m\}$. This distributional assumption ensures analytically tractable aggregate import demand functions. The shape parameter, φ^k , governs how much a given variety, $\mathbf{z}$, is likely to differ in productivity across countries and implies a trade elasticity of $1 + \varphi^k$ in sector k . Low values of φ^k are associated with large cross-country variations in

⁵The derivations in this subsection follow those in [Eaton and Kortum \(2002\)](#). See the [Online Appendix](#) for details.

productivity and a low trade elasticity. In contrast, as $\varphi^k \rightarrow \infty$, the level of productivity associated with tradable varieties becomes common across countries, implying a high trade elasticity.⁶

Constant returns to scale in (1) and competitive pricing imply that the price of traded variety $\mathbf{z}$ charged by country n , denoted $p_{n,t}^k(\mathbf{z})$, is equal to its marginal cost,

$$p_{n,t}^k(\mathbf{z}) \propto \frac{W_{n,t}^\gamma (P_{n,t}^m)^{1-\gamma}}{z_n}, \quad k \in \{c, m\},$$

where $W_{n,t}$ and $P_{n,t}^m$ are, respectively, the nominal wage and the price of materials in n .⁷ In addition, cost minimization implies that $W_{n,t} \ell_{n,t}^k(\mathbf{z}) = \frac{\gamma}{1-\gamma} P_{n,t}^m M_{n,t}^k(\mathbf{z})$.

Tradable goods, whether final or intermediate, imported by country n from country n' are subject to iceberg shipping costs such that only a fraction $1/\kappa_{nn'}^k \in [0, 1]$ of these goods make it to their destination (with $\kappa_{nn}^k = 1$). Country n acquires each variety $\mathbf{z}$ of tradable goods from the country that supplies it most cheaply given production costs and bilateral trade costs in different locations. In units of the local currency, the price of tradable goods of variety $\mathbf{z}$ in sector k paid by country n is then

$$P_{n,t}^k(\mathbf{z}) = \min_{n'} \left\{ \kappa_{nn'}^k \mathcal{E}_{nn',t} p_{n',t}^k(\mathbf{z}) \right\} = \min_{n'} \left\{ \frac{\kappa_{nn'}^k \mathcal{E}_{nn',t} W_{n',t}^\gamma (P_{n',t}^m)^{1-\gamma}}{z_{n'}} \right\}, \quad k \in \{c, m\}.$$

The nominal exchange rate $\mathcal{E}_{nn',t}$ converts prices from country n' 's currency into that of country n .

Denote by $X_{nn',t}^k$ total expenditures by country n on tradable goods of type k from country n' . Then $X_{n,t}^k \equiv \sum_{n'} X_{nn',t}^k$ represents country n 's total expenditures on final goods ($k = c$) or intermediate goods ($k = m$). Under the maintained assumptions, each country purchases all tradable varieties but acquires any one variety, $\mathbf{z}$, from a single country (possibly itself). The assumption that $\mathbf{z}$ is Fréchet distributed ensures that the total value of trade between any country pair is a smooth function of foreign marginal production costs. In particular, given competitive markets, the share of country n 's expenditures on tradable goods of type k from country n' at date t , denoted $\varpi_{nn',t}^k$, is given by

$$\varpi_{nn',t}^k = \frac{X_{nn',t}^k}{X_{n,t}^k} = \frac{\left(\kappa_{nn'}^k \mathcal{E}_{nn',t} W_{n',t}^\gamma (P_{n',t}^m)^{1-\gamma} \right)^{-\varphi^k}}{\sum_{n''} \left(\kappa_{nn''}^k \mathcal{E}_{nn'',t} W_{n'',t}^\gamma (P_{n'',t}^m)^{1-\gamma} \right)^{-\varphi^k}}, \quad k \in \{c, m\}. \quad (2)$$

Thus, the share of country n 's expenditures spent on imports from country n' reflects the costs of acquiring varieties from n' , including production costs, $W_{n',t}$ and $P_{n',t}^m$, as well as bilateral shipping costs, $\kappa_{nn'}^k$, relative to all other countries (all expressed in n 's currency).

Two key differences distinguish intermediate goods from final goods. First, intermediate goods

⁶Home bias and trade elasticities then arise from the dispersion of product-level productivity shocks and trade costs. The demand functions for goods produced abroad can also be obtained using Armington preferences.

⁷We omit the scaling constant, $1/(\gamma^\gamma(1-\gamma)^{1-\gamma})$, which is unimportant for our purposes.

are used to produce either intermediate inputs or financial services while final goods are used for consumption. Second, trade elasticities and shipping costs may differ between intermediate and final goods, $\varphi^c \neq \varphi^m$ and $\kappa_{nn'}^c \neq \kappa_{nn'}^m, \forall n, n'$. Consequently, even if the costs of producing final goods and intermediate goods are the same in a given country n' (captured here by $W_{n',t}$ and $P_{n',t}^m$), trade shares in intermediate goods will generally deviate from those in final goods, $\varpi_{nn',t}^c \neq \varpi_{nn',t}^m$. This distinction allows intermediate and final goods trade to play different roles in generating cross-country comovement given observed differences in trade patterns between these sectors.

In between Layers 1 and 2 of Figure 4, traded varieties are assembled by importers in each destination country according to the technology,

$$Q_{n,t}^k = \left[\int \left(\sum_{n'} Q_{nn',t}^k(\mathbf{z}) \right)^{\frac{\chi-1}{\chi}} d\Phi^k(\mathbf{z}) \right]^{\frac{\chi}{\chi-1}}, \quad \chi > 1, \quad k \in \{c, m\}, \quad (3)$$

where $Q_{nn',t}^k(\mathbf{z})$, $k \in \{c, m\}$, denotes the quantity of tradable final or intermediate goods of variety $\mathbf{z}$ imported by n from n' , so that $q_{n',t}^k(\mathbf{z}) = \sum_n \kappa_{nn'}^k Q_{nn',t}^k(\mathbf{z})$.⁸ The price of the traded goods bundle, $Q_{n,t}^k$, is given by

$$P_{n,t}^{Q^k} = \Gamma \left(1 + \frac{1-\chi}{\varphi^k} \right)^{\frac{1}{1-\chi}} \left(\sum_{n'} \left(\kappa_{nn'}^k \mathcal{E}_{nn',t} W_{n',t}^\gamma (P_{n',t}^m)^{1-\gamma} \right)^{-\varphi^k} \right)^{-\frac{1}{\varphi^k}}, \quad k \in \{c, m\}, \quad (4)$$

where $\Gamma(\cdot)$ is the Gamma function.

3.2 Domestic Intermediate Input Producers and Retailers

We now address Layer 2 of Figure 4, where production is subject to Calvo (1983) pricing. As with tradable goods, we discuss sticky-price retailers (right-hand side of Figure 4) and intermediate input producers (left-hand side of Figure 4) in parallel since both face the same pricing problem.

Final goods used in consumption are purchased through domestic retailers indexed by $j \in [0, 1]$. Final goods sold by retailer j in country n at date t are denoted by $c_{n,t}(j)$. Retailers are not perfectly substitutable in household consumption. Thus, household preferences over final goods sold by different retailers are defined over a consumption bundle,

$$C_{n,t} = \left[\int_0^1 c_{n,t}(j)^{\frac{\varepsilon_{n,t}-1}{\varepsilon_{n,t}}} dj \right]^{\frac{\varepsilon_{n,t}}{\varepsilon_{n,t}-1}}, \quad \varepsilon_{n,t} > 1,$$

where $C_{n,t}$ also denotes aggregate consumption in country n at date t and $\varepsilon_{n,t}$ is a time-varying elasticity of substitution.

Similar to retailers, intermediate inputs supplied by producer j in country n at time t , denoted

⁸While we refer to importers who handle tradable goods, in equilibrium some varieties are produced domestically.

by $m_{n,t}(j)$, are not perfectly substitutable between producers so that

$$\mathcal{M}_{n,t} = \left[\int_0^1 m_{n,t}(j)^{\frac{\varrho_{n,t}-1}{\varrho_{n,t}}} dj \right]^{\frac{\varrho_{n,t}}{\varrho_{n,t}-1}}, \quad \varrho_{n,t} > 1,$$

where $\mathcal{M}_{n,t}$ denotes an aggregate of materials and financial services such that $\mathcal{M}_{n,t} = M_{n,t} + F_{n,t}$ and $\varrho_{n,t}$ is a time-varying elasticity of substitution.⁹

Given a price $P_{n,t}(j)$ of final goods sold by retailer j , household expenditure minimization implies a demand function, $c_{n,t}(j) = (P_{n,t}(j)/P_{n,t})^{-\varepsilon_{n,t}} C_{n,t}$, where $P_{n,t} = [\int_0^1 P_{n,t}(j)^{1-\varepsilon_{n,t}} dj]^{1/(1-\varepsilon_{n,t})}$ is the price deflator associated with aggregate consumption in country n , i.e., the model equivalent of the consumer price index in the data. Similarly, given a price $P_{n,t}^m(j)$ for sticky-price intermediate input, j , the associated demand function is $m_{n,t}(j) = (P_{n,t}^m(j)/P_{n,t}^m)^{-\varrho_{n,t}} \mathcal{M}_{n,t}$, where $P_{n,t}^m = [\int_0^1 P_{n,t}^m(j)^{1-\varrho_{n,t}} dj]^{1/(1-\varrho_{n,t})}$ is the price deflator corresponding to the aggregate of materials and financial services in country n .

Sticky-price retailers and intermediate input producers purchase bundles of traded varieties from importers, $Q_{n,t}^c$ and $Q_{n,t}^m$ (defined in equation (3)), respectively, to produce sales at home using the technology

$$c_{n,t}(j) = A_{n,t} Q_{n,t}^c(j) \quad \text{and} \quad m_{n,t}(j) = A_{n,t} Q_{n,t}^m(j), \quad (5)$$

where $A_{n,t}$ denotes technical progress in country n and $Q_{n,t}^k(j)$, $k \in \{c, m\}$, is the demand for traded-variety bundles by retailer or intermediate input producer j . These firms minimize costs, $P_{n,t}^{Q^k} Q_{n,t}^k(j)$, $k \in \{c, m\}$, subject to the technology (5), implying a marginal cost per unit of sector k goods sold, $MC_{n,t}^k$, equal to $P_{n,t}^{Q^k}/A_{n,t}$. Real marginal costs, therefore, are given by

$$mc_{n,t}^k = \frac{P_{n,t}^{Q^k}}{P_{n,t} A_{n,t}}, \quad k \in \{c, m\}, \quad (6)$$

where we have deflated the marginal cost for both final goods and intermediate inputs by $P_{n,t}$.

The expression for real marginal costs, (6), reflects foreign costs associated with producing traded-variety bundles, $Q_{n,t}^k(j)$, embodied in the price of these bundles, $P_{n,t}^{Q^k}$, in equation (4). It thus captures how production costs, $W_{n',t}$ and $P_{n',t}^m$, trade costs, $\kappa_{nn'}^k$, and exchange rates, $\mathcal{E}_{nn',t}$, across different countries all factor into the price, $P_{n,t}^{Q^k}$, of the traded goods bundle, $Q_{n,t}^k$, purchased by country n firms, i.e., its retailers and intermediate input producers. This mechanism is analogous to how these same factors determine the corresponding import shares in equation (2). Equation (4) therefore captures the role of *backward trade linkages*, or alternatively country n 's import network, in determining domestic marginal costs. Since these linkages directly affect real profits of country n retailers and intermediate input producers, they also affect their pricing decisions.

Following Calvo (1983), in each period, sticky-price firms in country n are unable to adjust

⁹Whether financial services are produced in the retail intermediate goods sector is immaterial for our findings.

their price with probability θ_n^k , $k \in \{c, m\}$, in which case they index their price increases to steady-state inflation in their respective sectors. For example, retailers set their price using the indexation rule, $P_{n,t}(j) = (1 + \pi_n)P_{n,t-1}(j)$, where π_n is country n 's long-run or steady-state inflation rate. With probability $1 - \theta_n^c$, a retailer is able to choose a price, $P_{n,t}^*$, to maximize its expected present discounted value of future profits,

$$P_{n,t}^* = \arg \max E_t \sum_{k=0}^{\infty} \beta^k \frac{\lambda_{n,t+k}}{\lambda_{n,t}} (\theta_n^c)^k \left[\left(\frac{P_{n,t}^*(1 + \pi_n)^k}{P_{n,t+k}} \right)^{1-\varepsilon_{n,t+k}} - mc_{n,t+k}^c \left(\frac{P_{n,t}^*(1 + \pi_n)^k}{P_{n,t+k}} \right)^{-\varepsilon_{n,t+k}} \right] C_{n,t+k},$$

where $\lambda_{n,t}$ is households' marginal utility of consumption in country n , and $\beta^k \frac{\lambda_{n,t+k}}{\lambda_{n,t}}$ is their stochastic discount factor from t to $t+k$. The intermediate input producer's problem, though analogous, yields a slightly different relationship,

$$P_{n,t}^{m,*} = \arg \max E_t \sum_{k=0}^{\infty} \beta^k \frac{\lambda_{n,t+k}}{\lambda_{n,t}} (\theta_n^m)^k \left[\left(\frac{P_{n,t}^{m,*}(1 + \pi_n)^k}{P_{n,t+k}^m} \right)^{1-\varrho_{n,t+k}} \frac{P_{n,t+k}^m}{P_{n,t+k}} - mc_{n,t+k}^m \left(\frac{P_{n,t}^{m,*}(1 + \pi_n)^k}{P_{n,t+k}^m} \right)^{-\varrho_{n,t+k}} \right] \mathcal{M}_{n,t+k},$$

which now includes an additional term capturing the price of materials relative to final goods, $P_{n,t+k}^m/P_{n,t+k}$. This relative price correction reflects the fact that households ultimately value profits in terms of the final consumption good.

The associated first-order conditions imply desired markups over marginal costs, $\mu_{n,t}^c = \frac{\varepsilon_{n,t}}{\varepsilon_{n,t}-1}$ and $\mu_{n,t}^m = \frac{\varrho_{n,t}}{\varrho_{n,t}-1}$, for retailers and intermediate input producers, respectively. Absent shocks to $\varepsilon_{n,t}$ and $\varrho_{n,t}$, these markups are constant and nominal prices are proportional to a weighted average of expected future nominal marginal costs. Inflation, therefore, will tend to rise when these marginal costs are expected to increase. Crucially, because the marginal costs of producing consumption goods and intermediate inputs, $mc_{n,t+k}^k$, depend on foreign costs embodied in $P_{n,t+k}^{Q^k}$ through equation (6), shocks in all trading partner countries affect domestic prices and inflation.

3.3 Households

The representative household in country n has preferences defined by

$$\sum_{t=0}^{\infty} \beta^t \left\{ \frac{(C_{n,t}/A_{n,t})^{1-\sigma_n} - 1}{1-\sigma_n} - \omega_n \frac{L_{n,t}^{1+\eta_n}}{1+\eta_n} \right\}$$

and faces the budget constraint,

$$P_{n,t}C_{n,t} + \frac{B_{n,t}}{R_{n,t}} + E_t \left[\frac{V_{t+1}}{\mathcal{E}_{rn,t}} S_{n,t+1} \right] + P_{n,t}^m F_{n,t} = W_{n,t}L_{n,t} + \Pi_{n,t} + B_{n,t-1} + \frac{1}{\mathcal{E}_{rn,t}} S_{n,t}, \quad (7)$$

where $L_{n,t}$ denotes labor input, $W_{n,t}$ denotes nominal wages, $\Pi_{n,t}$ denotes nominal firm profits, and $B_{n,t}$ denotes the quantity of non-state-contingent bonds traded domestically by households at date t . Firm profits in country n include those from retailers and intermediate goods producers,

$$\Pi_{n,t} = \underbrace{[P_{n,t} - \Delta_{n,t}^c MC_{n,t}^c] C_{n,t}}_{\text{Retailers' Profits}} + \underbrace{[P_{n,t}^m - \Delta_{n,t}^m MC_{n,t}^m] \mathcal{M}_{n,t}}_{\text{Intermediate Goods Producers' Profits}},$$

where $\Delta_{n,t}^c = \int_0^1 \left(\frac{P_{n,t}(j)}{P_{n,t}} \right)^{-\varepsilon_{n,t}} dj$ and $\Delta_{n,t}^m = \int_0^1 \left(\frac{P_{n,t}^m(j)}{P_{n,t}^m} \right)^{-\varrho_{n,t}} dj$ are measures of relative price distortions in retail and intermediate goods markets respectively. Non-state-contingent bonds trade at price $1/R_{n,t}$ and pay 1 unit of the local currency in the following period. Therefore, the first two terms on the left-hand side of the household budget constraint (7) capture spending on consumption and bond purchases while the first three terms on the right-hand side capture labor income, profits, and bond returns with all prices expressed in country n 's local currency.

The household budget constraint (7) differs from its conventional closed-economy counterpart in that countries also trade state-contingent securities internationally, $S_{n,t+1}$. These securities are purchased at date t by country n at price V_{t+1} , expressed in the currency of a reference country r . Each security pays off 1 unit of the reference country currency, translated into local currency units through the exchange rate $\mathcal{E}_{rn,t}$ in the budget constraint (7).¹⁰ Under no arbitrage in currency markets, $\mathcal{E}_{rr,t} = 1$.

As in [Schmitt-Grohé and Uribe \(2003\)](#), trading securities internationally is subject to portfolio adjustment costs. To carry out these trades, households purchase financial services, $F_{n,t}$, at price $P_{n,t}^m$. Similar to [Ohanian, Restrepo-Echavarria, and Wright \(2018\)](#), these financial services cover portfolio adjustment costs that are borne separately for each state-contingent security,

$$P_{n,t}^m F_{n,t} = E_t \left[P_{n,t}^m A_{n,t} \Theta_n \left(\frac{V_{t+1}}{\mathcal{E}_{rn,t} P_{n,t}} \frac{S_{n,t+1}}{A_{n,t}} + \frac{1}{\tau} \xi_{n,t} \right) \right].$$

The function $\Theta_n(\cdot)$ reflects a cost incurred by country n in adjusting its financial position. We assume that $\Theta_n(0) = \Theta'_n(0) = 0$ and $\Theta''_n(\cdot) = \tau > 0$ so that portfolio adjustment costs increase at an increasing rate as country n 's financial position increases in absolute value. The curvature parameter τ captures the degree of financial frictions in global financial markets: $\tau \rightarrow 0$ corresponds to perfect capital markets and $\tau \rightarrow \infty$ represents financial autarky. The function Θ_n varies with two objects. First, portfolio adjustment costs incurred by country n depend on $\frac{V_{t+1} S_{n,t+1}}{\mathcal{E}_{rn,t} P_{n,t} A_{n,t}}$, the

¹⁰Thus, if reference country r uses, say, the Euro and country n is the U.S., $\mathcal{E}_{rn,t}$ is expressed in €/\$. Moreover, $\frac{1}{\mathcal{E}_{rn,t}} S_{n,t}$ then represents a payoff in dollars from $S_{n,t}$ shares of the state-contingent security purchased at date $t-1$. Observe further that no-arbitrage in currency markets implies that $\mathcal{E}_{nn',t} = \mathcal{E}_{nn'',t} \mathcal{E}_{n''n',t}$.

real value of state-contingent securities purchased in global financial markets in units of local goods (i.e., the consumption bundle, $C_{n,t}$) normalized by $A_{n,t}$ to account for country n 's level of technical progress. Second, the term $\frac{1}{\tau}\xi_{n,t}$ captures exogenous disturbances that affect country n 's ability to trade in international financial markets.

Substantively, financial market adjustment costs, Θ_n , and shocks, $\xi_{n,t}$, allow the estimated model to match exchange rate movements. In particular, they imply deviations from the UIP condition that are an important feature of exchange rate data. Since exchange rates generally affect the behavior of domestic inflation in an international setting (Clarida et al., 2002; Galí and Monacelli, 2005), UIP deviations are part of global inflation dynamics.

3.4 Market Clearing

Bringing together the production and household sides of each country's economy, the value of traded varieties of final or intermediate goods produced by country n (in units of the local currency) is the sum of its exports to other countries (and itself), $\sum_{n'} \mathcal{E}_{nn',t} X_{n',t}^k$, $k \in \{c, m\}$. In equilibrium, this sum must reflect the total demand from all countries for country n 's varieties of final and intermediate goods. Therefore, $\sum_{n'} \mathcal{E}_{nn',t} X_{n',t}^k$ is also the total revenue of country n 's final or intermediate goods producers which, given constant returns and competitive markets, must equal these producers' input costs, $W_{n,t} L_{n,t}^k + P_{n,t}^m M_{n,t}^k$. Here, $L_{n,t}^k \equiv \int \ell_{n,t}^k(\mathbf{z}) d\Phi^k(\mathbf{z})$ and $M_{n,t}^k \equiv \int M_{n,t}^k(\mathbf{z}) d\Phi^k(\mathbf{z})$ represent total labor and materials used in the production of traded goods. Hence,

$$W_{n,t} L_{n,t}^k + P_{n,t}^m M_{n,t}^k = \sum_{n'} \mathcal{E}_{nn',t} \varpi_{n',t}^k X_{n',t}^k, \quad k \in \{c, m\}. \quad (8)$$

The left-hand side is the total value of varieties of traded final and intermediate goods produced by country n in units of the local currency. Equation (8), therefore, highlights *forward trade linkages*, or alternatively country n 's export network, in determining the value of domestic output.

3.5 Monetary Authority

We close the model with a monetary policy rule that typically depends on the output gap and inflation (e.g., Taylor, 1993, 1999). In Section 5 we use a forward-looking rule that allows us to solve the model analytically; in Section 6 we introduce forward-guidance shocks that allow us to address the zero lower bound within a log-linearized version of the model. These are discussed further in their respective sections.

3.6 Steady State

We now highlight salient implications of the model's steady state. See Section D of the [Online Appendix](#) for details.

The World’s Balanced Growth Path: In departing from the closed-economy environment, we focus on a world balanced growth path with constant country shares in the world economy, so that no country’s share of the world economy grows or shrinks indefinitely. While our baseline estimation assumes common steady-state TFP growth across countries, the model can accommodate country-specific steady-state growth rates.¹¹ For a given economy n , the derivation of country-specific balanced growth paths for real quantities and steady-state inflation follows that of closed-economy models. In particular, real quantities grow at rate $g_n = E[g_{n,t}]$, which denotes the long-run mean of technical progress, $g_{n,t} = \frac{A_{n,t}}{A_{n,t-1}}$ (assumed to be common across countries in our baseline estimation). In addition, prices increase at the rate $1 + \pi_n$, which also determines the steady-state interest rate through the Fisher equation, $1 + \pi_n = \frac{\beta R_n}{g_n}$. We allow steady-state inflation to be country-specific.

Trade Balances: While the world economy inherits the dynamics of Calvo pricing, filtered through multilateral trade interactions, its steady state mimics the features of [Eaton and Kortum \(2002\)](#)’s static framework. In particular, the form of portfolio adjustment costs does not pin down countries’ steady-state trade balance. This leads us to adopt a benchmark defined by balanced trade in the long run.

That said, even over periods as long as the sample we use for estimation in Section 6 (16 years, from 2004Q3 to 2019Q4), a country’s net asset position can differ from zero on average. We address this observation following the approach proposed by [Dekle, Eaton, and Kortum \(2007\)](#) in a static environment but now applied to the steady state of our dynamic setting. Specifically, we first write a variant of the economic environment whose steady state can be matched to observed average regional trade imbalances over our entire sample. This can be done by allowing for exogenous frictions in international asset markets even in the steady state, $\xi_n \neq 0$. Then, for the set of parameters implied by a world with long-run trade imbalances, we calculate counterfactual steady-state allocations and prices corresponding to zero trade imbalances, i.e., consistent with $\xi_n = 0 \forall n$, in which case real net asset positions are zero for all countries, $S_n = 0 \forall n$. Analogously to [Dekle et al. \(2007\)](#), the resulting counterfactual world steady-state allocations without imbalances can be used to produce a linearized model for estimation and analysis using standard linear rational expectations toolkits.

¹¹The existence of a global balanced growth path where no country eventually dominates or becomes irrelevant in the world economy is shown in the [Online Appendix](#). This requires, among other conditions, that the real exchange rate for each country n relative to the reference country, $\mathcal{E}_{rn,t} \frac{P_{n,t}}{P_{r,t}}$, grows in the long run at a rate that reflects the difference in technical progress between country n and the reference country. We consider the more flexible specification in Section H of the [Online Appendix](#) and continue to find an important role for trade. There, country-specific growth rates are a convenient shorthand for the sustained differences in growth rates that are a feature of the data over long periods given the absence of capital accumulation or other slow-moving endogenous state variables in our model. See [Sala \(2015\)](#) and [Ho \(2024\)](#) on how variation at different frequencies can matter for parameter estimates and interpretation of the model.

4 The Linearized Global New Keynesian Model

We now turn our attention to key aspects of the model solution, casting some of its equations in terms of expressions familiar from the NK and international trade literatures. To obtain conventional NK expressions as special cases, we log-linearize the deflated-detrended equilibrium equations around their steady state. Thus, all variables in the expressions below refer to their appropriately deflated-detrended counterparts.¹² We use a ‘hat’ over variables to denote log-deviations from steady state (i.e., $\hat{x}_{n,t} = \log(x_{n,t}) - \log(x_n)$), use dx to denote level deviations from steady state (i.e., $dx_{n,t} = x_{n,t} - x_n$), and express all equations in vector form by stacking country-specific variables into vectors, $\hat{\mathbf{x}}_t = (\hat{x}_{1,t}, \dots, \hat{x}_{N,t})'$.

To develop analytical intuition, we discuss the key economic forces at work using a simplified version of our world economy. In this version of the model, we set $\varepsilon_{n,t} = \varrho_{n,t}$, $\varphi^c = \varphi^m = \varphi$, $\theta_n^c = \theta_n^m = \theta_n$ and $\kappa_{nn'}^c = \kappa_{nn'}^m = \kappa_{nn'} \forall n, n'$. These assumptions effectively collapse the traded intermediate goods and final goods sectors in Layer 1 of Figure 4 into a single sector. In addition, we set the materials share of gross output, $1 - \gamma$, to zero, thus abstracting from roundabout production. The domestic implications of foreign production costs can then be written in terms of labor costs (i.e., wages) only. We further assume that the demand faced by sticky-price firms is subsidized at rate $1 + \tau_n^k$, $k \in \{c, m\}$, which we set equal to the markup to free our discussion from monopolistic pricing distortions in steady state (Galí, 2008). Thus, the long-run real marginal cost of sticky-price final goods and intermediate inputs is 1 in all countries, $mc_n^k = 1$, $k \in \{c, m\}$. We let $\mathcal{E}_{n,t} \equiv \mathcal{E}_{rn,t}$ for notational convenience and, without loss of generality, take country 1 to be the reference country (i.e., $r = 1$). We then define the trend-adjusted real exchange rate, which converts country n final goods into units of country 1 final goods, as $e_{n,t} = \mathcal{E}_{n,t} \frac{A_{n,t} P_{n,t}}{A_{1,t} P_{1,t}}$. Finally, we set the country-specific parameters, σ_n , η_n , ω_n , θ_n , etc., to be the same across countries to simplify notation.

Under these assumptions, the interaction between nominal rigidities, international trade, and international financial flows can be summarized by two blocks of equations. The first block describes conventional NK mechanisms in all countries. The second block captures forces underlying international trade in goods and financial assets.

¹²See Section C of the [Online Appendix](#) for details of the model normalization with respect to country-specific inflation, $1 + \pi_n$, and technical progress, g_n .

4.1 The New Keynesian Block

The NK block reflects intertemporal mechanisms at home, domestic labor supply, and monetary policy. In vector form and using a standard monetary policy rule, we have

$$\widehat{\mathbf{C}}_t = E_t \widehat{\mathbf{C}}_{t+1} - \frac{1}{\sigma} \left(\widehat{\mathbf{R}}_t - E_t \widehat{\boldsymbol{\pi}}_{t+1} - E_t \widehat{\mathbf{g}}_{t+1} \right), \quad (9)$$

$$\widehat{\boldsymbol{\pi}}_t = \frac{(1-\theta)(1-\beta\theta)}{\theta} (\widehat{\mathbf{m}}\mathbf{c}_t + \widehat{\boldsymbol{\mu}}_t) + \beta(E_t[\widehat{\boldsymbol{\pi}}_{t+1}]), \quad (10)$$

$$\widehat{\mathbf{R}}_t = \rho \widehat{\mathbf{R}}_{t-1} + (1-\rho)(\phi_\pi \widehat{\boldsymbol{\pi}}_t + \phi_Y \widehat{\mathbf{Y}}_t) + \widehat{\boldsymbol{\nu}}_t, \quad (11)$$

$$\widehat{\mathbf{w}}_t = \eta \widehat{\mathbf{L}}_t + \sigma \widehat{\mathbf{C}}_t, \quad (12)$$

where $\widehat{\mathbf{C}}_t$ is a vector that contains consumption deviations from steady state for each country, $\widehat{\mathbf{C}}_t = (\widehat{C}_{1,t}, \dots, \widehat{C}_{N,t})$, and similarly for $\widehat{\boldsymbol{\pi}}_t$, $\widehat{\mathbf{R}}_t$, etc., and where we have stacked the equations for each country. Equations (9) to (11) replicate familiar expressions from the NK literature: Equation (9) is the household Euler equation for each country, equation (10) describes a vectorized NKPC written in terms of marginal costs rather than the output gap (with the usual slope, $\kappa \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$), and equation (11) describes a monetary policy rule for each country. Equation (12) describes labor supply in all countries with its attendant income and substitution effects. This model block includes three exogenous shocks in each country: shocks to technical progress, $\widehat{\mathbf{g}}_t$, markup shocks, $\widehat{\boldsymbol{\mu}}_t$, and monetary policy shocks, $\widehat{\boldsymbol{\nu}}_t$.

In the absence of trade, the NK block reduces to a set of conventional closed-economy three-equation NK models (e.g., An and Schorfheide, 2007; Galí, 2008), thus yielding isolated NK economies (i.e., autarky). Specifically, without trade and roundabout production, the real marginal cost of sticky-price goods, $\widehat{\mathbf{m}}\mathbf{c}_t$, is determined by wages, $\widehat{\mathbf{w}}_t$, while linearized output, $\widehat{\mathbf{Y}}_t$, equates to both consumption, $\widehat{\mathbf{C}}_t$, and employment, $\widehat{\mathbf{L}}_t$, so that, $\widehat{\mathbf{m}}\mathbf{c}_t = \widehat{\mathbf{w}}_t = (\eta + \sigma) \widehat{\mathbf{Y}}_t$, as in the conventional NK setting country by country.

When countries trade, the marginal cost of sticky-price goods no longer equates to payments for domestic inputs. Instead, it now reflects trade in goods and assets, along with global market clearing. These international forces are described in the second block of equations.

4.2 The International Block

The second block of equations comprises relationships that arise from international trade. These include four sets of equations describing i) the marginal cost of producing sticky-price goods in each country as a function of cost conditions abroad, ii) market clearing conditions for traded goods, iii) the balance of payments in each country, and iv) conditions for optimal trade in financial assets.

i) Marginal Cost of Sticky-Price Goods: Unlike a closed economy, countries' marginal costs depend on production costs in all trading partners. In particular, equation (4) implies that

$$\widehat{e}_t + \widehat{mc}_t = \varpi(\widehat{e}_t + \widehat{w}_t), \quad (13)$$

where $\widehat{e}_t$, $\widehat{mc}_t$, and $\widehat{w}_t$ are vectors of exchange rates, marginal costs, and wages respectively, in log-linearized form. The left-hand side of equation (13) is the marginal cost of producing sticky-price goods for each country in real units of the reference country's goods. This is determined, on the right-hand side, by wages in each country (given $\gamma = 1$), expressed in the reference country's goods and weighted by the matrix of import shares, $\varpi = \{\varpi_{nn'}\}$. Therefore, the influence that a country n' has on country n 's marginal costs increases in proportion to how much n imports from n' , $\varpi_{nn'}$.

ii) Market Clearing for Traded Goods: There are N market clearing conditions for traded goods, one for each country. These can be expressed in vector form in a way that describes the makeup of the real trade balance. From equation (8), along with the assumptions in this section,

$$\underbrace{\widehat{Y}_t - \widehat{C}_t}_{\text{real trade balance}} = \underbrace{(\psi^T - I)\widehat{C}_t}_{\text{relative demand in export markets}} - \underbrace{(1 + \varphi)}_{\text{price elasticity of trade}} \underbrace{(I - \psi^T \varpi)(\widehat{e}_t + \widehat{w}_t)}_{\text{relative price at destination}}, \quad (14)$$

where $\psi = \{\psi_{nn'}\}$ denotes the matrix of (steady-state) export shares from country n' to n .¹³

The left-hand side of the equation, $\widehat{Y}_t - \widehat{C}_t$, captures real quantities produced and consumed, defining the real trade balance. This trade balance depends on the relative demand in export markets, the first term on the right-hand side of equation (14). It moves towards a surplus when the consumption of home goods abroad, $\psi^T \widehat{C}_t$, increases. Here, each foreign country's consumption of home-produced goods is weighted by its share of exports from the home country. Conversely, the real trade balance moves towards a deficit when domestic consumption, $I\widehat{C}_t$, increases.

The real trade balance also depends on the relative price of exports in foreign markets, the second term on the right-hand side of equation (14). This term compares the price of exports from each country (in real units of the reference country), $\widehat{e}_t + \widehat{w}_t$, with the corresponding prices of goods available in destination countries, $\varpi(\widehat{e}_t + \widehat{w}_t)$, weighted by the export matrix, ψ^T . Put simply, when the price of the consumption bundle in country n rises, the trade balance in country n' improves in proportion to its exports to country n . As such, the term $(I - \psi^T \varpi)(\widehat{e}_t + \widehat{w}_t)$ represents the substitution from countries with higher costs to those with lower costs.

The price elasticity of trade, $1 + \varphi$, governs the scale of real trade adjustments to relative export prices. Larger values of $1 + \varphi$ imply less dispersion in the productivity of any given variety across countries. In that case, firms are more sensitive to a given relative price change and substitute

¹³Formally, $\psi_{nn'} = \frac{\varpi_{nn'} e_n mc_n C_n}{\sum_{n''} \varpi_{n''n'} e_{n''} mc_{n''} C_{n''}}$, where C_n is total expenditures in country n .

inputs more readily across countries, resulting in larger relative price effects.

iii) Balance of Payments: Rearranging countries' household budget constraints, (7), linearized around a steady state with no monopolistic trade distortions, yields the following expression relating the trade balance and the terms of trade to financial flows:

$$\underbrace{\hat{\mathbf{Y}}_t - \hat{\mathbf{C}}_t}_{\text{real trade balance}} + \underbrace{(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{e}}_t + \hat{\mathbf{w}}_t)}_{\text{terms of trade}} = \underbrace{Vg_1(1 + \pi_1)E_t[ds_{t+1}/(\mathbf{e} \times \mathbf{C})] - ds_t/(\mathbf{e} \times \mathbf{C})}_{\text{financial flows}}, \quad (15)$$

where '/' and '×' denote, respectively, element-wise (Hadamard) division and product operations. The left-hand side of the equation is a vector of trade balances for each country in local units. It can be decomposed into a real trade balance of quantities produced and consumed, $\hat{\mathbf{Y}}_t - \hat{\mathbf{C}}_t$, and a measure of the terms of trade for each country (scaled by domestic import shares), $(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{e}}_t + \hat{\mathbf{w}}_t)$.¹⁴ The terms of trade capture the wedge between production costs (which are a function of local factor prices), $\mathbf{I}(\hat{\mathbf{e}}_{n,t} + \hat{\mathbf{w}}_{n,t})$, and consumption costs (which are a trade-weighted average of foreign factor prices and exchange rates), $\boldsymbol{\varpi}(\hat{\mathbf{e}}_{n,t} + \hat{\mathbf{w}}_{n,t})$. Importantly, the equation highlights that the terms of trade also affect the real domestic value of the trade balance that needs to be covered by financial flows.

The right-hand side captures financial flows normalized by consumption. Frictions in international financial markets imply that adjustments to countries' net asset positions are costly and thus distort consumption allocations across time and states of nature. When portfolio adjustment costs are infinitely high, trade is balanced period by period, creating a tight link between consumption, output, and exchange rates.

iv) Financial Asset Allocations: Finally, around a steady state with balanced trade, the Euler equation governing the evolution of countries' financial assets satisfies

$$\underbrace{\mathbf{1}\hat{\mathbf{C}}_{1,t} - \hat{\mathbf{C}}_t}_{\text{relative consumption}} = \frac{1}{\sigma} \underbrace{\hat{\mathbf{e}}_t}_{\text{real exchange rate}} + \underbrace{\beta \frac{\tau}{\sigma} \left(\overbrace{d\mathbf{S}_t/\mathbf{e} - \mathbf{1}dS_{1,t}}^{\text{cumulative financial asset position}} + \overbrace{d\boldsymbol{\Xi}_t - \mathbf{1}d\boldsymbol{\Xi}_{1,t}}^{\text{cumulative portfolio adjustment shocks}} \right)}_{\text{asset pricing wedge}}, \quad (16)$$

where $d\mathbf{S}_t = \sum_{k=-\infty}^t ds_k$, $d\boldsymbol{\Xi}_t = \frac{1}{\sigma} \sum_{k=-\infty}^{t-1} d\boldsymbol{\xi}_k$, and $\mathbf{1}$ denotes an $N \times 1$ vector of ones. Absent frictions in global financial markets, defined by $\tau = 0$ and $d\boldsymbol{\xi}_{t-k} = 0 \ \forall k$, equation (16) reduces to the expression highlighted by [Backus and Smith \(1993\)](#). In that case, the (log) ratio of consumption between any two countries, $\mathbf{1}\hat{\mathbf{C}}_{1,t} - \hat{\mathbf{C}}_t$, reflects variations in their real exchange rate, $(1/\sigma)\hat{\mathbf{e}}_t$ (i.e., the relative price of consumption between the two countries). Put simply, a depreciation of the

¹⁴The terms of trade is the ratio of a country's export prices to import prices (in common units, here the reference country's final goods). Thus country n 's linearized terms of trade are given by $\hat{\mathbf{e}}_{n,t} + \hat{\mathbf{w}}_{n,t} - \frac{1}{1-\varpi_{nn}} \sum_{n' \neq n} \varpi_{nn'}(\hat{\mathbf{e}}_{n',t} + \hat{\mathbf{w}}_{n',t})$, or in matrix form, $(\text{diag}(\mathbf{I} - \boldsymbol{\varpi})^{-1})(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{e}}_{n,t} + \hat{\mathbf{w}}_{n,t})$.

domestic currency goes hand in hand with higher consumption of home goods (as consumption goods abroad become more expensive).

However, [Backus and Smith \(1993\)](#) also note that the data do not support such a connection between countries' relative consumption and real exchange rates. This 'consumption-exchange rate disconnect puzzle' suggests frictions in international financial markets that operate along two dimensions in equation (16):¹⁵ one relates to exogenous disturbances affecting each country's trading, $d\Xi_t - \mathbf{1}d\Xi_{1,t}$, and the other relates to endogenous portfolio adjustments (relative to the reference country), $d\mathbf{S}_t/e - \mathbf{1}dS_{1,t}$, where $d\mathbf{S}_t$ is a vector representing the history of countries' net asset positions (in linearized form). This history matters because financial frictions affect consumption growth through the Euler equation, and thus have a permanent effect on consumption levels.

5 Multilateral Spillovers in the World Economy

The key difference between the world economy described above and benchmark NKOE models is the propagation of country-specific demand disturbances through multilateral trade. This propagation creates endogenous cross-country comovement directly between trading partners, and indirectly through knock-on effects generated by expenditure switching across countries. The indirect knock-on effects exist even with just two regions, in which case linkages are simply reciprocal so that trade induces straightforward back-and-forth echoes from pairwise exchanges. With more than two regions, comovement between any country pair also emerges from common exposure to third countries in addition to direct trade linkages.

In what follows, we consider a special case of our model that yields an analytical solution. We can thus characterize the direct and indirect spillovers across countries, clarifying how these effects depend on: i) financial markets, ii) sticky consumer goods prices, iii) the role of demand shocks, and iv) the degree to which individual countries are aggregated into regions.

5.1 An Analytical Example

To obtain closed-form solutions, we maintain the setup of Section 4 (i.e., $\varepsilon_{n,t} = \varrho_{n,t}$, $\varphi^c = \varphi^m = \varphi$, $\theta_n^c = \theta_n^m = \theta_n$, $\kappa_{nn'}^c = \kappa_{nn'}^m = \kappa_{nn'} \forall n, n'$, and $1 - \gamma = 0$) and make two additional assumptions. First, all shocks are *i.i.d.* across countries and over time and uncorrelated with each other. Therefore, all comovement in this example arises from idiosyncratic country-specific shocks through endogenous spillovers rather than exogenous global shocks. Second, following [Clarida et al. \(2002\)](#), we replace the monetary policy rule (11) with a forward-looking inflation-centric rule in every country,

$$\hat{R}_t = \phi E_t \hat{\pi}_{t+1} + \sigma \nu_t.$$

¹⁵See [Kollmann \(1995\)](#), [Benigno and Thoenissen \(2008\)](#), and [Corsetti, Dedola, and Leduc \(2008\)](#) for examples of papers that specifically address the [Backus and Smith \(1993\)](#) puzzle through financial frictions.

Monetary policy, therefore, is symmetric across countries. For transparency, but without loss of generality, we let all elements of the monetary shocks, $\boldsymbol{\nu}_t$, have unit variances.

These assumptions imply a solution for consumption of the form,¹⁶

$$\hat{\mathbf{C}}_t = -\boldsymbol{\nu}_t.$$

That is, $\hat{\mathbf{C}}_{n,t}$ depends only on its own-country monetary policy shocks. Since these shocks are independent across countries in this example, consumption is also uncorrelated across countries, $E[\hat{\mathbf{C}}_t \hat{\mathbf{C}}_t^T] = \mathbf{I}$. As expected, lowering nominal rates, $\nu_{n,t} < 0$, in a given country n raises its consumption relative to trend. In what follows, we lay out the mechanisms at work by focusing on the limiting case with no frictions in global financial markets, $\tau = 0$ and $d\boldsymbol{\xi}_t = 0 \forall t$. Because of real trade frictions, exchange rate variations imply that consumption may differ across countries even with frictionless financial markets—recall equation (16).

5.2 International Comovement from Demand Shocks

Under the above assumptions, we obtain analytical expressions for output and inflation that illustrate how the model reproduces the positive cross-country correlations described in Section 2. In particular, the solution for output, in vector form, is

$$\hat{\mathbf{Y}}_t = -\mathcal{A}_{YY}^{-1} \boldsymbol{\psi}^T \boldsymbol{\nu}_t, \text{ where } \mathcal{A}_{YY}^{-1} = (1 - b)(\mathbf{I} - b\boldsymbol{\psi}^T \boldsymbol{\varpi})^{-1} \text{ and } b = \frac{(1 + \varphi)\eta}{1 + (1 + \varphi)\eta}. \quad (17)$$

Absent trade, $\boldsymbol{\varpi} = \boldsymbol{\psi}^T = \mathbf{I}$ and equation (17) reduces to $\hat{\mathbf{Y}} = -\boldsymbol{\nu}_t = \hat{\mathbf{C}}_t$ as each country's production adjusts to meet its own local demand. With trade, the export matrix $\boldsymbol{\psi}^T$ captures the direct trade spillovers: When an expansionary monetary shock, $\nu_{n',t} < 0$, increases demand in country n' , output in country n increases in proportion to its exports to country n' . The Leontief inverse, $\mathcal{A}_{YY}^{-1}$, summarizes the knock-on effects from successive rounds of import and export substitutions summarized by the trade matrices, $\boldsymbol{\varpi}$ and $\boldsymbol{\psi}^T$, respectively. These knock-on effects exist even when $N = 2$ but increase in complexity when $N > 2$ because they are further propagated by third-country trading partners. The scale of these effects depends on the parameter, $b \in (0, 1)$, which reflects elasticities with respect to trade, $1 + \varphi$, and labor, $1/\eta$, as discussed below.

The solution for inflation also reflects spillovers from foreign demand shocks:

$$\hat{\pi}_t = \kappa\eta\boldsymbol{\varpi}\hat{\mathbf{Y}}_t - \kappa\sigma\boldsymbol{\nu}_t + \kappa\boldsymbol{\mu}_t, \quad (18)$$

where $\kappa \equiv \frac{(1-\theta)(1-\beta\theta)}{\theta}$ is the usual slope of the NK Phillips curve. Thus, domestic inflation comoves with output not only at home but also abroad, as in the bottom right panel of Figure 2. The strength of this comovement is governed by countries' trade relationships through the import matrix, $\boldsymbol{\varpi}$.¹⁷

¹⁶Derivations in Section F.4 of the [Online Appendix](#).

¹⁷In a closed economy, (18) becomes the familiar NK expression, $\hat{\pi}_t = \kappa(\eta + \sigma)\hat{\mathbf{Y}}_t + \kappa\boldsymbol{\mu}_t$, with $\hat{\mathbf{Y}}_t = \hat{\mathbf{C}}_t = -\boldsymbol{\nu}_t$ as

Equation (18) also makes clear that cross-country correlations of inflation will tend to be lower than those of output for two reasons. First, the term $\kappa\sigma\boldsymbol{\nu}_t$ reflects household consumption smoothing through internationally traded state-contingent securities. In response to an expansionary monetary shock, $\nu_{j,t} < 0$, country j 's demand for these securities increases, leading its exchange rate to depreciate and its inflation to rise. Second, the assumptions here imply that markup shocks, $\boldsymbol{\mu}_t$, only affect domestic inflation.

The solutions for output, (17), and inflation, (18), imply positive comovement in output across countries, positive comovement in inflation across countries, and positive comovement between inflation and output across countries, consistent with the empirical evidence in Section 2. We formalize this theoretical result in Proposition 1 below.

Proposition 1. *For any matrix $\mathbf{M}$, let $\mathbf{M} \geq 0$ if and only if $m_{ij} \geq 0 \forall i, j$. Then, under the maintained assumptions, $E[\hat{\mathbf{Y}}_t \hat{\mathbf{Y}}_t^T] \geq 0$, $E[\hat{\boldsymbol{\pi}}_t \hat{\boldsymbol{\pi}}_t^T] \geq 0$ and $E[\hat{\boldsymbol{\pi}}_t \hat{\mathbf{Y}}_t^T] \geq 0$.*

Proof. See Section F.4 of the [Online Appendix](#).

The global comovement properties highlighted in Proposition 1 derive from both direct and indirect effects of trade. Consider the effects on country n of an expansionary monetary shock that raises consumption in n' , $\hat{C}_{n',t} = -\nu_{n',t} > 0$. From equation (17) and the Neumann series expansion of $\mathcal{A}_{\mathbf{Y}\mathbf{Y}}^{-1}$, we can summarize the effects of this demand increase on countries' output growth as

$$\hat{\mathbf{Y}}_t = \underbrace{-(1-b)\boldsymbol{\psi}^T \boldsymbol{\nu}_t}_{\text{direct effects}} - \underbrace{(1-b)(b\boldsymbol{\psi}^T \boldsymbol{\varpi} + b^2(\boldsymbol{\psi}^T \boldsymbol{\varpi})^2 + b^3(\boldsymbol{\psi}^T \boldsymbol{\varpi})^3 + \dots)\boldsymbol{\psi}^T \boldsymbol{\nu}_t}_{\text{indirect effects via expenditure switching}}. \quad (19)$$

Equation (19) characterizes direct and indirect spillovers, which then extend to inflation via equation (18). Without trade, $\boldsymbol{\varpi} = \boldsymbol{\psi}^T = \mathbf{I}$ and $E[\hat{Y}_{n,t} \hat{Y}_{n',t}] = E[\hat{\pi}_{n,t} \hat{\pi}_{n',t}] = E[\hat{\pi}_{n,t} \hat{Y}_{n',t}] = E[\hat{C}_{n,t} \hat{C}_{n',t}] = 0$ for $n \neq n'$, i.e., cross-country comovement can only arise from global shocks.

Since consumption in country n' includes foreign goods from country n , there is a *direct* positive demand spillover onto country n . The effect is greater the more country n exports to country n' , as reflected in the matrix of export shares, $\boldsymbol{\psi}^T$. Specifically, production in each country immediately increases in proportion to its exports to country n' via forward linkages, $-(1-b)\boldsymbol{\psi}^T \boldsymbol{\nu}_t > 0$.

However, additional *indirect* knock-on effects also arise through repeated rounds of trade created by import and export substitution, or expenditure switching, involving both backward and forward linkages captured by the terms $-(1-b)b^k(\boldsymbol{\psi}^T \boldsymbol{\varpi})^k \boldsymbol{\psi}^T \boldsymbol{\nu}_t$, $k > 0$, on the right-hand side of (19). It is because of these repeated rounds of expenditure switching that ‘a little trade can go a long way.’

With only two countries, these knock-on effects represent back-and-forth ripples from one-to-one exchanges. When country 1 is hit by an expansionary shock, its demand for goods increases, including for imports from country 2. This effect increases foreign labor demand and, therefore, foreign wages. As wages rise in country 2, demand abroad for country 1 goods increases, thus raising

inflation now depends only on domestic conditions.

production and wages in country 1, leading to a new round of demand for country 2's goods, and so on back and forth.

With $N \geq 3$, the nature of expenditure switching underlying new rounds of trade becomes more involved. As the new round of trade starts, the increases in production and wages (i.e., production costs) in country 1 mean that another country, say country 3, will redirect some of its imports away from country 1 toward other countries, including country 2. This import substitution effect is more pronounced the larger the share of country 3's imports from country 1 in the matrix of import shares, ϖ . The resulting increase in demand for country 2's goods will also be larger the more country 2 exports to country 3, as reflected in the export matrix, ψ^T . These import and export substitution effects explain the term $\psi^T \varpi$ in equation (19). The propagation of the initial stimulative shock in country 1 continues further afield as higher export activity in country 2 raises labor demand and wages in that country. Therefore, its trading partners, for instance country 4, redirect some of their imports from country 2 toward other countries, including back toward country 1. Production, labor demand, and wages then rise anew in country 1, thus generating new demand for foreign goods and a new round of trade, $-(1-b)b^{k+1}(\psi^T \varpi)^{k+1} \psi^T \nu_t > 0$ in the Neumann series, (19), and so on.

As indicated earlier, the scale of these spillovers depends on the trade and labor elasticities, $1 + \varphi$ and $1/\eta$, respectively, through the term $b = \frac{(1+\varphi)\eta}{1+(1+\varphi)\eta}$ in equation (19). The smaller the trade elasticity, $1 + \varphi$, the less sensitive countries are to changes in export prices and the less easily they substitute across trading partners. The greater the labor supply elasticity, $1/\eta$, the less wages (production costs) increase in country n' as demand for its goods rises, thus also reducing the extent of trade substitution across countries. In the limit, as $\eta \rightarrow 0$, $1/\eta \rightarrow \infty$ and $b \rightarrow 0$ so that the knock-on effects from expenditure switching vanish entirely in equation (19). Cross-country comovement then arises only by way of direct pairwise trade.

5.3 Beggar-thy-Neighbor Effects

In the stylized example underlying Proposition 1, demand shocks at home generate positive spillovers abroad, consistent with the VAR evidence in Section 2. This finding runs counter to the beggar-thy-neighbor hypothesis in international finance, where local demand expansions can lead to contractions in trading partner countries. In particular, given an expansionary monetary policy shock at home, the local exchange rate depreciates and expenditures switch from foreign to domestic goods. Corsetti and Pesenti (2001) show formally that the contraction abroad emerges if the demand-switching effect exceeds the more direct overall demand expansion generated by the monetary policy shock.

Those same forces are also present in our model, as shown in the decomposition between direct (aggregate demand) effects and indirect (expenditure switching) effects in equation (19). However, the indirect effects in this analytical example end up adding to rather than subtracting from the direct effects. Here, the local price of traded goods increases in response to a positive local demand

shock, raising the price of goods sold by the home country relative to those of trading partners and encouraging expenditure switching towards foreign goods. As discussed in the context of equation (15), the terms of trade in our model are proportional to $(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{w}}_t + \hat{\mathbf{e}}_t)$ (footnote 14). Therefore, local goods become more expensive when local wages, $\hat{w}_{n,t}$, increase but less expensive when exchange rates, $\hat{e}_{n,t}$, depreciate. Within our analytical example, wage increases exceed the exchange rate depreciation, raising the price of home goods relative to foreign goods. Expenditures therefore switch toward foreign goods and create positive cross-country spillovers.

In the more general framework with roundabout production and financial frictions, such as that estimated in Section 6, the relative impact of demand shocks on exchange rates and local tradable goods prices can flip, with the former exceeding the latter and beggar-thy-neighbor effects dominating. First, with roundabout production, the price of materials is itself sticky, thus making traded goods' prices even stickier in the producer currency. This feature would then mitigate expenditure switching. Second, when financial frictions constrain trade imbalances, trade deficits cannot adjust freely, leading exchange rates to depreciate more steeply in response to local demand shocks.

In Section F.5 of the [Online Appendix](#), we show analytically that in a version of the stylized model under financial autarky, $\tau \rightarrow \infty$, negative spillovers can in fact emerge as beggar-thy-neighbor effects prevail. We summarize this result in the following proposition, proven for the case where trade elasticities are low ($\varphi \rightarrow 0$).

Proposition 2. *Consider the case of financial autarky, $\tau \rightarrow \infty$. Then, given an import share matrix, $\boldsymbol{\varpi}$, $\lim_{\varphi \rightarrow 0} \hat{\mathbf{Y}}_t = -\boldsymbol{\varpi}^{-1} \boldsymbol{\nu}_t$. If $\boldsymbol{\varpi}$ is diagonally dominant ($\varpi_{ii} > 1/2 \forall i$) and every country imports from at least one other country (for each i , $\varpi_{ij} > 0$ for some $j \neq i$), then, in the limit with $\varphi \rightarrow 0$:*

- i) a monetary expansion in some country lowers output in at least one other country (i.e., $\boldsymbol{\varpi}^{-1}$ has negative off-diagonal terms) and*
- ii) some country pairs have negatively correlated output (i.e., the covariance matrix, $E[\hat{\mathbf{Y}}_t \hat{\mathbf{Y}}_t^T]$, has some negative off-diagonal terms).*

Proof. See Section F.5 of the [Online Appendix](#).

In other words, given financial autarky and a low enough trade elasticity ($\varphi \rightarrow 0$), the beggar-thy-neighbor mechanism prevails in at least some country pairs. Financial autarky means that trade must be balanced for each country. When trade is unit elastic ($\varphi \rightarrow 0$), this requires that $\hat{\mathbf{C}}_t = \boldsymbol{\varpi} \hat{\mathbf{Y}}_t \iff \hat{\mathbf{Y}}_t = \boldsymbol{\varpi}^{-1} \hat{\mathbf{C}}_t$, so that the effects of monetary shocks spill over across countries in proportion to the inverse of the import matrix $\boldsymbol{\varpi}^{-1}$. Proposition 2 then states that this inverse generically features negative off-diagonal elements, so that a monetary stimulus in country n , $\nu_{n,t} < 0$, increases output at home but lowers that of its trading partners. Intuitively, a domestic

demand expansion has to be met by a reallocation of global production towards the home country in order to keep trade balanced.¹⁸

In summary, spillovers in our model may be either negative or positive depending on parameter values. The sign of spillovers, therefore, is an empirical question, one that our Bayesian estimation in Section 6 is designed to answer.

5.4 Producer Currency Pricing

In our benchmark framework, our modeling of Calvo (1983) pricing implies less than full pass-through of imported goods prices to consumer prices. However, the location of price stickiness in the production chain is not innocuous. In Section G of the Online Appendix, we consider the case where traded goods prices are also sticky in the currency of origin before the goods are shipped: producer currency pricing (PCP). This stickiness arises through an additional upstream layer of production that itself provides sticky-price inputs to tradable goods firms (Layer 1 of Figure 4). We show that the scale of spillovers, b , in equation (19) now also declines with the degree of PCP (i.e., the stickiness of tradable goods prices). Intuitively, when tradable goods face nominal frictions, their prices become less responsive to domestic shocks. Consequently, PCP dampens the scale of expenditure switching, similar to a low trade elasticity or a high elasticity of labor supply, and by implication the knock-on effects of trade.

Our discussion in Section G of the Online Appendix further underscores that as Layer 2 goods prices become fully flexible, the knock-on effects of trade vanish entirely for *any* level of PCP. Such an environment, with flexible consumer prices but sticky traded goods prices, is closer to conventional NKOE models in which foreign demand shocks affect local output only through the direct effects of trade. Put differently, imperfect pass-through of imported goods prices to consumer prices, consistent with the empirical evidence in Devereux and Yetman (2010), is critical for our findings.

Fully flexible consumer prices eliminate the knock-on effects of trade because with fully flexible consumer prices, the terms of trade no longer react endogenously to the cost of producing tradable goods (wages in the stylized model). Instead, marginal costs become fixed (since $P_{n,t}^Q = P_{n,t} A_{n,t}$ at all dates), and the terms of trade move one-for-one with exchange rates, $(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{e}}_t + \hat{\mathbf{w}}_t) = (\boldsymbol{\varpi}^{-1} - \mathbf{I})\hat{\mathbf{e}}_t$ (equation (13) with $\widehat{\mathbf{m}\mathbf{c}}_t = 0$).¹⁹ Exchange rates, $\hat{\mathbf{e}}_t$, are in turn pinned down by relative consumption between countries (equation (16) with $\tau = 0$). Therefore, the terms of trade, $(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{e}}_t + \hat{\mathbf{w}}_t)$, become divorced from changes in production costs, $\hat{\mathbf{w}}_t$, precluding the expenditure switching that underlies the knock-on effects of trade. Consequently, demand shocks only generate global comovement through direct trade effects, regardless of the degree of PCP.

¹⁸In Section F.5 of the Online Appendix (Proposition 3), we further prove that given a sufficient degree of diagonal dominance, the beggar-thy-neighbor mechanism dominates in every trading partner country of every country.

¹⁹The expression for terms of trade here presumes flexible prices in the production of tradable goods. More generally, we would have terms of trade given by $(\mathbf{I} - \boldsymbol{\varpi})(\hat{\mathbf{e}}_t + \hat{\mathbf{t}}_t)$, where $\hat{\mathbf{t}}_t$ is the real price of inputs to tradables as defined in Section G of the Online Appendix.

Simply put, with fully flexible consumer prices, a little trade no longer goes a long way.²⁰

5.5 Supply vs. Demand Shocks and Consumption vs. Output Comovement

Two additional observations are worth noting with respect to Proposition 1. One addresses the role of supply shocks relative to demand shocks. The other concerns differences in the cross-country comovement of consumption growth relative to output growth.

First, observe that *i.i.d.* shocks to the growth rate of a country's TFP do not appear in the solution described in equations (17) and (18). Supply shocks, therefore, are absent from the key derivations underlying Proposition 1. Similar to demand shocks, local TFP shocks raise the demand for goods at home via higher domestic wages. However, unlike demand shocks, local TFP shocks also raise the supply of goods available at home. The latter mechanism mitigates the role of international trade in meeting the increased demand for goods at home, eliminating it entirely when these shocks are *i.i.d.* In that case, TFP shocks generate cross-country comovement in neither consumption nor output.

Second, Backus, Kehoe, and Kydland (1992) show that IRBC models generally imply cross-country consumption correlations that are higher than those of output, but this implication runs counter to the data. In contrast, in our setting, $E[\hat{C}_{n,t}\hat{C}_{n',t}] = 0$ while $E[\hat{Y}_{n,t}\hat{Y}_{n',t}] > 0$ for any country pair (n, n') . Therefore, cross-country output correlations always exceed their consumption counterpart as in the data. Here, an idiosyncratic increase in consumption in any country raises production in all other countries. In fact, because of multilateral trade, an increase in demand in country n not only induces higher production in all of its trading partners, n' , but also in all of n' 's trading partners, n'' , and so on. Therefore, uncorrelated demand shocks can produce correlated output fluctuations while generating uncorrelated consumption movements across countries.

5.6 Cross-Country Spillovers and Aggregation

While Proposition 1 establishes that, given only country-specific shocks, our model can produce positive pairwise cross-country comovement in output, $E[\hat{Y}_t\hat{Y}_t^T] \geq 0$, inflation, $E[\hat{\pi}_t\hat{\pi}_t^T] \geq 0$, and between output and inflation, $E[\hat{\pi}_t\hat{Y}_t^T] \geq 0$, it does not tell us how the strength of this comovement changes with the number of regions or countries, N . How the strength of comovement varies with N depends primarily on two key features: i) how the structure of the trade matrix changes as one considers an increasing number of countries, and ii) how the structure of shocks changes as the world economy becomes more disaggregated.

To fix ideas, consider two regions, one made up of a large country (interpreted as the U.S.) and

²⁰The model extension with PCP can alternatively be interpreted as one with nominal wage rigidity, similar to that studied by Huo et al. (2024).

the other representing the rest of the world (RoW) with the following trade structure:

$$\varpi = \begin{array}{cc} \text{RoW} & \text{U.S.} \\ \left[\begin{array}{cc} 1 - \zeta + (1 - \iota)\zeta & \iota\zeta \\ \zeta & 1 - \zeta \end{array} \right] & \begin{array}{c} \text{RoW} \\ \text{U.S.} \end{array} \end{array}.$$

In the last row, the U.S. produces a share, $1 - \zeta$, of final goods domestically and imports a share, ζ , from the RoW. In the first row, the RoW produces a share, $1 - \zeta$, of goods domestically, imports a share, $\iota\zeta$, from the U.S., and imports a share, $(1 - \iota)\zeta$, from non-U.S. countries. As we break down the RoW into smaller regions or individual countries, the key assumption is that the U.S. remains a central trading partner of regions making up the RoW (e.g., the E.U., China, etc.). Thus, as N increases, the share of goods, $\iota\zeta$, imported from the U.S. by all countries stays fixed while the import share, $(1 - \iota)\zeta$, is distributed evenly among non-U.S. countries. For arbitrary N , this gives

$$\varpi(N) = \left[\begin{array}{ccc} \overbrace{\begin{array}{cc} 1 - \zeta + \frac{1-\iota}{N-1}\zeta & \cdots & \frac{1-\iota}{N-1}\zeta \\ \vdots & \ddots & \vdots \\ \frac{1-\iota}{N-1}\zeta & \cdots & 1 - \zeta + \frac{1-\iota}{N-1}\zeta \end{array}}^{\text{RoW}} & \begin{array}{c} \text{U.S.} \\ \vdots \\ \iota\zeta \\ 1 - \zeta \end{array} \end{array} \right] \left. \begin{array}{c} \\ \\ \\ \end{array} \right\} \begin{array}{c} \text{RoW} \\ \\ \text{U.S.} \end{array} . \quad (20)$$

In the limit, the trade network embodied in equation (20) approaches a ‘star network’ with the U.S. as the central node. In practice, there may be two or three such nodes in the world trade network.

The other key empirical feature of disaggregation is that as N increases, so does the variance of region-specific shocks. Put another way, when considering the RoW as a single block of countries, country-specific shocks within that block average out, leaving a more prominent role for global factors. As we disaggregate that single block into smaller regions and N increases, these smaller regions’ shocks begin to matter in and of themselves, and compete with global factors.²¹

In what follows, we interpret regions as multi-country aggregates and examine how the analysis changes with the degree of disaggregation. Specifically, we think of the $N - 1$ RoW regions in equation (20) as partitions of $N^* - 1$ actual RoW countries in the world economy (with a total of N^* countries including the U.S.). The structure of monetary policy shocks for each country, $n \in \{1, \dots, N^* - 1, US\}$, is then given by

$$\nu_{n,t} = \sqrt{\varrho}\nu_t^G + \sqrt{1 - \varrho}\tilde{\nu}_{n,t}, \quad (21)$$

where $\varrho < 1$, ν_t^G denotes the part of monetary policy that is global or common across countries and $\tilde{\nu}_{n,t}$ denotes the idiosyncratic component of country n ’s monetary policy. Grouping the RoW

²¹This is analogous to multisector closed economy environments where the variance of sector-specific shocks increases as the number of sectors considered increases, see Foerster, Sarte, and Watson (2011).

Table 1: Parameter Values for Analytical Model

Parameter	Value
φ	Fréchet Parameter (Trade Elasticity Minus One)
η	Inverse Labor Supply Elasticity
ζ	Share of Foreign Produced Consumption
ι	U.S. Share of Trade
ϱ	Contribution of Global Factor to Shock Variance
N^*	Total Number of Countries

countries into $N - 1$ regions gives $r \equiv (N^* - 1)/(N - 1)$ countries per region. Assuming that $r \in \mathbb{Z}$ for simplicity, it follows that the covariance matrix for $\boldsymbol{\nu}_t \equiv (\nu_{1,t}, \dots, \nu_{N-1,t}, \nu_{US,t})'$ satisfies

$$Cov[\nu_{US,t}, \nu_{n,t}] = Cov[\nu_{n,t}, \nu_{n',t}] = \varrho \quad (22)$$

$$Var[\nu_{US,t}] = 1 \quad (23)$$

$$Var[\nu_{n,t}] = \varrho + \frac{1 - \varrho}{r}. \quad (24)$$

The covariance in monetary policy between any region pair is always ϱ irrespective of the number of regions. When $N = N^*$, all countries in the world economy are individually taken into account (i.e., each region contains a single country, $r = 1$), and the variance of monetary policy shocks is 1 in every country. The correlation of shocks across RoW regions is then ϱ . As we aggregate the RoW into broader regions, country-specific shocks within the RoW average out and the resulting shock variance of these broader regions falls towards ϱ . In particular, when the RoW is treated as a single block of countries, $N = 2$, the variance of the RoW shocks is $Var[\nu_{1,t}] = \varrho + \frac{1 - \varrho}{N^* - 1}$, or approximately ϱ since the total number of countries in the world economy, N^* , is large. The correlation of shocks across RoW regions now rises to $\varrho/\sqrt{\varrho^2} = 1$, when N approaches 2. In short, higher levels of aggregation imply more correlated local shocks as the idiosyncratic variation averages out within regions.²²

We solve for the cross-country correlations in output in Proposition 1 using different degrees of disaggregation, N , and using the parameter values listed in Table 1. These parameters are chosen in line with our estimation results in Section 6 and imply $b = 0.8$. To isolate the role of trade, we compute the share of output correlation arising from trade relative to autarky,

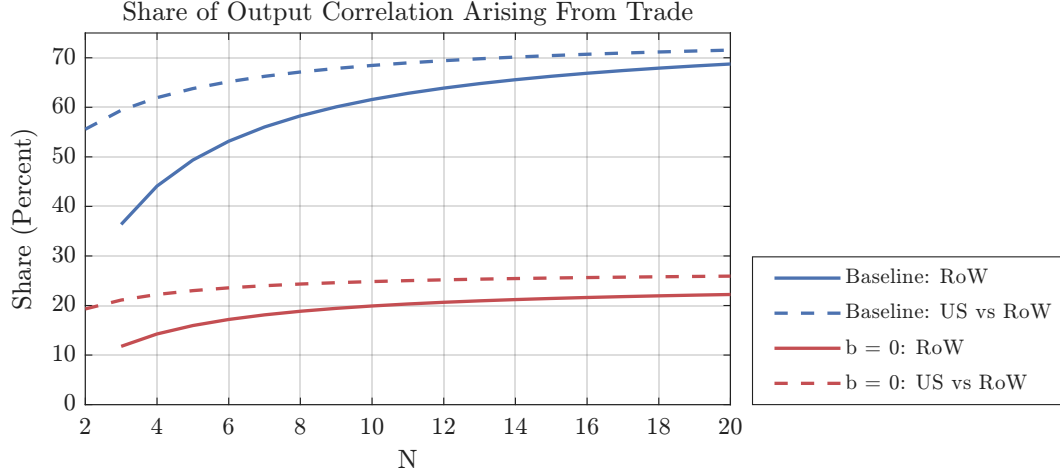
$$1 - \frac{Corr^{aut}(Y_{n,t}, Y_{n',t})}{Corr^{trade}(Y_{n,t}, Y_{n',t})},$$

where $Corr^{trade}$ and $Corr^{aut}$ denote the correlations with and without trade, respectively. We separately present results for the U.S. relative to the RoW, and the RoW countries among themselves.

The results are shown in Figure 5. In our baseline (in blue), the share of output correlation

²²For this exercise, we ignore the divisibility assumption and directly apply the above formulas when defining the covariance matrix of the shocks.

Figure 5: Contribution of Trade to Output Correlation in Analytical Model



arising from trade increases with N . As N increases (dividing the RoW into finer partitions), country-specific shocks become more salient. In autarky, the correlation of output across countries follows that of shocks and declines with N . With trade, country-specific shocks propagate across countries, so that the output correlation declines more slowly. Therefore, the propagation through trade contributes an increasing share of cross-country comovement. This effect levels out as N becomes large since global factors place an upper bound on the role of idiosyncratic shocks. However, the presence of a key trading partner with all other countries (i.e., the U.S.) ensures that comovement from idiosyncratic shocks remains even as disaggregation increases and most off-diagonal elements of the trade matrix become small.²³ Thus, while aggregating the RoW into a single region understates the role of trade, with $N = 5$ we capture 90 percent of the share of the U.S.-RoW correlation.

To highlight the role of cross-country spillovers through the knock-on effects from multilateral trade, we compare these results to the model with $b = 0$, shown by the red lines in Figure 5. Recall that this case arises in the limit when, for example, labor supply is infinitely elastic, trade is perfectly inelastic, or in a variant of the model where PCP is the only form of price stickiness. When $b = 0$, trade contributes much less to cross-country comovement, in accordance with Proposition 1 and equation (19), and in a way that is somewhat invariant with respect to N . Any observed comovement in output is then mostly attributed to global shocks common to all regions. The level difference between the blue and red lines indicates that even with only two regions, $N = 2$, some important knock-on effects remain through the back-and-forth echoes of pairwise trade. This is the key difference with conventional NKOE models. The difference in slopes between the blue and red lines illustrates how the number of countries amplifies the role of these indirect knock-on effects.

²³This finding is analogous to that of aggregate variability in production networks in which one sector serves as a key input supplier to all other sectors. In that case, the contribution of idiosyncratic shocks to aggregate variations has a strictly positive lower bound as N becomes large (Acemoglu, Carvalho, Ozdaglar, and Tahbaz-Salehi, 2012).

6 Quantitative Findings

To study the quantitative implications of our model, we revert to the full setup presented in Section 3 with trade in both intermediate and final goods as well as roundabout production. We then estimate the model using Bayesian methods and consider a set of counterfactuals to quantify the role of trade and other mechanisms for generating observed cross-country comovement.

6.1 Monetary Policy Rule

The monetary authority follows the (log-linearized) Taylor rule from [Smets and Wouters \(2007\)](#):

$$\mathbf{R}_t = \rho \mathbf{R}_{t-1} + (1 - \rho)(\phi_\pi \pi_t + \phi_y \mathbf{y}_t) + \phi_{\Delta y} \Delta \mathbf{y}_t + \boldsymbol{\nu}_t, \quad (25)$$

where $\boldsymbol{\nu}_t$ is a vector of exogenous shocks. To account for the zero lower bound, we follow [Campbell, Fisher, Justiniano, and Melosi \(2017\)](#) and introduce forward-guidance shocks into the model:

$$\boldsymbol{\nu}_t = \sum_{h=0}^H \boldsymbol{\nu}_{t-h}^h. \quad (26)$$

The shock $\boldsymbol{\nu}_{t-h}^h$ is known in period $t - h$ but only affects interest rates in period t . In other words, the nominal interest rate in period t depends on the interest rate in period $t - 1$, contemporaneous inflation and output gap (level and growth rates), a monetary shock that is revealed in period t , and a set of forward-guidance shocks that are known in periods $t - H, \dots, t - 1$ but only realized in period t .

To retain the convenience of a log-linear model for estimation, [Campbell et al. \(2017\)](#) use forward rates as observables. The zero lower bound is not binding for the forward rate and the forward-guidance shocks provide the flexibility for the model to fit the data. As discussed below, we follow a similar strategy, but replace the forward rates with one-year government bond yields, which also exhibit variation even when policy rates are constrained by the zero lower bound. The one-year maturity leads us to choose $H = 3$.

6.2 Shock Structure

Our model includes four types of shocks: TFP growth shocks, $g_{n,t}$, markup shocks, $\mu_{n,t}$, monetary policy (including forward-guidance) shocks, $\boldsymbol{\nu}_{n,t}^h$, and shocks to portfolio costs, $\xi_{n,t}$. The first three are standard in the NK literature and the last one allows us to match the behavior of real exchange rates, as discussed in Section 3.

To allow for common shocks across countries, we consider a factor structure for the first three

shocks.²⁴ In particular, for a generic shock $x_{n,t}$, $x \in \{g, \mu, \nu^h\}$:

$$x_{n,t} = \lambda_{x,n} x_t^G + \tilde{x}_{n,t}, \quad (27)$$

$$x_t^G = \rho_x^G x_{t-1}^G + \sigma_x^G \epsilon_t^G, \quad (28)$$

$$\tilde{x}_{n,t} = \tilde{\rho}_{x,n} \tilde{x}_{n,t-1} + \tilde{\sigma}_{x,n} \tilde{\epsilon}_{n,t}. \quad (29)$$

Thus, each shock consists of a global factor, x_t^G , and an idiosyncratic country component, $\tilde{x}_{n,t}$, both of which follow AR(1) processes. We follow [Campbell et al. \(2017\)](#) and assume that $\rho_\nu^G = \tilde{\rho}_{\nu,n} = 0$, but allow the persistence to be freely estimated for the TFP growth and markup shocks. Since $\lambda_{x,n}$ and σ_x^G cannot be separately identified, we normalize $\sigma_x^G = 1/100$. The sign of $\lambda_{x,n}$ is identified through its prior.²⁵ With this factor structure, comovement across countries arises from both common global shocks and spillovers from country-specific shocks through trade. Note that trade also affects the propagation of global shocks.

6.3 Data and Calibrated Parameters

We use data for the U.S., China, the E.U., Japan, and Canada over the period 2004Q3 through 2019Q4. The first four countries capture the world's largest economies, while Canada is included as a major trading partner of the U.S. The sample period allows us to have a balanced sample and captures most of the period following China's integration in the World Trade Organization.²⁶ Details of the data sources and construction are in Section H of the [Online Appendix](#).

To calibrate the matrices of import shares, ϖ^k , $k \in \{c, m\}$, we set their diagonal elements to the shares of domestic goods in absorption of final goods or of intermediate goods (including capital goods) for each country. The off-diagonal elements, $\varpi_{nn'}^k$, $k \in \{c, m\}$, are proportional to import shares of country n from country n' for every country pair (n, n') , scaled so that each row sums to one (since the model does not encompass the entire world economy). The import trade matrices, reported in Table 2, show that countries mostly purchase both intermediate and final goods from themselves.

We assume that all countries have the same steady-state productivity growth rate, which we calibrate to match average real GDP growth in Canada, the E.U., Japan, and the U.S.²⁷ We additionally calibrate the share of value added, γ , to 0.5, consistent with the share of materials in

²⁴Shocks to portfolio costs only matter to the degree that they are country-specific. Global shocks in international financial markets cancel out in equation (16) unless they impact each country differently.

²⁵[Baumeister and Hamilton \(2015\)](#) and [Matthes and Schwartzman \(2025\)](#) similarly use a prior for identification, but do so in the context of shock identification in vector autoregressions. Unlike those applications, the sign of $\lambda_{x,n}$ here is a normalization without economic content, making the identification scheme innocuous.

²⁶Extending the sample substantially further back would have required not only inferring the shocks with incomplete data, but also having to take a stand on sharp shifts in trade patterns (owing to China joining the World Trade Organization) and the formation of the European monetary union.

²⁷Thus, high GDP growth in China may imply that it deviates relatively more from the world steady-state growth rate. Section H.5 of the [Online Appendix](#) presents estimation results when we allow for different steady-state productivity growth rates across countries.

Table 2: Calibrated Parameters

Panel A: Final Goods Import Trade Matrix (ϖ^c)

	Canada	China	E.U.	Japan	U.S.
Canada	0.875	0.024	0.017	0.006	0.079
China	0.000	0.975	0.011	0.008	0.005
E.U.	0.002	0.069	0.884	0.014	0.032
Japan	0.000	0.023	0.009	0.963	0.005
U.S.	0.010	0.017	0.010	0.005	0.958

Panel B: Intermediate Goods Import Trade Matrix (ϖ^m)

	Canada	China	E.U.	Japan	U.S.
Canada	0.759	0.031	0.025	0.011	0.174
China	0.009	0.725	0.088	0.119	0.059
E.U.	0.006	0.103	0.753	0.039	0.099
Japan	0.002	0.047	0.017	0.910	0.025
U.S.	0.020	0.034	0.027	0.014	0.905

Notes: Calculations are described in Section H.1 of the [Online Appendix](#). Import shares are averages over 2004–2019 of annual import shares, using data from the World Integrated Trade Solution compiled by the World Bank and World Bank national accounts. Diagonal elements equal one minus total imports relative to absorption of final (Panel A) or intermediate (Panel B) goods. Off-diagonal elements are proportional to import shares from respective countries, scaled so that each row sums to one.

gross output across countries. Finally, we calibrate steady-state values for inflation, employment, and the wage bill based on time series means for each country over the sample period. See Section H.1 of the [Online Appendix](#) for details.

6.4 Estimation and Counterfactuals

We estimate the remaining parameters of the model using Bayesian methods. The estimation uses observed data for per capita GDP growth, inflation, and nominal exchange rates in the measurement equations for each country.²⁸ The first two are standard observables in the estimation of closed-economy NK models and exchange rates are included to account for their role in determining trade patterns and variations in cross-country inflation. In addition, we use one-year government bond yields for all countries except China. The one-year government bond yields replace the forward rates used by [Campbell et al. \(2017\)](#), as these forward rates are not available for Japan ([Kubota and Shintani, 2022](#)). This is also consistent with the VAR in Section 2. Similar to forward rates, the one-year rates show variation even when policy rates are constrained by the zero lower bound. We use the interbank rate for China since the zero lower bound did not bind there during the sample period and due to the lack of a liquid market for government bonds ([Adrian, 2019](#)).

Model parameter priors are summarized in Table H.2 in Section H.2 of the [Online Appendix](#).

²⁸Our measurement equation connects GDP to value added in the model. The distinction from gross output is essential because goods are in part used as materials.

The prior for the price elasticity of trade, $1 + \varphi^k$, $k \in \{c, m\}$, covers the range of estimates in the literature.²⁹ We use a relatively flat prior for the degree of adjustment costs in global financial markets, τ . Priors for the factor loadings are chosen so that global factors account for approximately half of the variation of each shock at the prior mode. As mentioned earlier, these priors also help normalize the sign of the factor loadings by placing a small probability that factor loadings for a given shock are negative for a majority of the shock realizations. The remaining priors are comparable to the existing literature (e.g., [An and Schorfheide, 2007](#); [Smets and Wouters, 2007](#)).

Accounting for international linkages within a multi-country sticky-price framework raises two computational challenges relative to existing work. First, with five countries, there are 121 parameters to be estimated and 107 equations characterizing the equilibrium even though we abstract from many common features in medium-scale NK models (e.g., habit formation and price indexation).³⁰ Second, the steady state needs to be solved numerically, as described in Section 3.6, which increases the time taken to compute the likelihood by 20 percent relative to steady-state calculations in prototypical NK models.

To address these challenges, we estimate the model using the adaptive sequential Monte Carlo (SMC) algorithm described in [Cai et al. \(2021\)](#). Relative to standard Markov chain Monte Carlo methods, SMC is more robust to irregular posteriors and improves computational efficiency by allowing for parallelization.³¹ Details can be found in Section H.4 of the [Online Appendix](#).

To study the quantitative role of trade in our estimated model, we use the Kalman smoother to obtain the sequence of shocks implied by the model with parameters at their posterior mean. We then compute the implied counterfactual cross-country correlations for alternative parameterizations of the model, given the same sequence of shocks.

6.5 Posterior Estimates and Model Validation

We find a price elasticity of trade for final goods and intermediates, $1 + \varphi^k$, $k \in \{c, m\}$, of 1.46 and 1.22, respectively, consistent with estimates typically found in the international macroeconomics literature for the price elasticity of trade (e.g., [Reinert and Roland-Holst, 1992](#); [Blonigen and Wilson, 1999](#); [Drozd, Kolbin, and Nosal, 2021](#)). The aggregate data thus favor a lower elasticity than is typically obtained in the trade literature. As explained in Section 5, the larger elasticities from the trade literature would strengthen the role of trade in our model all else equal.

The posterior mean for τ of 0.03 implies relatively low endogenous portfolio costs. In particular, the model at its posterior mean implies that UIP deviations between the U.S. and Canada, China, the E.U., and Japan are primarily driven by (differences in) exogenous financial shocks, $d\xi_t - \mathbf{1}d\xi_{1,t}$,

²⁹Microeconomic estimates of trade elasticities center around 4 but are as large as 17; see Footnote 44 in [Caliendo and Parro \(2015\)](#) and Section 4.2 in [Head and Mayer \(2014\)](#) for comprehensive summaries of estimates. Macroeconomic estimates tend to center around 2.

³⁰In comparison, the medium-scale NK model in [Smets and Wouters \(2007\)](#) has 36 parameters and 32 equations.

³¹See Section H.4 of the [Online Appendix](#) for further discussion of how this would compare with standard Markov Chain Monte Carlo approaches.

Table 3: Moments in the Data and Estimated Model

Moment	Data	Baseline	No Trade (Re-estimated)	No Trade (Counterfactual)
Targeted				
1. autocorr(Δe_t)	0.35	0.35	0.35	0.59
2. std(Δe_t)	3.61	3.61	3.61	3.77
Untargeted				
3. std(ΔC_t)	0.66	1.13	0.74	1.05
4. corr($\Delta C_t, \Delta Y_t$)	0.56	0.69	1.00	1.00
5. corr($\Delta C_t - \Delta C_{US,t}, \Delta e_t$)	0.19	0.13	-0.03	0.24
6. Fama Coefficient	-1.10	-1.60	-0.79	0.62

Notes: All moments are averaged across countries.

with standard deviations that are, respectively, 3.9, 3.0, 4.7, and 10.1 times as large as that of the endogenous portfolio costs governed by τ (see Section F.3 of the [Online Appendix](#)). The estimate is far in the left tail of our prior, with a *c.d.f.* of less than 10^{-5} , suggesting that the data heavily favor such a small value.

Section H.5 of the [Online Appendix](#) presents the full set of posterior estimates and shows that key structural parameters such as the inverse intertemporal elasticity of substitution, σ_n , inverse labor supply elasticity, η_n , and Calvo price-setting parameter, θ_n , lie around the ranges estimated in closed-economy settings.

Table 3 shows that the estimated model is able to match several key empirical moments relatively well. For each moment, we compare our baseline model to the counterfactual without trade as well as a re-estimated version of the model without trade.³²

Rows 1 and 2 show the autocorrelation and standard deviation of real exchange rate changes. The Bayesian estimation matches these by construction, since we use data on nominal exchange rates and inflation. In the counterfactual without trade, exchange rate changes become substantially more persistent relative to the data.

Since we do not use consumption data in our estimation, we consider two untargeted domestic business cycle moments that involve consumption in rows 3 and 4—the standard deviation of consumption growth and the correlation between consumption and output growth. The estimated model overshoots both moments somewhat, though adding missing features such as investment would naturally improve the model fit along these dimensions. In the absence of trade, consumption and output must move one-for-one, implying $\text{corr}(\Delta C_t, \Delta Y_t) = 1$. Trade breaks this perfect correlation and brings us substantially closer to the empirical correlation of 0.56.

Rows 5 and 6 consider correlations with the exchange rate. Row 5 reexamines the [Backus and Smith \(1993\)](#) puzzle. Our model not only generates a positive correlation between relative consumption and exchange rates, but is able to explain about 70 percent of the empirical correlation.

³²We can do these comparisons since exchange rate moments remain well-defined in the model without trade through financial asset allocation decisions captured in equation (16).

In contrast, the model without trade, when re-estimated, generates a negative correlation, consistent with the findings of [Backus and Smith \(1993\)](#) for other international models. This occurs despite the model matching exchange rates by construction and having the financial shocks that help drive a wedge between relative consumption and exchange rates.

Row 6 considers the coefficient from a regression of nominal exchange rate depreciation on interest rate differentials, proposed by [Fama \(1984\)](#) as a test of the UIP condition. Since the estimation only uses short-term interest rates for China, this serves as a further test of model fit. We find a coefficient of -1.60 , which matches the sign but somewhat overshoots in magnitude relative to the data. We additionally note that the untargeted interest rates in our model have a relatively high average correlation of 0.91 with their empirical counterparts.

6.6 Multilateral Trade and Comovement Across Countries

We now present our main quantitative findings—the roles of various model ingredients for the cross-country comovement. These are summarized in Table 4.³³

Role of Trade: In keeping with Proposition 1, we find that trade plays a substantial role in driving cross-country correlations. By construction, the baseline model matches the (average pairwise) cross-country correlations in GDP growth, inflation, and between GDP growth and inflation. Once we shut down trade in line A4, the cross-country correlation of GDP growth falls sharply from 0.39 to 0.07, the cross-country correlation of inflation falls from 0.45 to 0.34, and the GDP growth-inflation cross-country correlation falls from 0.25 to 0.14. The larger role of trade in driving GDP growth correlations relative to inflation is consistent with the stylized model version of Section 5. Recall in equation (18) that the cross-country correlations in inflation were attenuated relative to GDP growth by exchange rate adjustments and markup shocks.

The last column of line A2 in Table 4 confirms quantitatively the intuition in Proposition 1 with respect to the Backus-Kehoe-Kydland puzzle. [Backus et al. \(1992\)](#) observe that IRBC models commonly imply that consumption growth is more correlated across countries than output growth despite the opposite being true in the data. For our sample of countries, the corresponding average pairwise correlations are 0.39 for output growth and 0.18 for consumption growth. Despite matching the observed GDP growth cross-country correlations by construction, our baseline model with nominal rigidities and multilateral trade yields an (average pairwise) cross-country consumption growth correlation of close to 0, lower than that of output growth, as an untargeted moment. The intuition for this result carries over from the special case in Section 5. Even with uncorrelated consumption across countries, direct demand spillovers, amplified through the knock-on effects of multilateral trade, imply positive cross-country comovement in output growth. In contrast, when we re-estimate the model without trade (line A3), the average cross-country correlation of consumption

³³Section H.5 of the [Online Appendix](#) presents results when we use the same model parameters but omit the Great Recession when computing the cross-country correlations.

Table 4: Mean Cross-Country Correlations

Panel A: Five Country				
Model	Mean Cross-Country Correlation			
	GDP Growth	Inflation	GDP Growth– Inflation	Consumption Growth
<u>Benchmarks</u>				
A1. Data	0.39	0.45	0.25	0.18
A2. Baseline	0.39	0.45	0.25	−0.03
A3. No Trade (Re-estimated)	0.39	0.45	0.25	0.39
<u>Role of Trade</u>				
A4. No Trade (Counterfactual)	0.07	0.34	0.14	0.07
A5. Infinite Labor Elasticity ($\eta = 0$)	−0.04	0.11	0.05	−0.06
A6. Financial Autarky ($\tau = 10^6$)	−0.12	0.11	−0.01	0.14
<u>Role of Country-Specific Shocks</u>				
A7. Monetary Shocks Only	0.39	−0.00	0.11	−0.07
A8. TFP and Markup Shocks Only	0.01	0.22	−0.04	−0.07
A9. Financial Shocks Only	−0.09	−0.05	−0.09	−0.14
<u>Alternative Mechanisms</u>				
A10. Flexible Price, Financial Autarky, Country-Specific TFP Shocks Only	−0.00	−0.10	−0.06	−0.00
A11. No Materials ($1 - \gamma = 0$)	0.31	0.44	0.23	0.11
A12. Symmetric Monetary Policy	0.39	0.40	0.22	−0.02
Panel B: Two Country				
Model	Mean Cross-Country Correlation			
	GDP Growth	Inflation	GDP Growth– Inflation	Consumption Growth
B1. Data	0.56	0.72	0.35	0.49
B2. Baseline	0.56	0.72	0.35	0.63
B3. No Trade (Counterfactual)	0.65	0.72	0.37	0.65

Notes: All correlations are averaged across country pairs.

growth becomes 2.2 times that of the data. In the absence of trade, consumption growth moves one-for-one with output growth.

Finally, Panel B of Table 4 shows that these results do depend on the presence of multiple countries. In particular, we re-estimate the model considering only two regions—the U.S. and the Rest of the World (formed by aggregating Canada, China, E.U., and Japan)—and repeat the exercise above. Consistent with the intuition provided in Section 5, cross-country correlations increase notably as country-specific shocks average out. Moreover, we find that shutting down trade now increases the cross-country correlations slightly. Though consistent with the illustration in Section 5, these results are far more dramatic. The differences arise in part because the five- and two-country environments differ not only in the mechanics of the model but also in parameter estimates. In particular, unlike Section 5 where we kept parameters constant as we changed the

number of regions, here we re-estimate the model and allow for different parameter values. In order to match the empirical comovement, the likelihood then favors parameter values that assign a greater role to global shocks, thus further reducing the estimated role of trade.

Key Mechanisms: Equation (19) suggests that the indirect network effects of trade constitute a key mechanism underlying cross-country comovement. To assess these effects quantitatively, we consider a counterfactual with an infinite labor elasticity ($\eta = 0$). In the analytical model, this implies $b = 0$ and shuts down all indirect effects in equation (19). While the estimated model does not present a similarly clean expression, it remains true that a larger labor elasticity reduces the response of wages to demand shocks. This lowers the degree of trade substitution among countries and dampens indirect cross-country spillovers. Line A5 of Table 4 shows that cross-country comovement indeed declines dramatically, with the cross-country correlation of GDP growth even turning slightly negative.

As illustrated in Proposition 2, the role of capital markets is a key determinant of the direction of expenditure switching. Recall that with $\tau \rightarrow \infty$, the proposition highlighted a case where the beggar-thy-neighbor mechanism prevails and cross-country comovement can become negative. To study this effect quantitatively, we set $\tau = 10^6$ in our baseline model in line A6. Consistent with the analytical results, cross-country GDP growth correlations become negative. Moreover, cross-country correlations of inflation fall markedly, as do those between GDP growth and inflation. In particular, all the off-diagonal elements of both $(\varpi^m)^{-1}$ and $(\varpi^c)^{-1}$ are zero or negative (see Table H.1 in Section H.1 of the [Online Appendix](#)), consistent with Proposition 2.

While Propositions 1 and 2 provided intuition, these quantitative counterfactuals nevertheless make clear that the role of trade implied by the model is parameter-dependent. Our estimation allows the data to inform not only the relative volatility of global and country-specific shocks, but also key elasticities and frictions in the environment. The likelihood’s ability to distinguish these features is governed by how the model disciplines comovement from country-specific shocks conditional on particular parameter values. For example, in the analytical model, equation (19) shows that given b , the trade matrices, ϖ and ψ^T , pin down the comovement that arises from country-specific monetary shocks. Equation (18) similarly restricts how much inflation can simultaneously comove for given parameter values.

Role of Different Shocks: Lines A7 to A9 of Table 4 unpack the contribution of different shocks. To isolate the role of trade, we include only country-specific shocks in these counterfactuals.

The results further emphasize the role of demand in our model. In particular, line A7 shows that country-specific monetary shocks on their own generate the comovement in GDP growth observed in the data, with an average of 0.39. In addition, monetary shocks are able to generate almost 1/2 of the comovement between GDP growth and inflation observed across countries. The cross-country correlation of inflation falls markedly when driven solely by country-specific monetary shocks, to

around 0. Our analytical model highlighted that with financial flows, exchange rate movements counteract spillovers to inflation. Moreover, in our quantitative model, the domestic monetary policy rule implies that interest rates rise in response to an expansionary foreign monetary shock, further dampening (and potentially even reversing) the response of domestic inflation.

Line A8 indicates that country-specific supply (i.e., TFP and markup) shocks alone have trouble reproducing the comovement observed in the data. The cross-country correlation of GDP growth, and that between GDP growth and inflation, both fall to close to zero. Nevertheless, the cross-country correlation of inflation remains notably positive at 0.22. A key difference from our analytical model, where each of these correlations would be zero, is that interest rates in the quantitative model respond to inflationary shocks through the monetary policy rule. Thus, in response to a positive markup shock that raises inflation in country n , the domestic monetary authority raises interest rates to bring inflation closer to target. However, this policy move lowers demand in country n and, through trade, in other countries $n' \neq n$. Consequently, interest rates fall in other countries, n' , according to their monetary policy rules, which in turn places upward pressure on n' 's inflation, thus creating positive comovement in inflation between countries n and n' .

Finally, we find that financial shocks, $\xi_{n,t}$, generate negative comovement across countries. In particular, differences in financial shock realizations across countries drive a wedge in the [Backus and Smith \(1993\)](#) condition, (16). Therefore, financial shocks in a country drive its consumption, and through that output, in the opposite direction from their foreign counterparts.

6.7 Alternative Mechanisms

Our model includes other mechanisms that also generate cross-country comovement. We now study the quantitative importance of these.

Demand Shocks and Sticky Prices vs. Supply Shocks and Flexible Prices: First, we consider a model with flexible prices ($\theta_n^k = 10^{-6}$, $k \in \{c, m\}$), financial autarky ($\tau = 10^6$), and driven by country-specific TFP shocks only. This configuration mirrors the main setup of [Huo et al. \(2024\)](#), but without their detailed modeling of sectoral linkages. Line A10 shows that in that case, all cross-country correlations fall steeply relative to the baseline. The cross-country correlation of GDP growth falls to around 0, echoing the finding in [Huo et al. \(2024\)](#) that with financial autarky and TFP shocks only, global shocks play an important role in matching the observed cross-country comovement in output growth.

Our analysis points to three key differences from our baseline to explain these results. First, contrary to demand shocks, positive local TFP shocks increase the supply of goods available at home and, therefore, mitigate the role of international trade in meeting domestic demand. Second, under financial autarky, countries can no longer run trade surpluses or deficits. As countries trade mostly with themselves, trade patterns become minimally affected by disturbances and result in lower comovement across countries. Finally, with TFP shocks as the sole exogenous drivers and

flexible prices, local shocks give rise to higher domestic inflation and a stronger interest rate response under the maintained monetary policy rules. These higher rates then attenuate the effects of the initial shocks.

Roundabout Production: As in [Auer, Levchenko, and Sauré \(2019\)](#), [Afrouzi and Bhattarai \(2023\)](#), and [Devereux, Gente, and Yu \(2023\)](#), our results are partly driven by the feedback effects from input-output relationships stemming from roundabout production. This feature by itself generates cross-country comovement in that foreign shocks not only affect domestic consumption but also feed back into the domestic production of traded goods. In addition, because of roundabout production, the input cost of traded goods inherits nominal rigidities from sticky materials prices.

To assess the importance of these mechanisms, we consider a counterfactual in which we set the share of materials in gross output, $1 - \gamma$, to zero. The production of tradables then depends only on local labor. Line A11 in Table 4 shows that removing roundabout production from our model reduces the cross-country comovement in GDP growth by about 20 percent, that in inflation by only 4 percent, and the comovement between GDP growth and inflation by 11 percent. While these effects highlight the quantitative importance of roundabout production, they are nevertheless significantly smaller than the overall effects of trade captured in line A4.

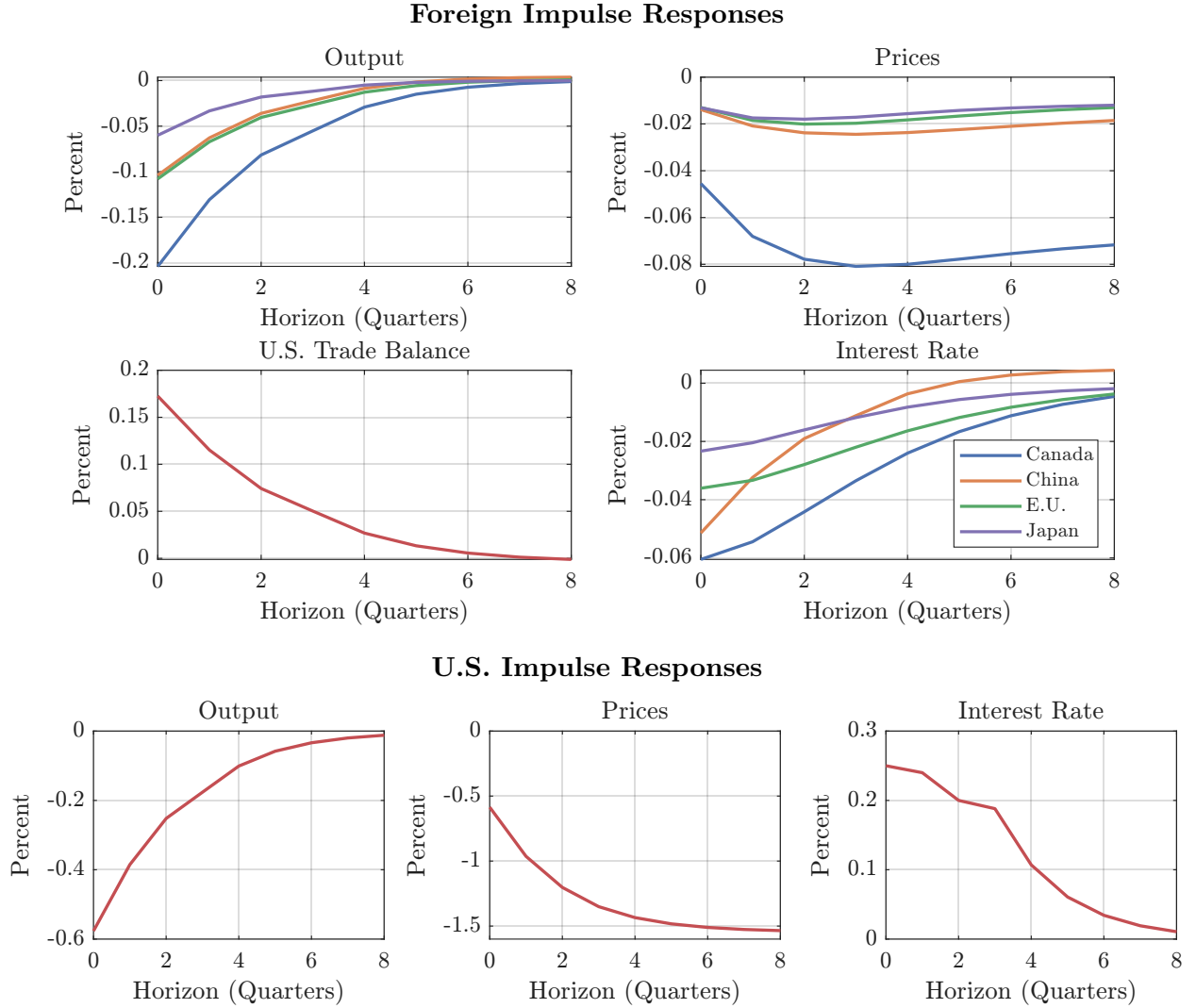
Asymmetric Monetary Policy: Monetary policy also matters for the propagation of shocks by responding to local prices and quantities while influencing exchange rate fluctuations (e.g., [Obstfeld and Rogoff, 2002](#); [Corsetti, Dedola, and Leduc, 2010](#)). Consequently, the asymmetry of monetary policy rules across countries in our estimation is another mechanism that can meaningfully affect comovement across countries.

In line A12 of Table 4, we set the monetary policy coefficients in each country to be the mean estimate across countries. With these symmetric monetary policy rules, we find that the average cross-country output correlation is essentially unaffected. The average cross-country correlation of inflation falls by 12 percent and the average cross-country correlation between GDP growth and inflation falls by 13 percent. Put simply, while the asymmetry in monetary policy can explain a share of the role of trade for cross-country correlations in inflation, it is not the primary mechanism driving our results.

6.8 Impulse Responses to U.S. Monetary Policy Shocks

We close our quantitative discussion by considering how each country responds to a contractionary U.S. monetary policy shock in the baseline model. For comparison with the VAR impulse responses in Section 2, we consider the combination of monetary shocks (including forward-guidance shocks) that, at horizon zero, generates a path for nominal interest rates that most closely matches that in Figure 3 (in terms of least squares). This ensures that the path of interest rates, while a surprise at horizon zero, is fully anticipated thereafter.

Figure 6: Responses to U.S. Monetary Policy Shock



Our baseline model is able to replicate the key qualitative features of the VAR responses. First, foreign output and inflation fall in response to the contractionary U.S. monetary shock, albeit by a smaller magnitude than documented in the VAR. The model responses are mitigated in part by foreign countries lowering their interest rates according to their respective monetary policy rules. Second, despite not using trade data in our estimation, the U.S. trade balance increases, matching the positive response in the export-import ratio in Section 2. This mechanism also surfaces in the stylized model version of Section 5. In that example, the contractionary monetary shock reduced demand in the U.S. without a comparable reduction in output. Consequently, in order for markets to clear, foreign countries consumed a larger share of U.S. and world production, thereby increasing the share of U.S. exports relative to imports.³⁴

³⁴For tractability and transparency, our framework abstracts from many features that medium-scale NK models often incorporate to match the exact VAR impulse responses of domestic variables in terms of their shape and

7 Conclusion

Despite many countries purchasing goods and services largely from themselves, there exists substantial comovement across countries in output growth, inflation, and between output growth and inflation. This paper presents a model with nominal rigidities and multilateral trade that reconciles these facts from country-specific shocks. Sizable comovement arises because domestic variables respond to foreign disturbances through both direct effects and knock-on effects from the network structure of trade. Our framework further helps resolve the Backus-Kehoe-Kydland puzzle and produces cross-country output correlations that exceed those of consumption. Quantitatively, our Bayesian estimation finds that absent trade, the average pairwise correlation across countries of output growth falls by 80 percent, that of inflation by 25 percent, and that between output growth and inflation by 45 percent.

magnitudes. In addition, our VAR results encompass a longer sample period and a larger panel of non-U.S. countries. The data sample used to estimate the baseline model allows for a balanced panel and keeps estimation feasible while being sufficient to illustrate the quantitative implications of our model.

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