Global Flight to Safety, Business Cycles, and the Dollar*

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Abstract

We estimate a two-country DSGE model with macroeconomic and financial data for the U.S. and the rest of the world. The model features time variation in agents' preference for safe bonds with a global flight-to-safety (GFS) component biased toward dollar-denominated safe bonds. Our estimation produces two main findings. First, GFS shocks are the most important driver of international business cycles. Second, GFS shocks contribute to the resolution of exchange rate puzzles. Movements in the dollar are largely accounted for by the GFS and other fundamental shocks, whereas pure deviations from uncovered interest rate parity play a more limited role.

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1 Introduction

The connection between exchange rates and international business cycles is a central topic in international macroeconomics. A large literature on exchange rate puzzles has documented that economic models fail to provide a unified account of economic and financial fluctuations across countries and empirically realistic properties of exchange rates. Against this backdrop, we introduce a time-varying global preference for safe assets, which we refer to as "global flight-to-safety" (henceforth, GFS) shocks, into an otherwise standard medium scale DSGE model and discipline its parameterization via Bayesian likelihood estimation. Our estimates indicate that the global flight-to-safety shocks are the main driver of international business cycles, generate correlation in economic activity across countries, and contribute to the resolution of exchange rate puzzles. Once these shocks are considered, exchange rate variations are largely accounted for by fundamentals.

Using Bayesian methods, we fit a two-country general equilibrium model to a standard set of macroeconomic and financial variables for the U.S. and the rest of the world over the period 1992-2019. We include a set of shocks, nominal and real rigidities, and financial frictions commonly adopted in closed-economy estimated DSGE models, such as those in Christiano, Eichenbaum, and Evans (2005), Smets and Wouters (2007), Justiniano, Primiceri, and Tambalotti (2010), and Christiano, Motto, and Rostagno (2014). A key new feature of our model is time variation in agents' preference for safe bonds, by which we aim to capture global flights to safety. We allow for a component of GFS shocks to be common across countries, which captures shifts in global risk aversion, and for these shocks to be biased toward safe assets denominated in dollars. Importantly, we do not impose ex-ante that contractionary GFS shocks cause the dollar to appreciate; rather, we make inferences from the data about the parameter governing the correlation between global flight to safety and the dollar.

Our estimation provides two main findings. First, GFS shocks are the main driver of fluctuations in global economic activity. These shocks explain 30 percent of the variation in world GDP growth, far more than any other shock category, and are also important drivers of fluctuations in the dollar and credit spreads. In addition, GFS shocks generate cross-country comovement in economic activity and financial conditions, as measured by credit spreads. Lastly, GFS shocks induce a high correlation between credit spreads and the dollar, in line with the empirical evidence. In particular, an adverse GFS shock lowers global GDP and inflation, widens global corporate credit spreads, and appreciates the dollar. This result relies on our estimation strongly preferring GFS shocks that are indeed dollar-biased, pointing to the safety role of dollar-denominated, risk-free assets in periods of financial and economic stress. Moreover, the empirical fit of the model, measured in terms of marginal likelihood statistics, overwhelmingly improves when the GFS shock is included, relative to specifications that consider global components in other shocks.

Our second finding is that in our estimated theoretical model, movements of the dollar are largely explained by fundamental shocks. In other words, the dollar is no longer disconnected from fundamentals (Itskhoki and Mukhin, 2021), and exchange rate puzzles are largely accounted for within the structure of the model. Estimated shocks to the uncovered interest parity (UIP) condition, which have been commonly found to be the main drivers of exchange rate fluctuations in the existing literature, explain only around a third of dollar fluctuations and have no bearing for macroeconomic and financial variables.

We then use our estimated model to decompose historical movements in the dollar and to assess its forecasting performance. First, we study two episodes of large dollar appreciation, one during the Global Financial Crisis of 2008-2010 and one when the U.S. policy rate exited the zero lower bound in 2014. We find that fundamental factors (captured by the interest rate differentials and the GFS shock) play a central role in accounting for the sharp dollar appreciation in both episodes. In contrast, our estimated model assigns virtually no role for "non-fundamental" deviations from UIP. Second, we show that our estimated model delivers in-sample forecasts of the nominal exchange rate that perform better than random walk statistical models, a classic benchmark, at horizons longer than a year. This empirical validation of our approach is important in light of the well-known difficulties that economic models have in competing with random walk models of the exchange rate (Meese and Rogoff, 1983; Rossi, 2013).

Literature Review. There is a large literature on the source of business cycle fluctuations. Recent advances in estimated DSGE models include Smets and Wouters (2007), Justiniano et al. (2010), and Christiano et al. (2014). These studies have identified driving forces of business cycles within closed-economy setups. Following the seminal contribution of Backus et al. (1994), several authors have studied the international transmission of business cycles within calibrated models, focusing on a limited number of country-specific disturbances. Examples of estimated multi-country models include Lubik and Schorfheide (2005), Rabanal and Tuesta (2010), Bodenstein, Guerrieri, and Kilian (2012), and Eichenbaum, Johannsen, and Rebelo (2021). Motivated by a growing literature pointing to the safety and liquidity services provided by dollar-denominated safe assets (Jiang et al., 2021b; Kekre and Lenel, 2024b; Jiang et al., 2021a), we provide evidence in favor of a global source of business cycle fluctuations that is tightly linked to the special role of the dollar as a safe asset. In this respect, our paper is also related to recent work that argues that a global financial cycle driven largely by U.S. financial developments plays an important role in shaping real economic fundamentals in individual economies, examples of which include Miranda-Agrippino and Rey (2020), Miranda-Agrippino and Rey (2022), and Di Giovanni et al. (2022). Unlike these authors, however, we do not find that U.S.-specific shocks have large macroeconomic spillovers on the foreign economy aggregate. Our statistical inference strongly points toward the important role of a global flight-to-safety shock that describes episodes of global economic slowdowns as associated with tight financial conditions and dollar appreciation.

Our work also contributes to the very extensive literature the exchange rate puzzles. Classic references include 1) Meese and Rogoff (1983), who first documented that a simple random walk statistical model has a better out-of-sample forecast performance than economic models (see also Engel and West (2005) and Rossi (2013)); 2) Backus and Smith (1993), who showed that the international risk-sharing conditions requiring relatively higher consumption in countries with lower relative prices is violated in the data (see also Kollmann (1995) and Corsetti et al. (2008)); 3) Chari et al. (2002), who document that monetary models cannot account for the volatility and persistence of the real exchange rate. Obstfeld and Rogoff (2000) provide a useful review of the literature.

To address these puzzles, an influential recent literature has highlighted the role of "non-fundamental" drivers of exchange rates, such as financial shocks, noise traders, portfolio costs, or other frictions in international financial markets Gabaix and Maggiori (2015); Itskhoki and Mukhin (2021); Maggiori (2022); Du and Schreger (2022). Our main contribution is to show that the inclusion of a global source of business cycles that captures time variation in preferences for dollar-denominated risk-free bonds in a medium-scale, multi-country DSGE model goes a long way in accounting for exchange rate puzzles. Importantly, our estimation assigns a limited role to non-fundamental drivers (i.e., pure deviations from uncovered interest parity) as a source of the exchange rate fluctuations, similar to the conclusions in Fukui et al. (2023), Kekre and Lenel (2024a), and Bodenstein et al. (2024).[1] The use of an estimated DSGE framework complements recent work by Kekre and Lenel (2024b), who also study the implications of flight to safety for dollar movements and activity but rely on a parsimonious calibrated model with few disturbances. Similarly, Engel and Wu (2024) provide evidence on the role of measures of financial market stress–such as the VIX and credit spreads–in forecasting the dollar. Our approach differs from these authors' in that it leverages the structure of a standard monetary dynamic general equilibrium model and a large data set of macroeconomic and financial variables to discipline the statistical inference and assess the forecasting performance of the model. From this perspective, our approach directly addresses the Alvarez et al. (2007) critique.

Our estimated model implies effects of GFS shocks that align with those identified through alternative approaches. Bodenstein et al. (2023) present estimates from a structural VAR in which the EBP serves as a proxy for global risk, and they characterize how shifts in global risk affect a set of global macroeconomic and financial variables. The transmission of GFS shocks in our estimated model matches those from the VAR model to a remarkable extent. According to both models, the typical GFS shock triggers a rise in U.S. and foreign corporate borrowing spreads, an appreciation of the dollar, and a decline in global economic activity and inflation. These effects are consistent with those in Georgiadis et al. (2024), who also find that an increase in global risk leads to dollar appreciation, using a methodology that relies on changes in the price of gold around narratively selected events of increases in global risk.

The remainder of the paper is organized as follows. Section 2 describes the model. Section 3 summarizes the data and estimation results. Section 4 discusses the key results that emerge from analysis of the estimated model. Section 5 concludes.

[1] While Fukui et al. (2023) uses differences in the response of floaters and peggers to US dollar changes to reach this conclusion, Kekre and Lenel (2024a) argues that a natural way to explain comovements between the exchange rate and interest rate differentials are small but very persistent changes in the natural rate across countries. Bodenstein et al. (2024) show that, in the presence of sufficiently high portfolio costs, shocks to trade flows can explain several exchange rate puzzles as these shocks lead to sizable endogenous deviations from uncovered interest rate parity. In addition, their model accounts for key moments of net exports over time.

2 Model

We consider an economy consisting of a home (H) country, the United States, and a foreign (F) country, capturing the rest of the world. The model includes a set of standard features that have been found to be important to describe the data in estimated closed-economy DSGE models (Christiano et al., 2005; Smets and Wouters, 2007; Eichenbaum et al., 2021). We also include frictions in financial intermediation as in Gertler and Karadi (2011) within each country. International financial markets are incomplete: only bonds denominated in U.S. dollars are traded internationally.

Agents in each country include households, retailers, producers of intermediate goods, and the government. We next describe the optimization problem facing each type of agent.

2.1 Households

Households in both countries have access to safe bonds denominated in the respective domestic currencies, but only bonds denominated in U.S. dollars are traded internationally.[2] Households derive utility from their holdings of this global safe dollar bond, which captures the liquidity and safety services of these assets as in Krishnamurthy and Vissing-Jorgensen (2012).[3] We allow for this preference for global safety to be subject to shocks. These shocks have two important features: First, a component of these shocks is allowed to be common across countries. Second, this common component can impact dollar-denominated and foreign currency-denominated safe bonds asymmetrically—allowing the model to capture a special role for dollar-denominated safe assets in contexts of generalized increased preference for safety.

2.1.1 Households at Home

There is a continuum of households, each of which consists of a continuum of members with measure unity. A measure $(1 - f)$ of family members are workers, and the remaining f are bankers. Workers supply differentiated labor to firms, while bankers manage financial institu-

[2] Maggiori et al. (2020) document a strong dollar bias in global investors' portfolios, consistent with our assumption.

[3] There is growing literature that considers models with (safe) bonds in the utility function as way to formalize preferences for wealth and liquidity services of safe assets, such as government bonds. See, for instance, Fisher (2015), Anzoategui et al. (2019), Michaillat and Saez (2021), and Cuba-Borda and Singh (2024).

tions. Wages earned by workers and profits earned by bankers are returned to the household, and there is perfect consumption insurance within the family. There is turnover between bankers and workers: in each period, a banker exits with probability $(1-\sigma)$ and becomes a worker. Exiting bankers transfer their net worth to the family and are replaced by an equal number, $(1-\sigma)f$, of workers who receive a startup wealth endowment, e_t.[4]

Let C_t be home households' consumption of the final good, $B_{H,t}$ their holdings of the home safe government bond (denominated in the currency of the home country—that is, in dollars), D_t holdings of bank deposits, $\widetilde{\Pi}_t$ profits from banks and firms, T_t government transfers, $n_t(i)$ the labor supply of differentiated labor variety i, and $w_t(i)$ its nominal wage. Then, the domestic household's decision problem is to choose C_t, $B_{H,t}$, D_t, and $\{n_t(i), w_t(i)\}$ to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \log\left(C_{t+j} - b\overline{C}_{t+j-1}\right) + (\zeta_{t+j}^{RP} + \zeta_{t+j}^{GFS})U(B_{H,t+j}) - \frac{\psi_N}{1+\eta} \int_{i \in \mathcal{W}_{t+j}} n_{t+j}(i)^{1+\eta} di \right\}, \quad (1)$$

subject to

$$P_t C_t + \frac{B_{H,t}}{R_t} + \frac{D_t}{R_t^d} = \int_{i \in \mathcal{W}_t} w_t(i) n_t(i) di + B_{H,t-1} + D_{t-1} + \widetilde{\Pi}_t + T_t, \quad (2)$$

$$n_t(i) = \left(\frac{w_t(i)}{W_t} \right)^{-\frac{1+\mu_{w,t}}{\mu_{w,t}}} N_t, \quad (3)$$

and the constraint that worker i gets to adjust the nominal wage optimally only with probability θ_w (Erceg et al., 2000). The variables R_t and R_t^d denote the gross returns from holding home bonds and bank deposits respectively, $\overline{C}_t$ is average consumption (that is, households' utility from consumption exhibits *external* habits), and total labor income $\int_{i \in \mathcal{W}_t} w_t(i) n_t(i) di$ is the sum of wage income across the subset $\mathcal{W}_t$ of family members that work at time t. Equation (2) is the budget constraint, and equation (3) is the demand for labor variety i, which reflects the optimal choice of employment agencies that buy differentiated labor from households and sell a homogeneous labor input, N_t, to intermediate good-producing firms at wage W_t.

The variables ζ_t^{RP} and ζ_t^{GFS} in equation (1) are exogenous shocks to the utility derived from holding safe dollar bonds, $B_{H,t}$. As Fisher (2015) discusses, these shocks provide an explicit formulation of the "risk premium" shocks in Smets and Wouters (2007). The distinction be-

[4]Following Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), this structure allows us to introduce financial intermediation while preserving a representative-family setting.

tween ζ_t^{RP} and ζ_t^{GFS} is that ζ_t^{RP} shifts U.S. households' preference for safety but not foreign households', whereas ζ_t^{GFS} affects both U.S. and foreign households' preference for safety simultaneously. For this reason, we label the latter as "global flight-to-safety" (henceforth, GFS) shock, while we refer to the ζ_t^{RP} as a "risk premium" shock as in Smets and Wouters (2007).

2.1.2 Households Abroad and Arbitrage

Foreign households can hold both dollar-denominated safe bonds and safe bonds denominated in the foreign currency, thus effectively acting as "arbitrageurs" across safe bonds in different currencies. Like households at home, households abroad derive utility from these bond holdings, and this utility is also subject to exogenous shocks.

We refer to variables pertaining the foreign economy by the symbol *. Let $B^*_{H,t}$ denote foreign households' holdings of the home (U.S.) government bond and $B^*_{F,t}$ their holdings of the foreign government bond. The foreign household's objective function is

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \Big\{ \log\left(C^*_{t+j} - b\overline{C}^*_{t+j-1}\right) + \left[\zeta^{RP*}_{t+j} + \zeta^{GFS}_{t+j}\right] U(B^*_{F,t+j}) + \left[\zeta^{RP*}_{t+j} + (1+\gamma)\zeta^{GFS}_{t+j} + \zeta^{UIP}_{t+j}\right] U(B^*_{H,t+j})$$
$$- \frac{\psi_N}{1+\eta} \int_{i \in \mathcal{W}^*_{t+j}} n^*_{t+j}(i)^{1+\eta} di \Big\} . \tag{4}$$

The first and last terms in equation (4) are analogous to those in the domestic household's objective function, (1), capturing the utility from consumption and disutility from labor. The second term captures the utility that foreign households derive from holdings of their own country's safe bond, $B^*_{F,t}$. This utility varies because of fluctuations in a risk premium shock specific to the foreign country, denoted ζ_t^{RP*}, as well as because of fluctuations in the global flight-to-safety shock, ζ_t^{GFS}. The third term refers to the utility flows to foreign households from their holdings of the *home* (dollar-denominated) bond, $B^*_{H,t}$. These holdings are *also* affected by the two shocks ζ_t^{RP*} and ζ_t^{GFS}. Note that we allow the GFS shock to affect the utility flows from home and foreign safe bonds asymmetrically, and the degree of asymmetry is governed by the parameter γ. Thus, if $\gamma > 0$, a positive GFS shock increases foreign households' utility from U.S. bonds *by more* than it increases their utility from foreign bonds. In this way the model can capture the notion that safe, dollar-denominated bonds issued by the U.S. are particularly valuable in flight-to-safety episodes, which has been highlighted in much recent literature in international finance..[5] We highlight, however, that we do not impose $\gamma > 0$ at the onset, but instead allow γ to be fully determined by the data (we assume a symmetric flat prior for γ centered at 0). As it turns out, we do find that the data strongly favors a positive value for γ.

Finally, we also include in equation (4) a shock, denoted ζ_t^{UIP}, which alters foreign households' preference for U.S. bonds *relative* to their preference for foreign bonds, without being associated with a generalized increased preference for safety (as is the case with the ζ_t^{GFS} shock). As will be clear momentarily, the shock ζ_t^{UIP} enters the model's uncovered interest parity (UIP) equation and no other equilibrium condition. For this reason, we refer to it as the "standard UIP" shock, although in the literature, it is also sometimes referred to as a "currency risk premium" shock (Erceg et al., 2006) or as a "financial" shock (Itskhoki and Mukhin, 2021).

Maximization of (4) is subject to the constraints

$$P_t^* C_t^* + \frac{B_{F,t}^*}{R_t^*} + \frac{\mathcal{E}_t B_{H,t}^*}{R_t \Psi_t} + \frac{D_t^*}{R_t^{d*}} = \int_{i \in \mathcal{W}_t^*} w_t^*(i) n_t^*(i) di + B_{F,t-1}^* + \mathcal{E}_t B_{H,t-1}^* + D_{t-1}^* + \widetilde{\Pi}_t^* + T_t^*, \quad (5)$$

$$n_t^*(i) = \left(\frac{w_t^*(i)}{W_t^*} \right)^{-\frac{1+\mu_w}{\mu_w}} N_t^*, \quad (6)$$

and the restriction that workers in the household can reset their nominal wage only with probability $1 - \theta_w$. The variable $\mathcal{E}_t$ denotes the nominal exchange rate, expressed in foreign currency units per dollar. Therefore, an increase in $\mathcal{E}_t$ corresponds to an appreciation of the dollar. Following Schmitt-Grohé and Uribe (2003), Ψ_t captures a portfolio cost associated with foreign households' holdings of the home bonds, which helps ensure that net foreign assets remain stationary in the model ($\overline{B}_{H,t}^*$ is average holdings of dollar bonds, implying that households do not internalize these portfolio costs). The functional form for Ψ_t is $\Psi_t \equiv 1 - \chi \frac{\mathcal{E}_t \overline{B}_{H,t}^*}{Y_t^* P_t^*}$, with $\chi > 0$.

The role of the risk shocks embedded in home and foreign households' preferences (ζ_t^{GFS}, ζ_t^{RP}, $\zeta_t^{RP^*}$, and ζ_t^{UIP}) is a key focus of our analysis. The next subsection describes the model's log-linearized Euler and interest parity equations to provide intuition on the transmission of these shocks.

[5] Work higlighting the international role of U.S. safe assets includes Gourinchas and Rey (2007), Maggiori (2017), Gopinath and Stein (2021), and Jiang et al. (2021b), among many others.

2.1.3 Euler Equations and Uncovered Interest Parity

Let $\pi_t \equiv \log(P_t/P_{t-1})$ denote CPI inflation and hats denote log-deviations from steady state. The domestic and foreign log-linearized Euler equations associated with the holdings of domestic and foreign bonds are respectively captured by equations (7) and (8) below:[6]

$$\hat{c}_t = c_1\hat{c}_{t-1} + (1-c_1)\mathbb{E}_t[\hat{c}_{t+1}] - c_2\left(\hat{r}_t - \mathbb{E}_t[\pi_{t+1}] + \zeta_t^{RP} + \zeta_t^{GFS}\right), \tag{7}$$

$$\hat{c}_t^* = c_1\hat{c}_{t-1}^* + (1-c_1)\mathbb{E}_t[\hat{c}_{t+1}^*] - c_2\left(\hat{r}_t^* - \mathbb{E}_t[\pi_{t+1}^*] + \zeta_t^{RP*} + \zeta_t^{GFS}\right), \tag{8}$$

where $c_1 \equiv b/(1+b)$ and $c_2 \equiv (1-b)/(1+b)$. Equations (7)-(8) indicate that higher values of the country-specific risk premium shocks, ζ_t^{RP} and ζ_t^{RP*}, depress consumption spending and therefore aggregate demand in that country by raising the value of saving relative to consuming. Increases in the global flight-to-safety shock ζ_t^{GFS} depress consumption spending in both countries simultaneously.

Combining equation (8) with the log-linearized Euler equation associated with foreign households' holdings of U.S. bonds yields the following version of the uncovered interest rate parity (UIP) condition:

$$rer_t = (\hat{r}_t - \mathbb{E}_t[\pi_{t+1}]) - \left(\hat{r}_t^* - \mathbb{E}_t[\pi_{t+1}^*]\right) + \gamma\zeta_t^{GFS} + \zeta_t^{UIP} - \chi_t + \mathbb{E}_t[rer_{t+1}], \tag{9}$$

where rer_t denotes the log of the U.S. real exchange rate (defined as the value of the U.S. consumption basket in terms of the foreign basket: $RER_t \equiv \mathcal{E}_t P_t/P_t^*$) and $\chi_t \equiv \chi\frac{\mathcal{E}}{Y^*P^*}\overline{B}^*_{H,t}$.[7] Equation (9) indicates that the dollar appreciates when the U.S. real interest rate rises relative to the foreign real rate, as in standard UIP logic. In addition, there are two exogenous sources of deviations from UIP: one driven by the global flight-to-safety shock, ζ_t^{GFS}, and present to the extent that $\gamma > 0$; and another driven by the standard UIP shock, ζ_t^{UIP}. Finally, a third source of UIP deviations arises owing to the presence of the portfolio cost, χ_t, with higher portfolio costs of dollar-denominated assets associated with a weaker dollar.[8]

[6] We log-linearize around a steady state in which $\zeta^{GFS} = \zeta^{RP} = \zeta^{RP*} = \zeta^{UIP} = 0$ and normalize $U(\cdot)$ so that in steady state, $\frac{U}{[C(1-b)]^{-1}} = 1$. Also, we abuse the notation for inflation rates and use $\pi_t \equiv \log(P_t/P_{t-1})$ and $\pi_t \equiv \frac{P_t - P_{t-1}}{P_{t-1}}$ interchangeably.

[7] Note that $\overline{B}^*_{H,t}$ equals zero in the deterministic steady state.

[8] Quantitatively, this component turns out to be very small in our estimation.

2.2 Employment Agencies

The remainder of the model is fairly standard, and fully symmetric across countries, so for brevity, we describe only the home economy here (the Appendix contains the full set of equilibrium conditions). A large number of competitive "employment agencies" combine specialized labor into a homogeneous labor input using an Armington aggregator:

$$N_t = \left[\int_{j \in \mathcal{W}_t} n_t(j)^{\frac{1}{1+\mu_{w,t}}} \right]^{1+\mu_{w,t}}, \tag{10}$$

where

$$\mu_{w,t} = \mu_w e^{\zeta_t^w} \tag{11}$$

and ζ_t^w is a wage markup shock. Let W_t be the wage firms pay for the homogeneous labor input. Employment agencies choose N_t and $\{n_t(j)\}_{j \in \mathcal{W}_t}$ to maximize profits:

$$W_t N_t - \int_{j \in \mathcal{W}_t} w_t(j) n_t(j) dj, \tag{12}$$

subject to equation (10).

2.3 Bankers

Bankers intermediate funds between households and firms. Each banker uses their own net worth, x_t, and deposits from other families to purchase capital K_t.[9] We denote by d_t real deposits—that is, $d_t \equiv \frac{D_t}{P_t}$—and Q_t the (real) price of capital. A representative banker's flow budget constraint is

$$Q_t K_t = x_t + \frac{d_t}{R_t^d}. \tag{13}$$

Banker net worth is the gross return on assets net the cost of deposits:

$$x_t = \left[r_t^k + Q_t(1-\delta) \right] K_{t-1} - d_{t-1} \frac{P_{t-1}}{P_t}, \tag{14}$$

where r_t^k is capital's rental rate and δ its depreciation.[10]

Following Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), we assume that there

[9] As in Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), one can think of banks making loans indexed to the quantity of capital purchased by firms.

[10] Banks also make a static capital utilization choice. Because the effects of such a choice on returns is of second order, we leave it out of the main text for ease of exposition. See the Appendix for details.

is an agency problem between bankers and depositors. In particular, after raising deposits and making loans to firms, a banker can divert a proportion κ of these loans and transfer them back to their own family. As a result, lenders will limit the amount they are willing to lend to bankers to make sure that bankers do not have an incentive to divert funds. Let V_t be the value to a banker of operating the bank honestly,. The incentive compatibility constraint is

$$V_t \geq e^{\zeta_t^\kappa} \kappa Q_t K_t, \tag{15}$$

where ζ_t^κ is an exogenous disturbance to the tightness of the banking friction affecting home banks.

In our calibration, the incentive constraint (15) is binding, and bankers in equilibrium will always make higher returns on their investment than what they pay on deposits. Therefore, they find it optimal to pay out dividends only upon exit. As a result, a banker's objective is to maximize the expected dividend payout upon exit. We denote by $\Lambda_{t,t+i} \equiv \beta^i (C_{t+i} - bC_{t+i-1})^{-1}/(C_t - bC_{t-1})^{-1}$ the household's stochastic discount factor between t and $t+i$. A banker's problem at time t is to choose capital, $\{K_{t+i}\}_{i=0}^\infty$, deposits, $\{D_{t+i}\}_{i=0}^\infty$, and net worth, $\{x_{t+i}\}_{i=0}^\infty$, to maximize

$$V_t = \mathbb{E}_t \sum_{i=0}^\infty \Lambda_{t,t+i} (1-\sigma) \sigma^{i-1} x_{t+i}, \tag{16}$$

subject to equations (13)-(15).

2.4 Final Consumption and Investment Goods

The final aggregate consumption good C_t^d is produced as a composite of a domestic intermediate goods bundle $C_{H,t}$ and foreign intermediate goods bundle $C_{F,t}$ by means of an Armington aggregator:

$$C_t^d = \left[\left(e^{\zeta_t^\omega} \omega \right)^{\frac{1}{\theta}} C_{H,t}^{\frac{\theta-1}{\theta}} + \left(1 - e^{\zeta_t^\omega} \omega \right)^{\frac{1}{\theta}} \left((1 - \psi_t^{MC}) C_{F,t} \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{17}$$

where $\theta \geq 0$ determines the elasticity of substitution between the domestic and foreign intermediate goods bundles. The production C_t^d has to equal the sum of domestic private and government consumption:

$$C_t^d = C_t + G_t. \tag{18}$$

Similarly, the final investment good is produced by combining a home-produced and an imported investment good:

$$I_t = \left[\left(e^{\zeta_t^\omega} \omega_I\right)^{\frac{1}{\theta}} I_{H,t}^{\frac{\theta-1}{\theta}} + \left(1 - e^{\zeta_t^\omega} \omega_I\right)^{\frac{1}{\theta}} \left((1-\psi_t^{MI}) I_{F,t}\right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}. \tag{19}$$

In both expressions above, (ζ_t^ω) is an exogenous disturbance to home bias in preferences. The variables ψ_t^{MC} and ψ_t^{MI} capture costs associated with changing the ratio of imported-to-domestic consumption or investment goods and take the following form:

$$\psi_t^{MC} = \frac{\psi_i}{2} \left(\frac{C_{F,t}/C_{F,t-1}}{C_{H,t}/C_{H,t-1}} - 1 \right)^2 \qquad \text{and} \qquad \psi_t^{MI} = \frac{\psi_i}{2} \left(\frac{I_{F,t}/I_{F,t-1}}{I_{H,t}/I_{H,t-1}} - 1 \right)^2.$$

This form of adjustment costs is common in the open-economy DSGE literature—for example, Erceg et al. (2006) or Eichenbaum et al. (2021)—and it allows us to capture a dampened short-run response of the import share to movements in the relative price of imports, consistent with the evidence.

Producers of the final consumption good choose $(C_{H,t+i}, C_{F,t+i}, C_{t+i})$ to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} \Lambda_{t,t+i} \left(C_{t+i}^d - \frac{P_{H,t+i}}{P_{t+i}} C_{H,t+i} - \frac{P_{F,t+i}}{P_{t+i}} C_{F,t+i} \right),$$

subject to equation (17), where $P_{H,t}$ and $P_{F,t}$ are the price of the domestic and foreign intermediate goods bundles, respectively. Similarly, producers of the final investment good choose $(I_{H,t}, I_{F,t}, I_t)$ to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} \Lambda_{t,t+i} \left(\frac{P_{I,t+i}}{P_{t+i}} I_{t+i} - \frac{P_{H,t+i}}{P_{t+i}} I_{H,t+i} - \frac{P_{F,t+i}}{P_{t+i}} I_{F,t+i} \right),$$

subject to equation (19), where $P_{I,t}$ is the price of the final investment good.[11]

The solution of the problems of the final consumption and investment goods producers determines aggregate domestic demand for the home intermediate good bundle,

$$Y_{H,t} = C_{H,t} + I_{H,t},$$

[11]Our model of the final consumption and investment goods sector follows closely Erceg et al. (2006).

and for the imported foreign intermediate goods bundle,

$$Y_{F,t} = C_{F,t} + I_{F,t}.$$

In turn, these bundles of intermediate goods are composites of intermediate goods varieties:

$$Y_{H,t} = \left(\int_0^1 Y_{H,t}^{\frac{1}{1+\mu_{ht}}}(h)dh \right)^{1+\mu_{ht}}, \tag{20}$$

$$Y_{F,t} = \left(\int_0^1 Y_{F,t}^{\frac{1}{1+\mu_{ft}}}(h)dh \right)^{1+\mu_{ft}}, \tag{21}$$

where

$$\mu_{jt} = \mu_j e^{\zeta_t^{\mu_j} + \bar{\zeta}_t^{\mu_j}} \text{ for } j \in \{h, f\} \tag{22}$$

are time-varying desired markups, which are buffeted by a transitory shock $\zeta_t^{\mu_j}$ and a highly persistent one $\bar{\zeta}_t^{\mu_j}$.

The home intermediate good bundle is supplied by perfectly competitive retailers at home, which maximize

$$P_{H,t}Y_{H,t} - \int_0^1 P_{H,t}(h)Y_{H,t}(h)dh,$$

subject to equation (20). Similarly, retailers of the foreign intermediate bundle at home maximize

$$P_{F,t}Y_{F,t} - \int_0^1 P_{F,t}(h)Y_{F,t}(h)dh,$$

subject to equation (21). The demand functions for differentiated intermediate goods from the domestic and foreign economies are

$$Y_{H,t}(h) = \left(\frac{P_{H,t}(h)}{P_{H,t}} \right)^{-\frac{1+\mu_{ht}}{\mu_{ht}}} Y_{H,t}, \tag{23}$$

$$Y_{F,t}(h) = \left(\frac{P_{F,t}(h)}{P_{F,t}} \right)^{-\frac{1+\mu_{ft}}{\mu_{ft}}} Y_{F,t}. \tag{24}$$

2.5 Intermediate Good Firms

There is a continuum of intermediate good retailers and a continuum of intermediate goods producers. Intermediate goods producers use a Cobb-Douglas production technology that employs labor and capital to produce a homogeneous intermediate good. Retailers then differentiate this intermediate good (at no cost) and sell it in a monopolistically competitive market subject to nominal rigidities, as in Calvo (1983).

2.5.1 Retailers of Intermediate Goods Varieties

In both the home and the foreign country, there are two types of retailers: domestic retailers and exporters. In each period, a domestic retailer can set its price optimally only with probability $1-\theta_p$ and otherwise follows an indexation rule whereby its price is indexed to previous-period inflation with exponent $\iota_p \in [0,1]$. Let MC_t be the real price of the homogeneous intermediate good and $\pi_{H,t} \equiv \frac{P_{H,t}-P_{H,t-1}}{P_{H,t-1}}$ be the rate of inflation of the domestic good bundle at home. A domestic retailer that resets its price at time t chooses the optimal reset price $P^o_{H,t}$ for the domestic market to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} (\theta_p)^i \Lambda_{t,t+i} \left(\frac{P^o_{H,t} \prod_{j=t}^{t+i-1} (1+\pi_{H,j})^{\iota_p}}{P_{t+i}} - MC_{t+i} \right) Y_{H,t+i}(h), \tag{25}$$

where the demand for retailer's intermediate good at time $t+i$ is[12]

$$Y_{H,t+i}(h) = \left[\frac{P^o_{H,t} \prod_{j=t}^{t+i-1} (1+\pi_{H,j})^{\iota_p}}{P_{H,t+i}} \right]^{-\frac{1+\mu_{ht}}{\mu_{ht}}} Y_{H,t+i}. \tag{26}$$

Similarly, with probability θ^x_p, exporting retailers cannot reset their price. We allow θ^x_p to differ from θ_p. Further we assume that exporting retailers set prices in the currency of the market in which the good is sold—that is, local currency pricing.[13] Accordingly, the optimal reset price $P^{o,*}_{H,t}$ for exporters maximizes

$$\mathbb{E}_t \sum_{i=0}^{\infty} (\theta^x_p)^i \Lambda_{t,t+i} \left(\frac{P^{o,*}_{H,t} \prod_{j=t}^{t+i-1} (1+\pi^*_{H,j})^{\iota^x_p}}{P_{t+i}} \mathcal{E}^{-1}_{t+i} - MC_{t+i} \right) Y^*_{H,t+i}(h), \tag{27}$$

where $\pi^*_{H,j} = \frac{P^*_{H,j}}{P^*_{H,j-1}}$ and

$$Y^*_{H,t+i}(h) = \left[\frac{P^{o,*}_{H,t} \prod_{j=t}^{t+i-1} (1+\pi^*_{H,j})^{\iota^x_p}}{P^*_{H,t+i}} \right]^{-\frac{1+\mu^*_{ht}}{\mu^*_{ht}}} Y^*_{H,t+i}. \tag{28}$$

[12]See equation (A.38) in the Appendix.
[13]See Devereux and Engel (2002).

2.5.2 Producers of the Intermediate Good

We assume a standard Cobb-Douglas production function for the homogeneous intermediate good:

$$Y_t = e^{\zeta_t^A} \bar{K}_t^{\alpha} N_t^{1-\alpha}, \tag{29}$$

where ζ_t^A is a shock to aggregate total factor productivity (TFP) and $\bar{K}_t$ is effective units of capital:

$$\bar{K}_t = K_{t-1} u_t, \tag{30}$$

where u_t denotes the utilization rate. Capital utilization entails a cost of installed capital $\mathcal{A}(u_t)K_{t-1}$, with function $\mathcal{A}(u_t)$ given by

$$\mathcal{A}(u_t) = r^K \frac{e^{\xi(u_t-1)-1}}{\xi}, \tag{31}$$

where $\bar{r}^K$ is the steady-state rental rate of capital. The utilization rate u_t is assumed to be chosen by bankers, as described in the Appendix.

Perfectly competitive producers choose how much effective capital to rent and labor to hire to maximize profits. This decision is given by

$$MC_t Y_t - \frac{W_t}{P_t} N_t - r_t^K \bar{K}_t, \tag{32}$$

subject to production function (29).

2.6 Capital Good Producers

Capital good producers use investment goods to produce new capital goods, subject to flow adjustment costs as in Christiano et al. (2005):

$$K_t - (1-\delta)K_{t-1} = e^{\zeta_t^I} I_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right], \tag{33}$$

where ζ_t^I is a shock to the marginal efficiency of investment as in Justiniano et al. (2010).

Capital goods producers choose (I_s, K_s) to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} \Lambda_{t,t+i} \left[Q_{t+i}\left[K_{t+i} - (1-\delta)K_{t+i-1}\right] - \frac{P_{t+i}^I}{P_{t+i}} I_{t+i}\right]. \tag{34}$$

2.7 Fiscal and Monetary Policy

The government finances expenditures with lump-sum taxes to balance its budget period by period:

$$T_t = G_t = e^{\zeta_t^G} G, \tag{35}$$

where G is steady-state government expenditure and ζ_t^G is a domestic government expenditure shock.

The monetary authority (both at home and abroad) sets nominal interest rates according to a policy rule in the spirit of Taylor, which responds to CPI inflation, Π_t, and the output gap:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_R} \left[\left(\frac{\prod_{s=0}^{3}(1+\pi_{t-s})^{0.25}}{e^{\zeta_t^\pi}(1+\bar{\pi})}\right)^{\varphi_\pi} \left(\frac{Y_t}{Y_t^{flex}}\right)^{\varphi_Y}\right]^{1-\varphi_R} e^{\zeta_t^R}, \tag{36}$$

where Y_t^{flex} is aggregate output in the flexible-price version of the economy, ζ_t^π is a shock to the inflation target, $\bar{\pi}$, and ζ_t^R is a monetary policy shock.

2.8 Market Clearing Conditions

The market clearing condition for intermediate goods is

$$Y_t = \int_0^1 Y_{H,t}(h)dh + \frac{n^*}{n}\int_0^1 Y_{H,t}^*(h)dh, \tag{37}$$

where n and n^* are the sizes of the home and foreign country, respectively.

Finally, we can express the equilibrium in the bond market by combining the budget constraint of the home and foreign households to get a balance of payments condition:

$$\frac{\mathcal{E}_t B_{H,t}^*}{R_t \Psi_t} = \mathcal{E}_t B_{H,t-1}^* + \mathcal{E}_t P_{F,t} Y_{F,t} - P_{H,t}^* Y_{H,t}^*. \tag{38}$$

3 Estimation

In this section we discuss the model estimation. We begin with a quick summary of our solution and estimation approach, after which we describe the data. Then, we summarize our choices for calibrated parameters and for priors. The remainder of the section discusses the estimation results.

3.1 Model Solution and Estimation

We compute a linear approximation to the model solution and estimate it with Bayesian methods.[14] We split the model parameters into two groups. Parameters in the first group are calibrated to match selected long-run moments or common values from the literature. For the second group of parameters, we specify priors and combine them with the model's likelihood function under the data listed below to arrive at their posterior distribution. To approximate the posterior, we first find the posterior mode and then explore the posterior with the Metropolis-Hastings algorithm.[15] To ensure convergence, we generate multiple chains of length 1,000,000, of which we drop the first 50 percent of observations. We allow for 5 percent *iid* measurement error in the foreign series in the estimation, to deal with both true measurement error in the series and noise generated by our data aggregation approach (discussed next).

3.2 Data

We use 21 quarterly time series that span the years 1973-2019. All quantity series are measured in per-capita units. Given data availability constraints, our estimation sample starts in 1992, and we use earlier data, when available, to form initial conditions.

As mentioned above, the home country in our model represents the U.S., and the foreign country captures the rest of the world. To construct time series for the rest of the world, we compute a weighted average of the available non-U.S.country series in a given quarter, using real exchange rate weights discussed in Appendix C. We thus build time series for the rest of the world for real GDP growth, real consumption growth, real investment growth, the policy rate, inflation—measured by the GDP deflator—and corporate bond spreads.

For the U.S., we use data for the same series as for the rest of the world. In addition, we also include data on the U.S. broad real exchange rate, real wage growth, 10-year PCE inflation expectations, import and export prices relative to the GDP deflator, and real import and export growth.[16] Finally, we use the "labor gap," constructed as in Campbell et al. (2017),

[14] For an introduction to estimating DSGE models with Bayesian methods, see, for example, An and Schorfheide (2007). We use DYNARE to implement the estimation. For documentation on DYNARE, see Adjemian et al. (2011).

[15] Given the large parameter space, we extensively explore different starting points for the search for the mode as well as small perturbations to the priors.

[16] Given data availability, we use forecasts both on inflation in 5-10 years and on inflation in 10 years for

as a measure of the cyclical component of total hours worked. This measure excludes low-frequency movements in the data that are not well captured by our model, which focuses on business-cycle frequencies.[17]

Appendix C discusses the data sources and details of the constructed series.

3.3 Calibration, Priors and Posteriors

Table 1 lists the calibrated parameters with their target values. We set the size of the home country to 1/4, which captures the share of U.S. GDP in the global economy. The discount factor, β, is set to imply an annualized interest rate of 4 percent, in line with the return to capital. We set the quarterly depreciation rate, δ, to 2.5 percent, a common value in the literature. The capital share, α, is set 0.29, in line with the labor share. We target a share of steady-state government expenditure, $\frac{G}{Y}$, of 22 percent, again a common value for models of the U.S. economy. The parameters controlling home bias in consumption and investment, ω and ω_I, are calibrated to match a steady state import share of consumption and investment of 7 and 50 percent, respectively.[18] We set the slope of the international bond adjustment costs, χ, to 0.01, in line with typical values used in the literature to induce stationarity (see Schmitt-Grohé and Uribe (2003)). The disutility weight on labor, ψ_n, is set to obtain a steady-state value of labor equal to a third. Finally, we set the wage and price markups to 15 percent, a common value in the literature.

Table 2 lists the structural parameters that we estimate, together with the priors and the posteriors from the estimation. Table 3 does the same for the shock processes. As shown in Table 2, we select the prior values of parameters that are also present in estimated closed-economy models following earlier research (see, for instance, Christiano et al. (2005), Smets and Wouters (2007), or Del Negro et al. (2015)). Turning to the parameters specific to the open economy, we used the following priors. For the elasticity of substitution between local and imported goods, θ, we chose a beta distribution with support (1,4), a mean of 2, and standard

subsets of the estimation period. Our observation equations account for the differences in the goods underlying the GDP deflator and the consumer price index in the model.

[17]We map U.S. hours worked in the model to the labor gap. As a result, structural changes in the labor market over time, like the rise in female labor force participation, are captured by TFP changes when we filter the data.

[18]The foreign home bias parameters are derived by scaling down ω and ω_I to impose balanced trade in steady state. We target a total import share of 15 percent and an investment share consistent with Erceg et al. (2008).

deviation of 0.33. This choice covers many parameter values used in the international macro literature. For the trade adjustment cost parameter, ψ_i, we use a beta distribution with support (0,20), mean 10, and standard deviation 2. While this mean is close to the value used in Erceg et al. (2006), the distribution allows for a wide range of estimates.[19] We selected a wide prior for γ to remain agnostic about the exchange rate effects of global flight-to-safety shocks. For the import pricing frictions, we choose the same priors as for the domestic pricing frictions.

The posterior distribution of the structural parameters provides four interesting observations. First, for the parameters that would apply to a closed economy, our estimates are generally close to those found in the literature estimating DSGE models for the U.S. economy—for example, Christiano et al. (2005), Smets and Wouters (2007), or Del Negro et al. (2015). Second, the posterior mode of the parameter γ is firmly positive, and so is the bulk of the mass of the posterior. This result implies that an increase in the global flight-to-safety shock is indeed associated with an appreciation of the dollar. Third, from the parameters controlling the trade elasticity at different horizons (θ and ψ_i), the posterior mean estimates suggest a long-run elasticity of 2.5, which is higher than the short-run elasticity of 0.5, as is consistent with business cycle and trade literature. Fourth, consistent with the high volatility of import and export prices in our data set, we find prices for internationally sold goods to be less sticky than those for domestically sold goods.

Turning to the shock processes, with the exception of the markup shocks, we assume shocks in the model follow first-order auto-regressive processes:

$$\log(\zeta_t^x) = \rho_x \log(\zeta_{t-1}^x) + \sigma_x \varepsilon_t^x, \tag{39}$$

where x denotes the variable associated to the shock, ρ_x is the persistence parameter, σ_x denotes the standard deviation, and the innovations are distributed according to $\varepsilon_t^x \sim N(0,1)$. We assume that markup shocks follow ARMA(1,1) processes, as in related literature (Smets and Wouters, 2007; Justiniano et al., 2010):[20]

$$\log(\zeta_t^x) = \rho_x \log(\zeta_{t-1}^x) + \sigma_x(\varepsilon_t^x - \theta_x \varepsilon_{t-1}^x). \tag{40}$$

[19]We used a beta distribution instead of a normal distribution for these two parameters to rule out extreme local modes we encountered in initial runs of the estimation.

[20]The only exception is the the persistent component of the markup shocks on domestic good sold abroad, $\zeta_t^{\mu_{H*}^P}$, discussed later, which follows an AR(1) process.

Our priors rely on the beta distribution for the persistence parameters and the inverse-gamma distribution for the standard deviation parameters.

The full list of shocks in our model is as follows. Starting with the home economy, in addition to the global flight-to-safety ζ_t^{GFS} and risk premium ζ_t^{RP} shocks, the model features shocks to the monetary policy rule, ζ_t^{R}, government spending, ζ_t^{G}, investment efficiency, ζ_t^{I}, the wage markup, ζ_t^{w}, the markup of home goods sold domestically, $\zeta_t^{\mu_H}$, total factor productivity, ζ_t^{A}, the inflation target, $\zeta_t^{\bar{\pi}}$, and the banking friction, ζ_t^{κ}. We allow for a global component of the latter shock as well, $\overline{\zeta}_t^{k}$.

The foreign economy is buffeted by an identical set of shocks; the one difference is that we do not include a wage markup shock abroad. The reason is that our data set does not include hours or wages for the foreign bloc, which complicates the task of identifying wage markup shocks. In addition, the foreign economy is also hit by the UIP shock, ζ_t^{UIP}.

Finally, our model also includes an array of shocks affecting international trade quantities and prices. We include time variation in U.S. and foreign home bias—through the shocks ζ_t^{ω} and $\zeta_t^{\omega *}$—which shifts the weight of the domestic good relative to the foreign good in the domestic and foreign consumption and investment baskets. These shocks allow the model to capture the low-frequency increases in trade shares due, for instance, to the reduction in policy-driven and technological trade barriers.[21] To capture movements in trade prices, we include shocks to the markups of goods traded across borders. Further, we split these shocks into highly persistent and transitory components. Thus, for example, $\zeta_t^{\mu_{H*}}$ captures the high-frequency movements in prices of domestic goods sold abroad, while $\zeta^{\mu_{H*}^P}$ targets the low-frequency movements in these prices.

Table 3 shows the prior specification and estimated posterior moments of the parameters governing these shock processes. Overall, the posterior distributions of shock variances and autocorrelations are much less dispersed than the prior distributions, indicating that the data are informative about these shock parameters. We highlight the following points. The shocks to home bias in trade, ζ_t^{w} and ζ_t^{w*}, are estimated to be quite persistent but with low volatility, consistent with the notion that these shocks capture slow-moving changes in trade shares. The GFS shock is estimated to have both high persistence and high volatility—higher than either the

[21]For a more extended discussion on the role of these shocks, see Bodenstein et al. (2024). For the United States, the recovered time series of these shocks appear to correlate well with the evolution of tariffs.

U.S-specific and the foreign-specific risk premium shocks. The MA component of the markup shocks is significant, consistent with previous studies.

4 Global Business Cycles and Exchange Rates

4.1 Historical Decompositions

A key finding from our analysis is that the global flight-to-safety shock is the central driver of global GDP growth. Figure 1 shows world GDP growth in the data (blue line)—which can be interpreted as the outcome of simulating our model assuming *all* estimated shocks took place, given the filter's estimate of the initial condition—against the simulated series of global GDP growth conditional on *only* realizations of the estimated GFS shock, given the same initial condition (red, dashed line). The GFS-only GDP growth series tracks the world GDP growth data remarkably well, with a correlation coefficient between the two series of [0.74]. The major downturns in global growth observed in the data—the early 1990s, the early 2000s, and the Global Financial Crisis (GFC)—are all associated with large negative realizations of the GFS shock. Notably, the GFS shock also accounts for the slow post-GFC recovery: note that if the only shock hitting the economy had been the GFS shock, the recovery would have been even slower.

Table 4 reports the variance decompositions of world aggregates from stochastic simulations of the model. For each variable shown in the rows, a given column displays the fraction of variance accounted for by the corresponding shock (or group of shocks). The first four columns show the role of the four individual risk-related shocks (GFS, U.S. risk premium, foreign risk premium, and UIP). The remaining columns show the role of groups of shocks (for example, the column "Monetary" shows the effects of both U.S. and foreign monetary shocks, and similarly for the other columns). The last column bundles together home and foreign TFP shocks and the home labor supply shock.

Two key findings stand out in Table 4. First, the GFS shock accounts for a large portion of fluctuations in global variables. Specifically, this shock explains about 22 percent of world GDP growth—more than any other risk shock or group of shocks—and 75 percent of credit spreads. Its role in explaining movements in world consumption growth, investment growth, and policy rates is also sizable, ranging from 17 to 23 percent. Notably, both U.S.- and foreign-specific risk premium shocks, which are often found to be important drivers of business cycles in closed-economy DSGE estimations (see, for instance, Smets and Wouters 2007), play a minor role in accounting for fluctuations in world aggregates, including world GDP and credit spreads. This observation points to the relevance of a global risk shock as a key driver of world macroeconomic and financial cycles. It contrasts with the points stressed by Miranda-Agrippino and Rey (2020), who argue that shocks originating in the U.S. (Primarily through shifts in U.S. monetary policy) are key drivers of the global economy.

Second, exchange rates do not appear to be disconnected from aggregate macroeconomic and financial disturbances. According to our estimated model, macroeconomic shocks explain about two-thirds of exchange rate fluctuations; monetary policy shocks, markup shocks, and households' home bias shocks are particularly important. These shocks also contribute to sizable movements in other macroeconomic variables, including inflation, output, and global trade. The GFS shock explains 10 percent of exchange rate fluctuations and has a prominent role during severe global downturns like the GFC, as discussed later. The UIP shock explains the residual fluctuations in exchange rates, with little macroeconomic impact on other variables.[22]

A few additional observations emerge from Table 4. First, global inflation is largely driven by the inflation target shocks and, to a lesser extent, by markup shocks. This result appears in line with other closed-economy DSGE estimations in which the Phillips curve is estimated to be quite flat. Second, world policy rates are explained largely by inflation target shocks. The significant role of these shocks reflects, in part, the slow-moving decline in (inflation and) interest rates in our sample.

The GFS shock is important not only for historical fluctuations in world GDP growth but also for fluctuations in U.S. and foreign GDP growth, as we show in Figure 2. In the foreign bloc (left panel), the model simulation conditional on only the GFS shock tracks the actual data particularly well. In the U.S., the association between actual and simulated GDP data appears less strong, in part because of the much higher quarterly volatility of the data series. Nonetheless, the GFS shock does account for a sizable portion of the major U.S. slowdowns—the

[22]Note that the UIP shock explains virtually none of the fluctuations in world variables other than the exchange rate, while it does account for a small amount of macroeconomic fluctuations in the U.S. and foreign blocks separately. This result emerges because these shocks tend to drive U.S. and foreign variables in opposite directions, reducing the shock's importance for global macroeconomic variables.

one in the early 2000s and the GFC.

Table 5 presents the variance decomposition for the U.S. variables in our estimation sample. A few notable findings emerge. First, the GFS shock plays an important role in U.S. business cycles: it accounts for about 8 percent of U.S. GDP growth fluctuations, more than 50 percent of the movements in credit spreads, and about 20 and 12 percent of fluctuations in hours and in the policy rate, respectively. Second, non-U.S. shocks (the sum of global and foreign factors in the first and second columns) explain 20 percent of fluctuations in U.S. GDP growth, over a quarter of fluctuations in U.S. hours and inflation, and more than half of fluctuations in U.S. exports. Thus, global factors seem to have meaningful impact on U.S. activity. That said, U.S. domestic factors remain important; supply (TFP and labor), investment-specific, monetary policy, and domestic risk-premium shocks each explain more than 10 percent of fluctuations in GDP growth.[23] Turning to trade, we see that the U.S. home bias shocks are important in accounting for fluctuations in U.S. import growth—a finding that is mirrored in the case of U.S. exports, which are largely driven by the foreign home bias shock (which in the table is included in the "All foreign shocks" column).

Finally, Table 6 reports the variance decomposition of the Foreign variables in our sample. The GFS shock accounts for a significant portion of fluctuations in foreign macroeconomic and financial variables. In particular, it explains roughly 20 percent of the variation in foreign GDP, consumption, and investment growth, and two-thirds of the movements in foreign spreads.[24] Foreign monetary and TFP shocks also play an important role in explaining GDP growth fluctuations. Perhaps more surprisingly, U.S.-specific shocks (which are bundled together in the second column) matter little for overall developments in the foreign bloc. Thus, while we found earlier that foreign factors have a material role in U.S. fluctuations, the converse is not true: U.S.-specific shocks have a near-negligible role in explaining non-U.S. fluctuations. This finding does not support the hypothesis in Miranda-Agrippino and Rey (2020) that global

[23]Note from Table 5 that the U.S. government spending shock is important for GDP growth but matters little for other variables. The reason is that this shock turns out to have a large impact on GDP growth at the high frequency but a smaller one at lower frequencies, and it does not deliver positive comovement between GDP and its components.

[24]It may seem surprising that the GFS shock explains a larger fraction of world fluctuations than of U.S. and foreign separately. However, this result can be understood by considering that the GFS shock is a common shock that affects both regions simultaneously. Consider, for example, a world comprising a continuum of small open economies, each affected by both a global shock and a purely idiosyncratic one with zero spillovers to other economies. The global shock explains a fraction of fluctuations in, say, the GDP of any specific economy, but explains all of the fluctuations in global GDP.

business cycles largely reflect U.S. factors.

4.2 Global Shocks, Model Fit, and Exchange Rates

Since Backus et al. (1994), a large literature has recognized the challenges of explaining macroeconomic comovement across countries and fluctuations in international prices in multi-country models driven by country-specific disturbances. In our baseline model, we argue that the global flight-to-safety shock goes a long way toward accounting for these empirical patterns. Given the global nature of this shock, here we investigate whether other global shocks improve the fit of the model in terms of the data density statistics as well as exchange rate variance explained by non-UIP shocks (a crude measure of the exchange rate disconnect).

Table 7 reports the statistical performance of the baseline model and alternative specifications with different types of global shocks. We consider experiments in which we re-estimate the model while adding a global component to one type of shock at a time, spanning the natural candidates, and dropping the GFS shock. The table reports the case of a global shock to home bias, marginal efficiency of investment, policy rates, TFP, and no global shocks at all. We clearly see that the fit, measured by the log data density, drops noticeably, relative to our preferred model, by more than 20 points. This remains true if we set γ equal to zero in the estimation of the model with the GFS shock and, therefore, do not allow the shock to directly affect the UIP condition.[25] Overall, these statistical results confirm that using a global shock that acts like a risk premium shock biased towards dollar-denominated assets is a promising approach for explaining international comovement and relative prices over the business cycle.

4.3 Macroeconomic and Exchange Rate Moments

This section provides additional insights on our findings by focusing on a set of key macroeconomic and exchange rate moments. The top part of the Table 8 shows correlations of world GDP growth with other world aggregates, the middle part shows pair-wise correlations between U.S. and foreign variables, and the bottom part presents real exchange rate moments that have been widely studied in the literature. The first column shows the corresponding values in the data and the remaining columns show the values of these moments in a model simulation in

[25] Notice though that this omission itself reduces the overall fit by 10 points, a sizable reduction.

which we feed the feed GFS shocks only (second column), the UIP shocks only (third column), and all the other shocks excluding these two (fourth column).

Several empirical patterns emerge from the data. First, world GDP growth is positively correlated with world investment and consumption growth as well as with world inflation and policy rates, as is consistent with typical country-specific business cycle moments. Second, world GDP growth is negatively correlated with credit spreads and with the dollar exchange rate, indicating that global downturns are associated with tight financial conditions and flight-to-safety flows that appreciate the U.S. dollar. Third, there is a considerable degree of comovement between U.S. and foreign variables. Fourth, exchange rates are very volatile (with exchange rate growth about four and a half times as volatile as U.S. GDP growth) and persistent, exhibit little correlation with relative consumption, and have a low, though positive, "Fama" coefficient (of 0.24 in our sample).[26] While these facts have been largely documented in the literature, it has proven challenging to provide a joint account of them.[27]

The estimated GFS shock delivers empirical properties of macroeconomic quantities and exchange rates in the model that are broadly consistent with the data. As reported in the third column of Table 8, the simulated series obtained by feeding only the GFS shock to our estimated model yields correlations of global variables and cross country comovements in line with their data counterpart. Notably, the shock also generates exchange rate moments broadly in line with the data, including the high relative exchange rate volatility and the low Fama coefficient. Hence, this shock plays a central role in allowing the model to capture fundamental properties of global macroeconomic and financial data. By contrast, the UIP shock, while consistent with some of the exchange rate properties, has implications for global macroeconomic moments that are generally at odds with the data.

4.4 Impulse Response Functions and Shock Transmission

We next analyze the transmission to the global economy of some of the key shocks considered in our estimation. Figure 3 shows the impulse responses to one-standard-deviation innovations

[26] When we consider a long sample starting in 1972, we find a Fama coefficient of -0.46. See Engel and Wu (2024) for evidence that the performance of "standard" exchange rate models has improved over time.

[27] For instance, standard IRBC models à *la* Backus et al. (1994) can reproduce domestic business cycle features when they consider country-specific (TFP) disturbances, but fail to explain movements in international prices and comovements among macroeconomic variables across countries, which are deemed "anomalies."

to the GFS shock (red lines), the U.S.-specific risk premium shock (blue, dash-dotted lines), and the UIP shock (yellow, dotted lines). A positive GFS shock depresses the level of U.S. and foreign GDP simultaneously and persistently, with a peak effect of about 0.4 percent in both countries. The lower activity is associated with lower inflation, particularly in the U.S., and an easing of monetary policy globally (not shown). Corporate bond spreads rise globally, and the U.S. dollar appreciates by nearly 1 percent on impact, before slowly returning to its pre-shock path. This dollar appreciation explains the larger drop in U.S. inflation compared, compared with foreign inflation.

While the size of the decline in GDP due to a GFS shock is virtually identical in both the U.S. and the foreign bloc, there are differences in its composition. The shock depresses foreign consumption and investment more than consumption and investment in the U.S. At the same time, the associated dollar appreciation contributes to depressing the trade balance in the U.S. (bottom right panel of Figure 3), hurting U.S. GDP. Thus, the decline in GDP abroad reflects depressed domestic absorption to a greater extent than in the U.S. Overall, the global effects of the GFS shock are consistent with a reorientation of capital flows away from the foreign economies and toward the U.S.: the dollar appreciates, foreign borrowing spreads rise somewhat more than those in the U.S., and foreign absorption falls more than absorption in the U.S.

Turning to the other shocks shown in Figure 3, we see that an increase in the U.S. risk premium shock induces similar dynamics as the GFS shock for U.S. GDP, inflation, the policy rate (not shown), and credit spreads. Unlike the GFS shock, however, the U.S. risk premium shock does not have any material spillovers to the foreign bloc and results in a dollar *depreciation*, as the expected path of U.S. real rates relative to foreign rates is lower to provide macroeconomic policy support to U.S. absorption. This dollar depreciation occurring alongside an increase credit spreads is at odds with the empirical cyclical properties documented in Table 8. Finally, a UIP shock leads to a large dollar appreciation but has little effect on U.S. and foreign macroeconomic variables. Hence, the estimation relies on the UIP shock to explain residual high-frequency variation in the dollar, with little macroeconomic imprint.

4.5 Exchange Rate Fluctuations, Fundamentals, and Predictability

This section provides a complementary perspective on the association between exchange rates and fundamentals. We first examine the historical exchange rate fluctuations through the lens of the model's version of the UIP condition. Specifically, we use our estimated model to explore whether observed exchange rate movements reflect fundamentals (embodied in both the interest differential term and in the GFS shock) or if instead they reflect "non-fundamental" factors of the kind emphasized by Itskhoki and Mukhin (2021), captured in the UIP shock ζ_t^{UIP}. Next, in the spirit of the Meese and Rogoff (1983) puzzle, we then turn to the performance of the estimated model in forecasting the exchange rate against a simple random walk model.

4.5.1 Exchange Rates and Fundamentals

Recall that equation (9) describes the standard uncovered interest parity condition relating the U.S. real exchange rate to interest rate differentials, the global flight-to-safety shock, and the residual UIP shock (up to bond adjustment costs). Iterating forward, we obtain

$$rer_t = \mathbb{E}_t\big[\sum_{i=0}^{\infty}(\hat{r}_{t+i}^{real} - \hat{r}_{t+i}^{real*})\big] + \gamma\overline{\zeta}_t^{GFS} + \overline{\zeta}_t^{UIP} - \overline{\chi}_t, \tag{41}$$

where $\hat{r}_t^{real} \equiv \hat{r}_t - \mathbb{E}_t[\pi_{t+1}]$ is the real interest rate, and

$$\overline{\zeta}_t^{GFS} \equiv \mathbb{E}_t\big[\sum_{i=0}^{\infty}\zeta_{t+i}^{GFS}\big] = \frac{1}{(1-\rho_{GFS})}\zeta_t^{GFS}, \tag{42}$$

$$\overline{\zeta}_t^{UIP} \equiv \mathbb{E}_t\big[\sum_{i=0}^{\infty}\zeta_{t+i}^{UIP}\big] = \frac{1}{(1-\rho_{UIP})}\zeta_t^{UIP}, \tag{43}$$

$$\overline{\chi}_t \equiv \mathbb{E}_t\big[\sum_{i=0}^{\infty}\chi_{t+i}\big] \tag{44}$$

are the forward-cumulated versions of ζ_t^{GFS}, ζ_t^{UIP}, and χ_t, respectively.[28] From equation (41), the dollar can appreciate because of a higher interest differential between the U.S. and the ROW, or because of positive flight-to-safety shocks ($\overline{\zeta}_t^{GFS}$, to the extent that $\gamma > 0$), or because of pure UIP shocks that raise households' utility from dollar-denominated bonds relative to that of bonds denominated in other currencies ($\overline{\zeta}_t^{UIP}$), or because of a lower expected path

[28] The real exchange rate is stationary in our model and equal to unity in steady state, so that $\lim_{i\to\infty}\mathbb{E}_t(rer_{t+i}) = 0$.

of dollar portfolio costs ($\overline{\chi}_t$). We interpret the first two terms in that equation as reflecting global fundamentals and the last two terms as reflecting forces not directly linked to real macroeconomic fundamentals, such as those stemming from financial imperfections or financial shocks (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021).

The black line in Figure 4 shows the value of the broad real dollar since 1990 (in four-quarter percent change), along with the variation explained by each of the components on the right-hand side of equation (41), shown by the colored bars.[29] A few observations stand out. First, the interest rate differential component plays a significant role in accounting for dollar movements: movements in the blue bars often track movements in the black line. Second, the flight-to-safety shock plays a significant role as well, particularly in the periods around the global slowdowns in our sample (the early 1990s, the early 2000s, and the GFC). All told, fundamental forces play a key role in driving exchange rate movements throughout the sample, and especially in the post-Global Financial Crisis period.

We next focus on two periods in which the dollar appreciated notably: the 2008 Global Financial Crisis (GFC), and the 2014-16 period. As shown in panel A of Figure 5, the model interprets the bulk of the dollar appreciation during the GFC as driven by the flight-to-safety shock. The interest differential component, by contrast, puts *downward* pressure on the dollar throughout the GFC, and the UIP shock plays a relatively minor role in this episode.

By contrast, as shown in panel B of Figure 5, the interest differential component explains the *entirety* of the dollar appreciation between 2014 and 2016: the model assigns a minimal role to both the flight-to-safety and the bond preference shocks in this period. This finding suggests that divergence in the anticipated policy rate paths between the U.S. and the ROW—which ultimately determine the path of the expected real rate differential—was largely responsible for the 20 percent appreciation of the dollar during this period.

A question of interest is whether the increasing gap between expected rate paths shown in the blue bars in panel B of Figure 5 is driven by movements in the expected path of U.S. rates, by movements the path of foreign rates, or by both. To address this question, in Figure 6, we show the expected sum of future short rates in each country bloc separately. The black, solid

[29] For simplicity, we bundle together the UIP shock component, $\overline{\zeta}_t^{UIP}$, and the portfolio cost component, $\overline{\chi}_t$, as both these components are associated with the economic forces highlighted in the "financial frictions" approach discussed in Maggiori (2022). Yakhin (2022) shows that to a first order, the financial friction in Gabaix and Maggiori (2015) is isomorphic to the bond portfolio cost assumed here.

line shows the U.S. path,

$$\hat{r}_{long,t} \equiv \mathbb{E}_t \sum_{i=0}^{\infty} \hat{r}^{real}_{t+i}, \tag{45}$$

and the blue, dashed line shows the foreign one,

$$\hat{r}^*_{long,t} \equiv \mathbb{E}_t \sum_{i=0}^{\infty} \hat{r}^{real*}_{t+i}. \tag{46}$$

The figure reveals that the divergence starting in 2014 is driven by a sharp rise in the expected path of U.S. rates. The home and foreign "long" rates had moved closely together between 2008 and 2014. From around 2015 onward, $\hat{r}_{long,t}$ rises sharply, while $\hat{r}^*_{long,t}$ remains close to its 2014 value. Thus, through the lens of the model, around 2015, market participants began expecting an increasingly steeper path of future U.S. real rates, while the expected path of foreign rates remained roughly unchanged. These developments triggered a sharp appreciation of the dollar.

4.5.2 Exchange Rate Predictability

We conclude our analysis of the link between exchange rates and fundamentals by discussing the performance of our estimated model with respect to forecasting the exchange rate. Since Meese and Rogoff (1983), a long literature has documented that a simple random walk model generates better forecasts of the nominal exchange rate than economic models (see Rossi (2013) for a recent review of the literature). Here, we show that our estimated model produces reasonable forecasts of the nominal exchange rate.

Table 9 reports the Root Mean Squared Error (RMSE) of forecasts of the broad real dollar at one-, three-, and five-year-ahead horizons. The first row presents RMSE derived from the estimated baseline model, while the second row reports those of a random walk model. The main finding of this exercise is that our estimated model does almost as well as the simple random walk model at short horizons (up to one year) but performs much better at medium horizons. As indicated by the third row, the RMSE of the estimated model is much lower than that of the random walk at three- and five-year horizons, the frequencies typically associated with business cycle dynamics. This finding is remarkable as it suggests that the model has a good statistical performance in explaining exchange rate fluctuations through a useful accounting of its fundamental forces, while it also allows for policy and counterfactual analysis.[30]

[30]Similar results hold for the real exchange rate. While we form each model forecast only based on data up to

5 Conclusion

We have estimated a macroeconomic model of the world economy featuring time variation in agents' preferences for safe assets, in which a component of this variation can be global and biased toward dollar-denominated safe assets. These GFS shocks emerge as the single most important driver of fluctuations in world GDP, explaining a considerable fraction of fluctuations in macroeconomic and financial variables, accounting for comovement across countries, and contributing to the resolution of exchange rate puzzles. A GFS shock depresses global activity and inflation, widens corporate borrowing spreads, and appreciates the dollar. Once these shocks are considered, exchange rate variations are largely accounted for by fundamentals; deviations from uncovered interest parity play only a limited role.

Our findings suggest that the importance of global factors in driving macroeconomic outcomes in individual countries may be greater than previously thought. This observation has material implications for questions such as the ability of domestically oriented monetary and financial policies to achieve stabilization objectives, the optimal design of such policies, and the desirability of coordinating policies across countries. These questions are interesting topics for future research.

the period of the forecast, we keep the model parameters fixed to the ones we estimated over the whole sample, giving the model forecast a certain advantage. As such, we view the results of the forecast exercise mainly as a validation of the model's ability to account for the exchange rate.

Tables and Figures

Table 1: Calibrated Parameters

Parameter	Symbol	Value
Home size	n	0.25
Discount factor	β	0.99
Depreciation rate of capital	δ	0.025
Capital share	α	0.29
Government expenditure as a share of GDP	$\frac{G}{Y}$	.22
Home bias in consumption goods	ω	.93
Home bias in investment goods	ω_I	0.5
Disutility weight on labor	ψ_n	370
Portfolio Cost	χ	0.01

Table 2: Estimated Structural Parameters: Prior and Posterior Distributions

		Prior			Posterior	
		Distr.	**Mean**	**SD**	**Mean**	**[10%, 90%]**
Preferences, Technology and Banking						
b	Habits	B	0.6	0.125	0.58	[0.54, 0.62]
η	Inverse Frisch	G	2	0.5	4.00	[3.17, 4.85]
θ	Home/foreign subst. elast.	B	2	0.33	2.06	[1.69, 2.46]
γ	GFS shock dollar bias	N	0	5	1.12	[0.74, 1.51]
ξ	Capital utilization cost	G	2	1	3.95	[2.40, 5.39]
ψ	Investment adj. cost	G	5	2	9.00	[6.80, 11.16]
ψ_i	Trade adj. cost	B	10	2	8.21	[4.56, 11.78]
ϕ	Steady-state leverage ratio	B	8	0.75	7.96	[6.84, 9.06]
σ	Banker survival	B	0.95	0.013	0.93	[0.91, 0.94]
100^*e	Banker endowment	IG	0.5	1	0.31	[0.14, 0.47]
Pricing						
θ_p	Dom. price rigidity	B	0.75	0.05	0.77	[0.73, 0.81]
θ_p^x	Trade price rigidity	B	0.75	0.05	0.68	[0.63, 0.73]
θ_w	Wage rigidity	B	0.75	0.05	0.91	[0.88, 0.94]
ι_p	Dom. price indexation	B	0.5	0.15	0.32	[0.21, 0.43]
ι_p^x	Trade price indexation	B	0.5	0.15	0.49	[0.23, 0.71]
ι_w	Wage indexation	B	0.5	0.15	0.10	[0.03, 0.16]
Monetary Policy						
φ_π	Taylor rule infl.	B	1.5	0.15	1.32	[1.17, 1.48]
φ_y	Taylor rule gap	B	0.1	0.033	0.11	[0.08, 0.14]
φ_r	Taylor rule lagged r	B	0.6	0.1	0.70	[0.65, 0.76]

Note: Prior and posterior distributions for structural parameters. B: "beta." N: "normal." G: "gamma." IG: "inverse gamma."

Table 3: Estimated Shock Parameters: Prior and Posterior Distribution

	Prior			Posterior	
	Distr.	**Mean**	**SD**	**Mean**	**[10%, 90%]**
Domestic Shocks					
$100\sigma_R$	IG	0.1	0.1	0.120	[0.105, 0.135]
σ_G	IG	0.01	0.05	0.018	[0.016, 0.020]
σ_I	IG	0.01	0.05	0.037	[0.028, 0.046]
σ_N	IG	0.01	0.05	0.030	[0.076, 0.134]
$100\sigma_{RP}$	IG	0.1	1	0.105	[0.076, 0.134]
σ_{μ_H}	IG	0.01	0.05	0.011	[0.009, 0.013]
σ_A	IG	0.01	0.05	0.005	[0.004, 0.005]
σ_κ	IG	0.005	0.05	0.008	[0.007, 0.010]
$100\sigma_{\bar{\pi}}$	IG	0.01	0.1	0.038	[0.032, 0.044]
ρ_R	B	0.4	0.125	0.577	[0.486, 0.664]
ρ_G	B	0.6	0.125	0.910	[0.871, 0.950]
ρ_I	B	0.6	0.125	0.914	[0.885, 0.942]
ρ_N	B	0.6	0.125	0.451	[0.280, 0.625]
ρ_{RP}	B	0.6	0.1	0.954	[0.939, 0.969]
ρ_{μ_H}	B	0.6	0.125	0.973	[0.962, 0.985]
ρ_A	B	0.6	0.125	0.922	[0.887, 0.958]
ρ_κ	B	0.6	0.125	0.815	[0.715, 0.922]
$\rho_{\bar{\pi}}$	B	0.995	0.002	0.995	[0.992, 0.998]
θ_{μ_H}	B	0.5	0.125	0.468	[0.352, 0.583]
θ_N	B	0.5	0.125	0.598	[0.459, 0.741]
Foreign Shocks					
$100\sigma_{UIP}$	IG	0.1	5	0.210	[0.130, 0.288]
$100\sigma_{R*}$	IG	0.1	0.1	0.095	[0.074, 0.117]
σ_{G*}	IG	0.01	0.05	0.010	[0.008, 0.012]
σ_{I*}	IG	0.01	0.05	0.050	[0.031, 0.068]
$100\sigma_{RP*}$	IG	0.1	1	0.158	[0.089, 0.224]
$\sigma_{\mu_{F*}}$	IG	0.01	0.05	0.011	[0.007, 0.015]
σ_{A*}	IG	0.01	0.05	0.013	[0.009, 0.018]
$\sigma_{\kappa*}$	IG	0.005	0.05	0.011	[0.009, 0.014]
ρ_{R*}	B	0.4	0.125	0.599	[0.487, 0.715]
ρ_{UIP}	B	0.6	0.125	0.909	[0.875, 0.945]
ρ_{G*}	B	0.6	0.125	0.809	[0.712, 0.911]
ρ_{I*}	B	0.6	0.125	0.453	[0.270, 0.638]
ρ_{RP*}	B	0.6	0.1	0.781	[0.693, 0.872]
$\rho_{\mu_{F*}}$	B	0.6	0.125	0.672	[0.504, 0.841]
ρ_{A*}	B	0.6	0.125	0.573	[0.392, 0.749]
$\rho_{\kappa*}$	B	0.6	0.125	0.774	[0.669, 0.882]
$\theta_{\mu_{F*}}$	IG	0.5	0.125	0.414	[0.233, 0.598]
Trade Shocks					
$\sigma_{\mu_{H*}}$	IG	0.01	0.05	0.057	[0.043, 0.071]
$\sigma_{\mu^P_{H*}}$	IG	0.01	0.05	0.025	[0.015, 0.035]
σ_{μ_F}	IG	0.01	0.05	0.014	[0.009, 0.019]
$\sigma_{\mu^P_F}$	IG	0.01	0.05	0.014	[0.011, 0.017]
σ_ω	IG	0.01	0.05	0.020	[0.010, 0.029]
$\sigma_{\omega*}$	IG	0.01	0.05	0.007	[0.003, 0.010]
$\rho_{\mu_{H*}}$	B	0.6	0.125	0.529	[0.345, 0.710]
$\rho_{\mu^P_{H*}}$	B	0.995	0.002	0.995	[0.992, 0.998]
ρ_{μ_F}	B	0.6	0.125	0.589	[0.389, 0.801]
$\rho_{\mu^P_F}$	B	0.995	0.002	0.995	[0.992, 0.998]
ρ_ω	B	0.6	0.125	0.816	[0.744, 0.888]
$\rho_{\omega*}$	B	0.6	0.125	0.765	[0.660, 0.875]
$\theta_{\mu_{H*}}$	B	0.5	0.125	0.571	[0.383, 0.753]
θ_{μ_F}	B	0.5	0.125	0.524	[0.330, 0.724]
GFS Shock					
$100\sigma_{GFS}$	IG	0.1	1	0.066	[0.051, 0.081]
ρ_{GFS}	B	0.6	0.125	0.957	[0.943, 0.971]

Note: Prior and posterior distributions for shock parameters. B:"beta." N: "normal." G: "gamma." IG: "inverse gamma."

Table 4: Variance Decomposition, World Variables

	Global flight-to-safety	**U.S. risk premium**	**Foreign risk premium**	**UIP**	**Monetary**	**Government**	**Markup**	**Inflation target**	**Home bias**	**Banking friction**	**Investment**	**TFP and labor supply**
World GDP growth	22.2	2.2	8.1	0	16.3	16	7.6	0.7	0	0.5	8.4	18.1
World consumption growth	22.9	5.2	15.5	0	19.5	1	7.8	0.9	0	0	1.5	25.5
World investment growth	17	0.5	0.5	0	8.6	0.4	10.6	0.3	0	3.4	49.8	9.1
World spread	75.5	0.6	2.1	0	4.8	0.1	1.2	0.2	0	11.4	1.7	2.8
World inflation	1.5	0.2	0.1	0	0.5	0.1	28.1	50.4	0	0	1.1	16.4
World policy rate	18	1.9	0.8	0	14.8	0.3	5.5	45.9	0	0.1	0.6	11.5
Real exchange rate growth	10.4	4.6	0.2	38.6	12.8	0.4	13.6	0.6	12.4	0	0.7	5.9

Note: The table shows the variance decomposition of world variables in the model, based on shock innovations from their Gaussian distributions. The first four columns show the individual contributions of the global flight-to-safety shock, the U.S. and foreign risk premium shocks, and the UIP shock, respectively. Each of the columns from "Monetary" through "Investment" bundles together the U.S. and foreign versions of each corresponding shock. The last column bundles together U.S. and foreign TFP and labor supply shocks.

Table 5: Variance Decomposition, U.S. Variables

	Global flight-to-safety	**All foreign shocks**	**UIP**	**U.S. home bias**	**U.S. risk premium**	**U.S. monetary**	**U.S. government**	**U.S. markup**	**U.S. inflation target**	**Banking friction**	**U.S. Investment**	**U.S. TFP and labor supply**
U.S. GDP growth	7.9	10.6	0.1	6.2	13.9	11.1	21.5	5	0.4	0.1	11.2	11.4
U.S. consumption growth	2.6	11.3	7.3	1.5	43.7	11.8	2.1	3.3	0.4	0	3.1	12.8
U.S. investment growth	0.2	4.9	5.8	0.6	1.1	2.6	0.2	5.4	0.1	0.8	75.8	2.1
U.S. spread	51.9	0.6	1.6	0.3	10.6	8.1	0.5	2.6	0.3	8.3	14.6	2.3
U.S. inflation	2.9	22.5	7.6	1.4	1.4	2	0.1	14.3	27.6	0	3.2	15.8
U.S. policy rate	12.5	1.4	0.9	0.9	10.9	16.1	0.6	8.9	34.2	0.1	1.4	12.2
U.S. hours	20.5	17.5	1.2	6.4	12.7	6	3	7.8	0.1	0	17.9	6.9
U.S. real exchange rate growth	10.4	24.2	38.5	6.7	4.5	7.6	0.3	4.4	0.3	0	0.6	2.3
U.S. import growth	0.7	3.6	1.7	55.9	0.8	2.4	0.5	5.8	0.1	0.3	25.1	2.5
U.S. export growth	10.9	54.7	19.3	3.8	3	3.4	0.2	2.3	0.1	0	1	1.2

Note: The table shows the variance decomposition of U.S. variables in the model, based on shock innovations from their Gaussian distributions. The first column shows the contribution of the global flight-to-safety shock. The second column bundles together all foreign shocks. The following columns show the contribution of the indicated shocks. The last column bundles together the U.S. TFP and labor supply shocks.

Table 6: Variance Decomposition, Foreign Variables

	Global flight-to-safety	**All U.S. shocks**	**UIP**	**Foreign home bias**	**Foreign risk premium**	**Foreign monetary**	**Foreign government**	**Foreign markup**	**Foreign inflation target**	**Foreign banking friction**	**Foreign Invest-ment**	**Foreign TFP**
Foreign GDP growth	17.7	1.9	0	1.7	10.4	17.7	16	8	0.8	0.4	5.2	19.7
Foreign consumption growth	21.4	1.4	1.6	0.3	19.7	18.5	0.6	8	0.9	0	0.6	26.7
Foreign investment growth	23.9	3.1	2.7	0.2	0.7	9.8	0.2	6.3	0.4	4.6	39	8.7
Foreign spread	67.6	0.3	0.2	0	3.4	6.4	0.1	1.5	0.3	16.4	1	3.7
Foreign inflation	1.2	1.5	1.6	0.2	0.1	0.7	0	25.4	52.9	0	0.3	14.2
Foreign policy rate	11	0.5	0.1	0.1	0.9	16	0.2	5.5	52.9	0	0.2	11.4

Note: The table shows the variance decomposition of foreign variables in the model, based on shock innovations from their Gaussian distributions. The first column shows the contribution of the global flight-to-safety shock. The second column bundles together all U.S. shocks. The following columns show the contribution of the indicated shocks.

Table 7: Log Data Density and Share of Dollar Variance
Accounted for by UIP Shocks with Alternative Global Shocks

	Log Data Density Modified Harmonic Mean	Share of Dollar Growth Variance Accounted for by UIP shock
Baseline Model	8543.7	38
Global Shock to Home Bias	8508.1	52
Global Shock to MEI	8516.3	52
Global Shock to Policy Rates	8519.9	45
Global Shock to TFP	8485.3	49
No Global Shocks	8501.9	49
$\gamma = 0$	8532.2	44

Table 8: International Correlations and Exchange Rate Moments

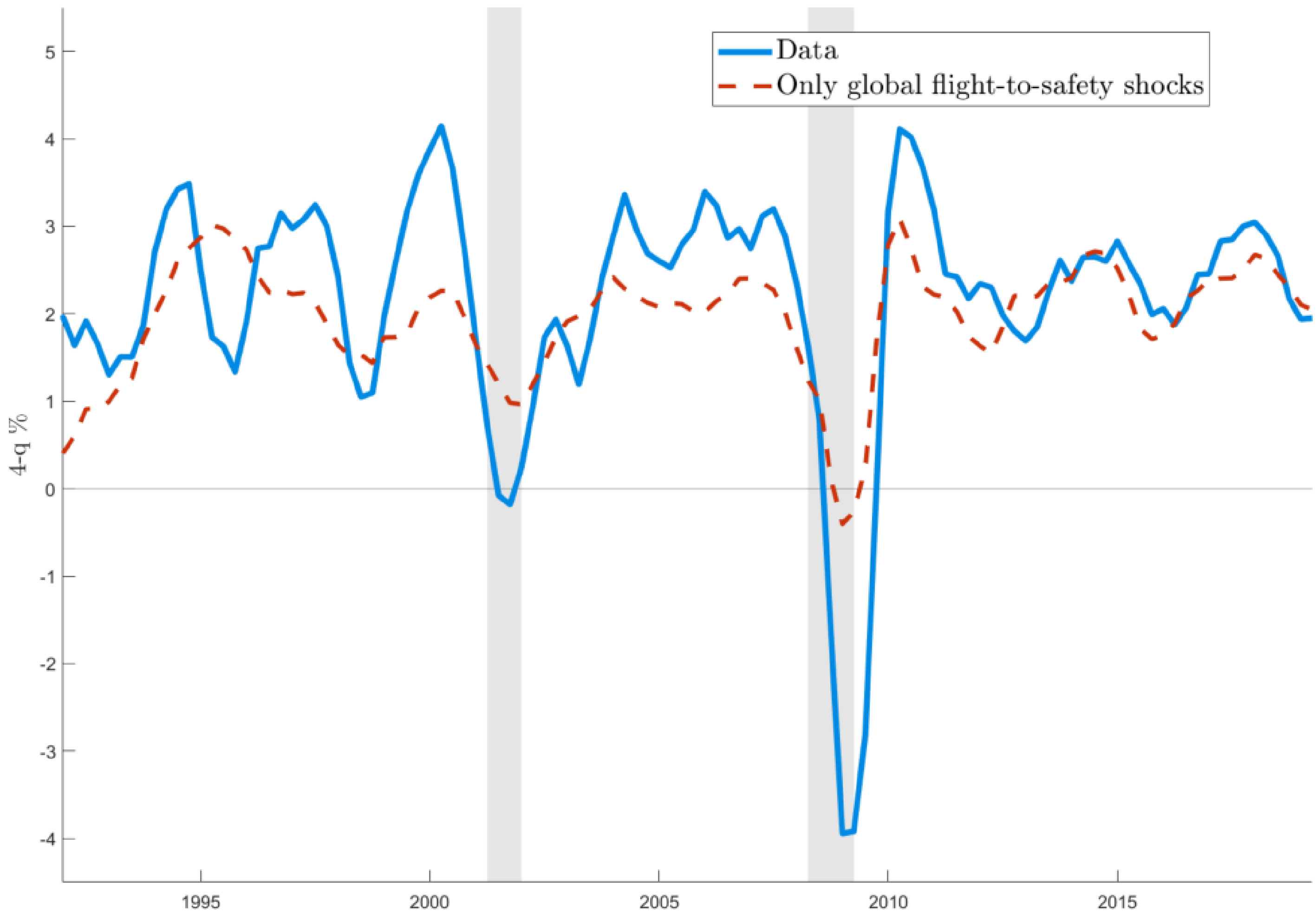
	Data	**GFS shock**	**UIP shock**	**All shocks except GFS and UIP**
A. Correlation of world GDP growth with:				
World consumption growth	0.765	0.974	0.685	0.743
World investment growth	0.800	0.893	0.802	0.616
World credit spread	-0.497	-0.417	0.897	-0.378
World inflation	0.270	0.720	0.510	-0.257
World policy rate	0.099	-0.044	0.356	-0.213
Change in dollar real exchange rate	-0.282	-0.786	-0.038	0.135
B. Correlations between U.S. and foreign:				
GDP growth	0.528	0.998	-0.974	0.063
Consumption growth	0.384	0.848	-1.000	-0.035
Investment growth	0.352	0.229	-0.999	0.042
Credit spread	0.919	0.984	-0.994	-0.039
Inflation	0.403	-0.077	-0.992	-0.018
Policy rate	0.845	0.991	-0.916	0.013
C. Exchange rate disconnect moments:				
$\rho(\Delta ner)$	0.253	-0.041	-0.063	0.107
$\sigma(\Delta ner)$, annualized %	9.753	3.436	6.595	7.427
$\sigma(\Delta ner)/\sigma(\Delta y)$	4.404	4.070	96.266	2.597
$\rho(rer)$	0.963	0.900	0.850	0.986
$\sigma(\Delta rer)/\sigma(\Delta ner)$	0.964	0.983	0.984	1.006
corr$(\Delta rer, \Delta ner)$	0.944	0.998	0.999	0.922
corr$(rer, c^* - c)$	-0.048	-0.006	-0.003	-0.015
Fama β	0.238	-2.256	-4.284	0.990
Fama R^2	0.003	0.023	0.036	0.153
$\sigma(\Delta y^{\text{world}})$, annualized %	1.745	0.894	0.004	1.670
$\sigma(\Delta c^{\text{world}})/\sigma(\Delta y^{\text{world}})$	0.795	1.034	0.853	1.011
$\sigma(\Delta inv^{\text{world}})/\sigma\Delta y^{\text{world}})$	2.483	2.238	5.562	2.655
corr(Δrer, world credit spread)	0.225	0.149	0.000	-0.032

Table 9: Dollar Forecast: Estimated DSGE Model vs. Random Walk

	RMSE 1-year	RMSE 3-year	RMSE 5-year
Estimated DSGE Model	5.27	8.22	10.39
Random Walk	5.24	10.80	16.12
Ratio: Model/Random Walk	1.01	0.76	0.64

Note: The table reports the Root Mean Squared Error (RMSE) of 1-year ahead, 3-year ahead, and 5-year ahead forecasts of the broad nominal dollar, constructed from the estimated DSGE model and from a random walk model of the dollar. The sample is from 1992Q1 to 2019Q2. We multiply the RMSE by 100 for better readability.

Figure 1: The Role of the GFS Shock in World GDP Growth

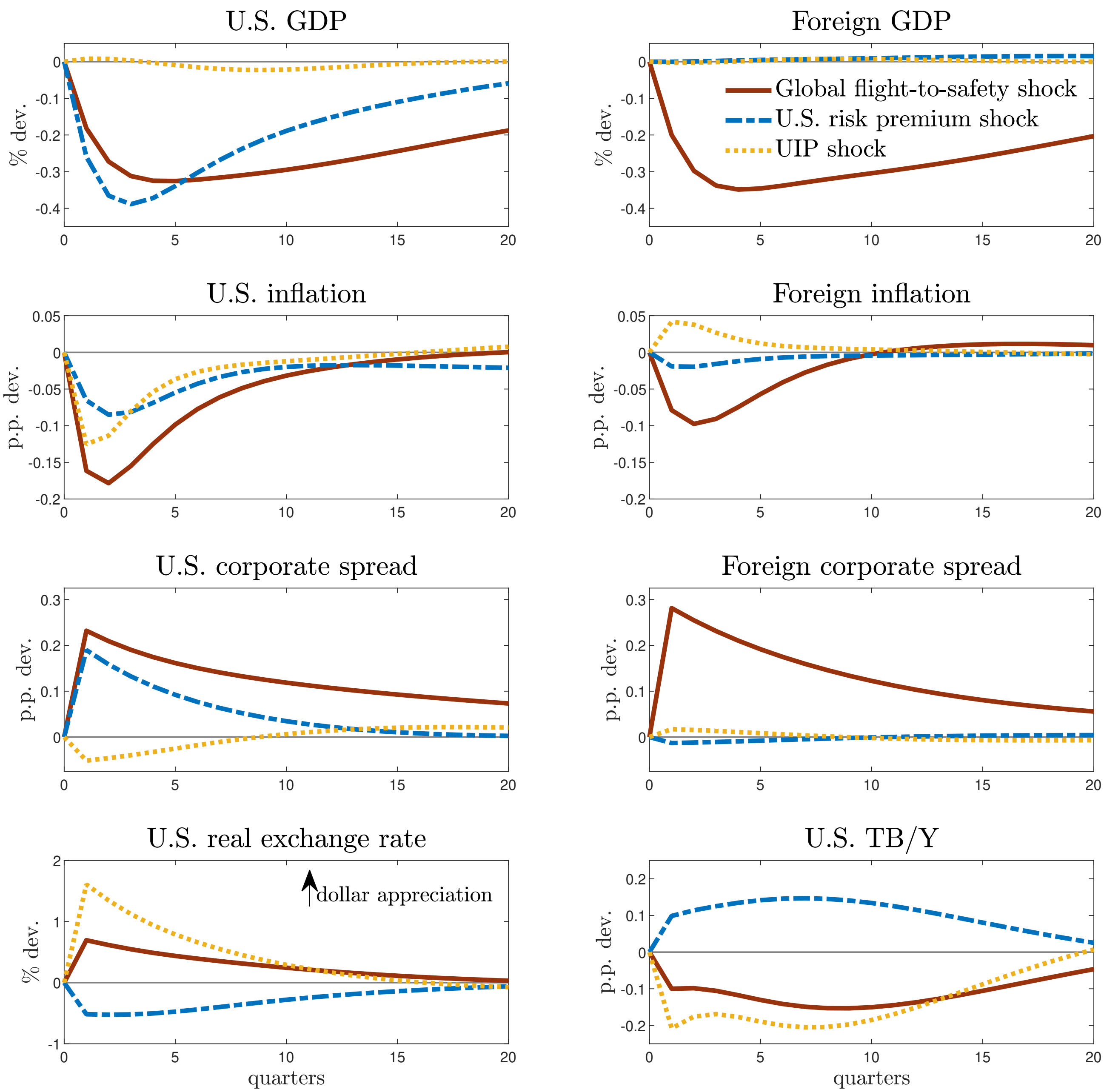


Note: World GDP growth in the data (blue, solid line) and in the model with GFS shocks only (red, dashed line). Shaded areas indicate global recessions, defined as periods when countries representing 50 percent of global GDP are classified as being in a recession.

Figure 2: The Role of the GFS Shock in U.S. and Foreign GDP Growth

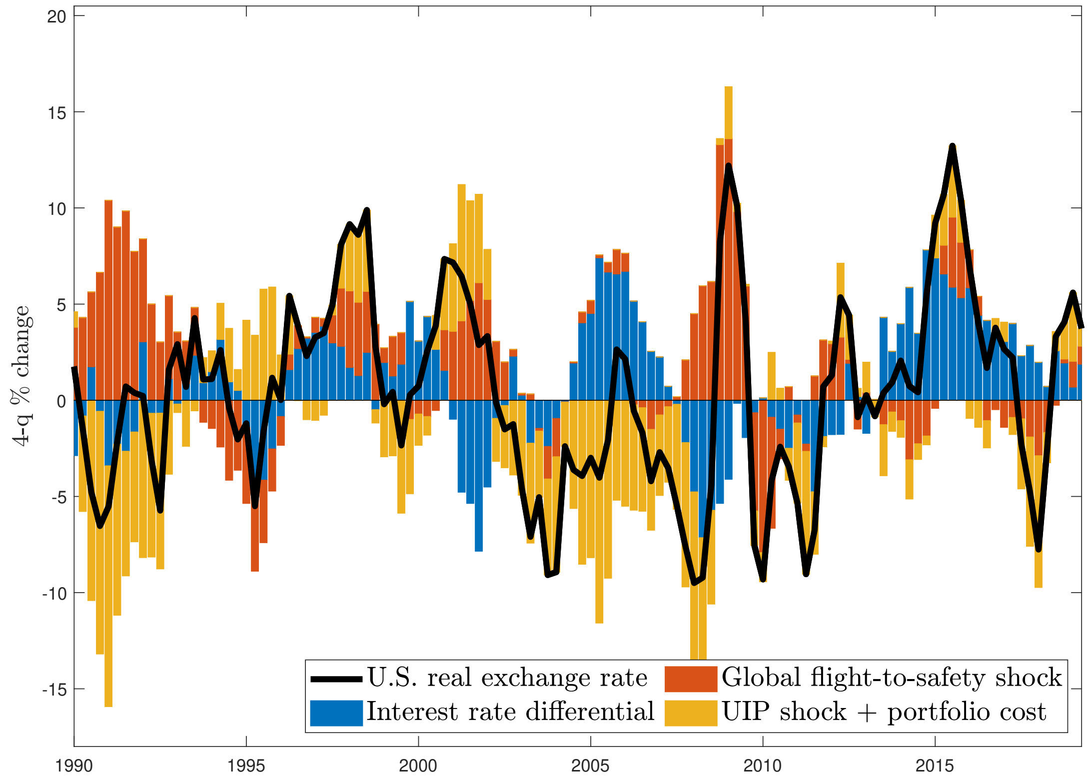
Note: Foreign (left panel) and U.S. (right panel) GDP growth in the data (blue, solid line) and in the model with GFS shocks only (red, dashed line). Shaded areas in the left chart indicate foreign recessions, defined as periods when countries representing 50 percent of non-U.S. GDP are classified as being in a recession. Shaded areas in the right chart indicate U.S. NBER recessions.

Figure 3: Risk Shocks in the Model: Impulse Responses



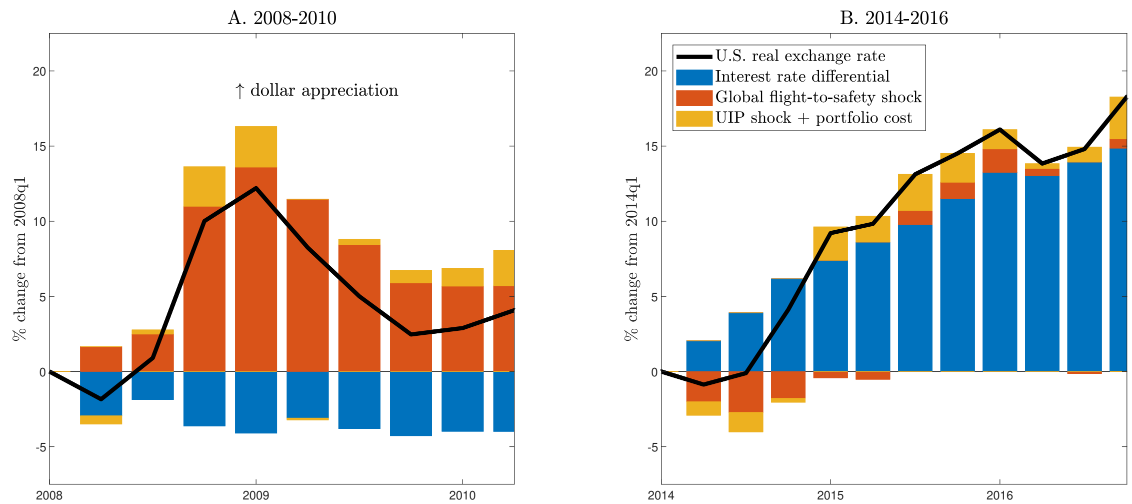
Note: Model impulse responses to a one-standard-deviation global flight-to-safety shock (red, thick line), U.S. risk premium shock (blue, dash-dotted line), and UIP shock (yellow, dotted line).

Figure 4: Drivers of Exchange Rate Movements



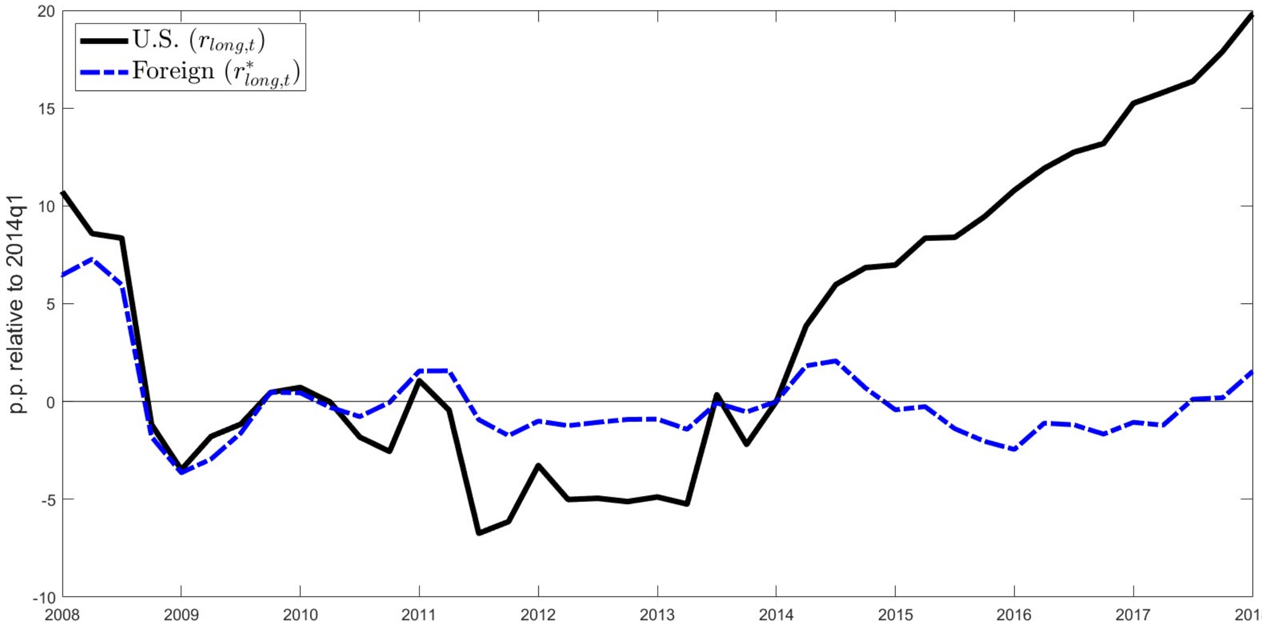
Note: The figure plots broad real dollar and its three components from decomposition (41) in 4-quarter percent changes. The black solid line shows the broad real dollar, the blue bars correspond to the interest rate differential, the red bars correspond to the flight-to-safety shock, and the yellow bars correspond to the UIP shock plus the portfolio cost.

Figure 5: Drivers of Exchange Rate Movements: Two Episodes



Note: The two panels plot the broad real dollar and its three components from decomposition (41) for the periods 2008-10 and 2014-16 as a percentage change from the level in the initial quarter. The black, solid line shows the broad real dollar, the blue bars correspond to the interest rate differential, the red bars correspond to the flight-to-safety shock, and the yellow bars correspond to the UIP shock plus the portfolio cost.

Figure 6: Evolution of U.S. and Foreign Long Rates, 2008-18



Note: The figure shows the evolution of U.S. and foreign "long rates," given by equations (45) and (46), respectively. Both series are rescaled so they are expressed relative to their 2014q1 level.

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Appendix

A Details on Agents' Decision Problems

A.1 Households

Home Optimization Problem:

The domestic household chooses consumption, (C_t), savings, $(B_{H,t}, D_t)$, and labor supply, $(\{n_t(i), w_t(i)\})$, to maximize its lifetime utility given by

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left\{ \log\left(C_{t+j} - b\overline{C}_{t+j-1}\right) + (\zeta^{RP}_{t+j} + \zeta^{GFS}_{t+j}) U(B_{H,t+j}) - \frac{\psi_N}{1+\eta} \int_{i \in \mathcal{W}_{t+j}} n_{t+j}(i)^{1+\eta} di \right\},$$

subject to

$$P_t C_t + \frac{B_{H,t}}{R_t} + \frac{D_t}{R^d_t} = \int_{i \in \mathcal{W}_t} w_t(i) n_t(i) di + B_{H,t-1} + D_{t-1} + \widetilde{\Pi}_t + T_t,$$

$$w_t(i) = \begin{cases} w_{t-1}(i) & \text{with probability } \theta_w, \\ w^o_t(i) & \text{with probability } 1-\theta_w, \end{cases}$$

$$n_t(i) = \left[\frac{w_t(i)}{W_t}\right]^{-\frac{1+\mu_{w,t}}{\mu_{w,t}}} N_t.$$

Optimality Conditions:

Taking FOCs and aggregating across households renders the following optimality conditions.

Consumption, C_t:

$$\frac{1}{C_t - bC_{t-1}} = \Xi_t P_t,$$

where Ξ_t is the Lagrange multiplier associated with the households' budget constraint. We define $\lambda_t \equiv \Xi_t P_t$.

Let $\Lambda_{t,s}$ denote the (real) stochastic discount factor between time t and time s, and π_t be (CPI) inflation:

$$\Lambda_{t,s} = \beta^{s-t} \frac{C_t - bC_{t-1}}{C_s - bC_{s-1}},$$

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}.$$

Home currency bonds, $B_{H,t}$:

$$1 = \mathbb{E}_t \Lambda_{t,t+1} \frac{R_t}{1+\pi_{t+1}} + (\zeta_t^{RP} + \zeta_t^{GFS}) \frac{\partial U(B_{H,t})}{\partial B_{H,t}} \frac{R_t P_t}{\lambda_t}. \tag{A.1}$$

Deposits, D_t:

$$1 = \mathbb{E}_t \Lambda_{t,t+1} \frac{R_t^d}{1+\pi_{t+1}}. \tag{A.2}$$

Optimal reset wage, $w_t^o(i)$:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} (\theta_w)^j \left(\frac{e^{\zeta_{t+j}^n} \psi_N n_{t+j}(i)^\eta}{\lambda_{t+j}} (1+\mu_w) - \frac{w_t^o(i)}{P_{t+j}} \right) = 0. \tag{A.3}$$

Labor, $n_t(i)$:

$$n_t(i) = \left[\frac{w_t(i)}{W_t} \right]^{-\frac{1+\mu_{w,t}}{\mu_{w,t}}} N_t. \tag{A.4}$$

Wage evolution, $w_t(i)$:

$$w_t(i) = \begin{cases} w_{t-1}(i) & \text{with probability } \theta_w, \\ w_t^o(i) & \text{with probability } 1-\theta_w. \end{cases} \tag{A.5}$$

Foreign Optimization Problem:

The foreign household chooses consumption, (C_t^*), savings, $\left(B_{F,t}^*, B_{H,t}^*, D_t^*\right)$, and labor supply, $(\{n_t^*(i), w_t^*(i)\})$, to maximize its lifetime utility, given by

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \Big\{ \log\left(C_{t+j}^* - b\overline{C}_{t+j-1}^* \right) + \left[\zeta_{t+j}^{RP*} + \zeta_{t+j}^{GFS} \right] U(B_{F,t+j}^*) + \left[\zeta_{t+j}^{RP*} + (1+\gamma)\zeta_{t+j}^{GFS} + \zeta_{t+j}^{UIP} \right] U(B_{H,t+j}^*) \\ - \frac{\psi_N}{1+\eta} \int_{i \in \mathcal{W}_{t+j}^*} n_{t+j}^*(i)^{1+\eta} di \Big\},$$

subject to

$$P_t^* C_t^* + \frac{B_{F,t}^*}{R_t^*} + \frac{\mathcal{E}_t B_{H,t}^*}{R_t \Psi_t} + \frac{D_t^*}{R_t^{d*}} = \int_{i \in \mathcal{W}_t^*} w_t^*(i) n_t^*(i) di + B_{F,t-1}^* + \mathcal{E}_t B_{H,t-1}^* + D_{t-1}^* + \widetilde{\Pi}_t^* + T_t^*,$$

$$w_t^*(i) = \begin{cases} w_{t-1}^*(i) & \text{with probability } \theta_w, \\ w^{o*}_t(i) & \text{with probability } 1-\theta_w, \end{cases}$$

$$n_t^*(i) = \left[\frac{w_t^*(i)}{W_t^*} \right]^{-\frac{1+\mu_w}{\mu_w}} N_t^*.$$

Optimality Conditions:

Consumption, C_t^*:

$$\frac{1}{C_t^* - bC_{t-1}^*} = \Xi_t^* P_t^* \equiv \lambda_t^*.$$

Foreign currency bonds, $B_{F,t}^*$:

$$1 = \mathbb{E}_t \Lambda_{t,t+1}^* \frac{R_t^*}{1+\pi_{t+1}^*} + (\zeta_t^{RP*} + \zeta_t^{GFS}) \frac{\partial U(B_{F,t}^*)}{\partial B_{F,t}^*} \frac{R_t^* P_t^*}{\lambda_t^*}. \quad \text{(A.6)}$$

Home currency bonds, $B_{H,t}^*$:

$$1 = \mathbb{E}_t \Lambda_{t,t+1}^* \frac{R_t \Psi_t}{1+\pi_{t+1}} \frac{RER_{t+1}}{RER_t} + (\zeta_t^{RP*} + (1+\gamma)\zeta_t^{GFS} + \zeta_t^{UIP}) \frac{\partial U(B_{H,t}^*)}{\partial B_{H,t}^*} \frac{R_t P_t}{\lambda_t^* RER_t}. \quad \text{(A.7)}$$

Deposits, D_t^*:

$$1 = \beta \mathbb{E}_t \Lambda_{t,t+1}^* \frac{R_t^{d*}}{1+\pi_{t+1}^*}. \quad \text{(A.8)}$$

Optimal reset wage, $w^{o*}_t(i)$:

$$\mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j}^* (\theta_w)^j \left(\frac{e^{\zeta_{t+j}^{*n}} \psi_N n_{t+j}^*(i)^\eta}{\lambda_{t+j}^*} (1+\mu_w) - \frac{w^{o*}_t(i)}{P_{t+j}^*} \right) = 0. \quad \text{(A.9)}$$

Labor, $n_t^*(i)$:

$$n_t^*(i) = \left[\frac{w_t^*(i)}{W_t^*} \right]^{-\frac{1+\mu_w}{\mu_w}} N_t^*. \quad \text{(A.10)}$$

Wage evolution, $w_t^*(i)$:

$$w_t^*(i) = \begin{cases} w_{t-1}^*(i) & \text{with probability } \theta_w, \\ w_t^{o*}(i) & \text{with probability } 1-\theta_w. \end{cases} \quad \text{(A.11)}$$

A.2 Bankers

Bank Optimal Utilization Choice:

A bank that enters time t with K_{t-1} units of capital and d_{t-1} real deposits can choose utilization at time t to maximize net worth:

$$\tilde{x}_t^o(K_{t-1}, d_{t-1}) \equiv \max_{u_t} \left(r_t^k u_t + Q_t (1-\delta) \right) K_{t-1} - d_{t-1} \frac{P_{t-1}}{P_t} - r^k \frac{\left(e^{\xi(u_t-1)} - 1\right)}{\xi} K_{t-1},$$

where the last term is the capital utilization cost given the specification adopted for $\mathcal{A}(u_t)$, and r^k is the steady-state value of the rental rate.

The optimality condition for u_t is

$$r_t^k = r^k e^{\xi(u_t-1)}. \quad \text{(A.12)}$$

Letting the optimized return on capital be given by

$$\hat{r}_t^k = r_t^k u_t - r^k \frac{\left(e^{\xi(u_t-1)} - 1\right)}{\xi}, \tag{A.13}$$

we have that at a first order, the effect of u_t on bank returns vanishes:

$$\hat{r}_t^k \approx r^k + \tilde{r}_t^k + r^k \tilde{u}_t - r^k e^{\xi(u-1)} \tilde{u}_t = r^k + \tilde{r}_t^k,$$

where the last equality follows from $u = 1$.

Bank Dynamic Portfolio Problem:

Let the banker's leverage ratio be

$$\phi_t \equiv \frac{Q_t K_t}{x_t}. \tag{A.14}$$

Using this expression and budget constraint (13), we can define

$$x_{t+1}^o(\phi_t, x_t) = \tilde{x}_{t+1}^o \left(\frac{\phi_t x_t}{Q_t}, (\phi_t - 1) x_t R_t^d \right).$$

We can now express the banker's problem recursively as follows:

$$V_t^o(x_t) = \max_{\phi_t} \beta \mathbb{E}_t \Lambda_{t,t+1} \left[(1-\sigma) x_{t+1}^o(\phi_t, x_t) + \sigma V_{t+1}^o(x_{t+1}^o(\phi_t, x_t)) \right],$$

subject to the incentive constraint (15) rewritten using equation (A.14) as

$$\frac{V_t}{x_t} \geq e^{\zeta_t^\kappa} \kappa \phi_t.$$

Assuming the incentive constraint binds and defining $\psi_t \equiv \frac{V_t}{x_t}$, the banker's optimality conditions are

$$\psi_t = e^{\zeta_t^\kappa} \kappa \phi_t, \tag{A.15}$$

$$\psi_t = \beta \mathbb{E}_t \Lambda_{t,t+1} \left(1 - \sigma + \sigma \psi_{t+1}\right) \left[\phi_t \left(\frac{\hat{r}_t^k + (1-\delta) Q_{t+1}}{Q_t} - \frac{R_t^d}{1+\pi_{t+1}} \right) + \frac{R_t^d}{1+\pi_{t+1}} \right]. \tag{A.16}$$

Aggregating banks' net worth yields

$$\bar{x}_t = \sigma \bar{x}_{t-1} \left[\phi_t \left(\frac{\hat{r}_t^k + (1-\delta) Q_{t+1}}{Q_t} - \frac{R_t^d}{1+\pi_{t+1}} \right) + \frac{R_t^d}{1+\pi_{t+1}} \right] (1+e), \tag{A.17}$$

where e is the fixed ratio between the total startup net worth that the family transfers to new bankers and the net worth of bankers that survive from the previous period.

Similarly, for foreign banks, we can collect optimality conditions for $\{u_t^*, \hat{r}_t^{k*}, K_t^*, \phi_t^*, \psi_t^*, \bar{x}_t^*\}$:

$$r_t^{k*} = r^k e^{\xi(u_t^*-1)}, \tag{A.18}$$

$$\hat{r}_t^{k*} = r_t^{k*} u_t - r^k \frac{\left(e^{\xi(u_t^*-1)} - 1\right)}{\xi}, \tag{A.19}$$

$$\phi_t^* = \frac{Q_t^* K_t^*}{\bar{x}_t^*}, \tag{A.20}$$

$$\psi_t^* = e^{\zeta_t^{\kappa*}} \kappa \phi_t^*, \tag{A.21}$$

$$\psi_t^* = \beta \mathbb{E}_t \Lambda_{t,t+1}^* \left(1 - \sigma + \sigma \psi_{t+1}^*\right) \left[\phi_t^* \left(\frac{\hat{r}_t^{k*} + (1-\delta) Q_{t+1}^*}{Q_t^*} - \frac{R_t^{*d}}{\pi_{t+1}^*}\right) + \frac{R_t^{*d}}{\pi_{t+1}^*}\right], \tag{A.22}$$

$$\bar{x}_t^* = \sigma \bar{x}_{t-1}^* \left[\phi_t^* \left(\frac{\hat{r}_t^{k*} + (1-\delta) Q_{t+1}^*}{Q_t^*} - \frac{R_t^{*d}}{1 + \pi_{t+1}^*}\right) + \frac{R_t^{*d}}{1 + \pi_{t+1}^*}\right] (1 + e). \tag{A.23}$$

A.3 Employment Agencies

Employment agencies choose N_t and $\{n_t(j)\}$ to maximize profits:

$$W_t N_t - \int_{j \in \mathcal{W}_t} w_t(j) n_t(j) dj,$$

subject to

$$N_t = \left[\int_{j \in \mathcal{W}_t} n_t(j)^{\frac{1}{1+\mu_{w,t}}} dj\right]^{1+\mu_{w,t}}.$$

The optimality conditions are given by the relative demand schedules in equation (A.4) plus a zero profit condition:

$$W_t^{-\frac{1}{\mu_{w,t}}} = \int_{j \in \mathcal{W}_t} w_t(j)^{-\frac{1}{\mu_{w,t}}} dj. \tag{A.24}$$

Abroad, there are no wage markup shocks, and the aggregate wage index there is given by

$$W_t^{*-\frac{1}{\mu_w}} = \int_{j \in \mathcal{W}_t^*} w_t(j)^{*-\frac{1}{\mu_w}} dj. \tag{A.25}$$

A.4 Final Consumption and Investment Goods

Choice of Domestic vs Foreign Intermediate:

Producers of the final consumption good choose $(C_{H,t}, C_{F,t}, C_t^d)$ to maximize the expected present value of profits given by

$$\mathbb{E}_t \sum_{i=0}^{\infty} \Lambda_{t,t+i} \left(C^d_{t+i} - \frac{P_{H,t+i}}{P_{t+i}} C_{H,t+i} - \frac{P_{F,t+i}}{P_{t+i}} C_{F,t+i} \right),$$

subject to the CES production technology

$$C^d_t = \left[\left(e^{\zeta^\omega_t} \omega\right)^{1/\theta} C_{H,t}^{\frac{\theta-1}{\theta}} + \left(1 - e^{\zeta^\omega_t} \omega\right)^{1/\theta} \left((1 - \psi^{M,C}_t) C_{F,t} \right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{A.26}$$

subject to equation (17), where $P_{H,t}$ and $P_{F,t}$ are the price of the domestic and foreign intermediate goods bundles, respectively. Similarly, producers of the final investment good choose $(I_{H,t}, I_{F,t}, I_t)$ to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} \Lambda_{t,t+i} \left(\frac{P_{I,t+i}}{P_{t+i}} I_{t+i} - \frac{P_{H,t+i}}{P_{t+i}} I_{H,t+i} - \frac{P_{F,t+i}}{P_{t+i}} I_{F,t+i} \right),$$

where the costs of adjusting consumption and investment imports are given by

$$\psi^{M,C}_t = \frac{\psi_i}{2} \left[\frac{\frac{C_{F,t}}{C_{F,t-1}}}{\frac{C_{H,t}}{C_{H,t-1}}} - 1 \right]^2 \qquad ; \qquad \psi^{M,I}_t = \frac{\psi_i}{2} \left[\frac{\frac{I_{F,t}}{I_{F,t-1}}}{\frac{I_{H,t}}{I_{H,t-1}}} - 1 \right]^2 .$$

Letting $p_{J,t} \equiv \frac{P_{J,t}}{P_t}$ for $J \in H, F$, the optimality conditions for $C_{H,t}$ and $C_{F,t}$ can be written as

$$\begin{aligned} p_{H,t} \;=\; & \left[e^{\zeta^\omega_t} \omega \left(\frac{C^d_t}{C_{H,t}} \right) \right]^{\frac{1}{\theta}} - \left[\left(1 - e^{\zeta^\omega_t} \omega\right) \left(\frac{C^d_t}{C_{F,t}} \right) \right]^{\frac{1}{\theta}} C_{F,t} \left(1 - \psi^{M,C}_t \right)^{-\frac{1}{\theta}} \frac{\partial \psi^{M,C}_t}{\partial C_{H,t}} \\ & - \beta \mathbb{E}_t \Lambda_{t,t+1} \left[\left(1 - e^{\zeta^\omega_{t+1}} \omega\right) \left(\frac{C^d_{t+1}}{C_{F,t+1}} \right) \right]^{\frac{1}{\theta}} C_{F,t+1} \left(1 - \psi^{M,C}_{t+1} \right)^{-\frac{1}{\theta}} \frac{\partial \psi^{M,C}_{t+1}}{\partial C_{H,t}}, \end{aligned} \tag{A.27}$$

$$\begin{aligned} p_{F,t} \;=\; & \left[\left(1 - e^{\zeta^\omega_t} \omega\right) \left(\frac{C^d_t}{C_{F,t}} \right) \right]^{\frac{1}{\theta}} - \left[\left(1 - e^{\zeta^\omega_t} \omega\right) \left(\frac{C^d_t}{C_{F,t}} \right) \right]^{\frac{1}{\theta}} C_{F,t} \left(1 - \psi^{M,C}_t \right)^{-\frac{1}{\theta}} \frac{\partial \psi^{M,C}_t}{\partial C_{F,t}} \\ & - \beta \mathbb{E}_t \Lambda_{t,t+1} \left[\left(1 - e^{\zeta^\omega_{t+1}} \omega\right) \left(\frac{C^d_{t+1}}{C_{F,t+1}} \right) \right]^{\frac{1}{\theta}} C_{F,t+1} \left(1 - \psi^{M,C}_{t+1} \right)^{-\frac{1}{\theta}} \frac{\partial \psi^{M,C}_{t+1}}{\partial C_{F,t}}. \end{aligned} \tag{A.28}$$

Similarly, letting $p_{I,t} = \frac{P^I_t}{P_t}$, an analogous problem for investment good producers, yields the following optimality conditions:

$$\begin{aligned} \frac{p_{H,t}}{p^I_t} \;=\; & \left[e^{\zeta^\omega_t} \omega_I \left(\frac{I_t}{I_{H,t}} \right) \right]^{\frac{1}{\theta}} - \left[\left(1 - e^{\zeta^\omega_t} \omega_I\right) \left(\frac{I_t}{I_{F,t}} \right) \right]^{\frac{1}{\theta}} I_{F,t} \left(1 - \psi^{M,I}_t \right)^{-\frac{1}{\theta}} \frac{\partial \psi^{M,I}_t}{\partial I_{H,t}} \\ & - \beta \mathbb{E}_t \Lambda_{t,t+1} \frac{p^I_{t+1}}{p^I_t} \left[\left(1 - e^{\zeta^\omega_{t+1}} \omega_I\right) \left(\frac{I_{t+1}}{I_{F,t+1}} \right) \right]^{\frac{1}{\theta}} I_{F,t+1} \left(1 - \psi^{M,I}_{t+1} \right)^{-\frac{1}{\theta}} \frac{\partial \psi^{M,I}_{t+1}}{\partial I_{H,t}}, \end{aligned} \tag{A.29}$$

$$\frac{p_{F,t}}{p^I_t} = \left[(1-e^{\zeta^\omega_t}\omega_I)\left(\frac{I_t}{I_{F,t}}\right)\right]^{\frac{1}{\theta}} - \left[\left(1-e^{\zeta^\omega_t}\omega_I\right)\left(\frac{I_t}{I_{F,t}}\right)\right]^{\frac{1}{\theta}} I_{F,t}\left(1-\psi^{M,I}_t\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{M,C}_t}{\partial I_{F,t}}$$
$$-\beta\mathbb{E}_t\Lambda_{t,t+1}\frac{p^I_{t+1}}{p^I_t}\left[\left(1-e^{\zeta^\omega_{t+1}}\omega_I\right)\left(\frac{C^d_{t+1}}{C_{F,t+1}}\right)\right]^{\frac{1}{\theta}} C_{F,t+1}\left(1-\psi^{M,C}_{t+1}\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{M,I}_{t+1}}{\partial I_{F,t}}, \quad \text{(A.30)}$$

$$I_t = \left[\left(e^{\zeta^\omega_t}\omega_I\right)^{1/\theta} I_{H,t}^{\frac{\theta-1}{\theta}} + \left(1-\left(e^{\zeta^\omega_t}\omega_I\right)\right)^{1/\theta}\left((1-\psi^{M,I}_t)I_{F,t}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}. \quad \text{(A.31)}$$

Abroad, foreign producers of the final consumption good solve an analogous problem with a production technology given by

$$C^{d*}_t = \left[\left(e^{\zeta^{\omega*}_t}\omega^*\right)^{1/\theta} C^*_{F,t}{}^{\frac{\theta-1}{\theta}} + \left(1-e^{\zeta^{\omega*}_t}\omega^*\right)^{1/\theta}\left((1-\psi^{*M,C}_t)C^*_{H,t}\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}. \quad \text{(A.32)}$$

Optimality conditions for foreign producers are given by

$$p^*_{F,t} = \left[e^{\zeta^{*\omega}_t}\omega^*\left(\frac{C^{*d}_t}{C^*_{F,t}}\right)\right]^{\frac{1}{\theta}} - \left[\left(1-e^{\zeta^{*\omega}_t}\omega^*\right)\left(\frac{C^{*d}_t}{C^*_{H,t}}\right)\right]^{\frac{1}{\theta}} C^*_{H,t}\left(1-\psi^{*M,C}_t\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{*M,C}_t}{\partial C^*_{F,t}}$$
$$-\beta\mathbb{E}_t\Lambda^*_{t,t+1}\left[\left(1-e^{\zeta^{*\omega}_{t+1}}\omega^*\right)\left(\frac{C^{d*}_{t+1}}{C^*_{H,t+1}}\right)\right]^{\frac{1}{\theta}} C^*_{H,t+1}\left(1-\psi^{*M,C}_{t+1}\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{*M,C}_{t+1}}{\partial C^*_{F,t}}, \quad \text{(A.33)}$$

$$p^*_{H,t} = \left[(1-e^{\zeta^{\omega*}_t}\omega^*)\left(\frac{C^{d*}_t}{C^*_{H,t}}\right)\right]^{\frac{1}{\theta}} - \left[\left(1-e^{\zeta^{\omega*}_t}\omega^*\right)\left(\frac{C^{d*}_t}{C^*_{H,t}}\right)\right]^{\frac{1}{\theta}} C^*_{H,t}\left(1-\psi^{M,C*}_t\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{M,C*}_t}{\partial C^*_{H,t}}$$
$$-\beta\mathbb{E}_t\Lambda^*_{t,t+1}\left[\left(1-e^{\zeta^{*\omega}_{t+1}}\omega^*\right)\left(\frac{C^{*d}_{t+1}}{C^*_{H,t+1}}\right)\right]^{\frac{1}{\theta}} C^*_{H,t+1}\left(1-\psi^{*M,C}_{t+1}\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{*M,C}_{t+1}}{\partial C^*_{H,t}}, \quad \text{(A.34)}$$

$$\frac{p^*_{F,t}}{p^{I*}_t} = \left[e^{\zeta^{*\omega}_t}\omega^*_I\left(\frac{I^*_t}{I^*_{F,t}}\right)\right]^{\frac{1}{\theta}} - \left[\left(1-e^{\zeta^{\omega*}_t}\omega^*_I\right)\left(\frac{I^*_t}{I^*_{H,t}}\right)\right]^{\frac{1}{\theta}} I^*_{H,t}\left(1-\psi^{M,I*}_t\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{M,I*}_t}{\partial I^*_{F,t}}$$
$$-\beta\mathbb{E}_t\Lambda^*_{t,t+1}\frac{p^{I*}_{t+1}}{p^{I*}_t}\left[\left(1-e^{\zeta^{*\omega}_{t+1}}\omega^*_I\right)\left(\frac{I^*_{t+1}}{I^*_{H,t+1}}\right)\right]^{\frac{1}{\theta}} I^*_{H,t+1}\left(1-\psi^{*M,I}_{t+1}\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{*M,I}_{t+1}}{\partial I^*_{F,t}}, \quad \text{(A.35)}$$

$$\frac{p_{H,t}^{*}}{p_t^{I*}} = \left[(1-e^{\zeta_t^{\omega*}}\omega_I^*)\left(\frac{I_t^*}{I_{H,t}^*}\right)\right]^{\frac{1}{\theta}} - \left[(1-e^{\zeta_t^{\omega*}}\omega_I^*)\left(\frac{I_t^*}{I_{H,t}^*}\right)\right]^{\frac{1}{\theta}} I_{H,t}^* \left(1-\psi_t^{M,I*}\right)^{-\frac{1}{\theta}} \frac{\partial \psi_t^{M,I*}}{\partial I_{H,t}^*}$$

$$-\beta \mathbb{E}_t \frac{p_{t+1}^{I*}}{p_t^{I*}} \Lambda_{t,t+1}^* \left[(1-e^{\zeta_{t+1}^{*\omega}}\omega_I^*)\left(\frac{C_{t+1}^{*d}}{C_{H,t+1}^*}\right)\right]^{\frac{1}{\theta}} C_{H,t+1}^* \left(1-\psi_{t+1}^{*M,C}\right)^{-\frac{1}{\theta}} \frac{\partial \psi_{t+1}^{*M,I}}{\partial I_{H,t}^*}, \quad \text{(A.36)}$$

$$I_t^* = \left[\left(e^{\zeta_t^{*\omega}}\omega_I^*\right)^{1/\theta} I_{F,t}^{*\,\frac{\theta-1}{\theta}} + \left(1-\left(e^{\zeta_t^{*\omega}}\omega_I^*\right)\right)^{1/\theta}\left((1-\psi^{*M,I}_{t})I_{H,t}^*\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}. \quad \text{(A.37)}$$

Choice of Intermediate Varieties:

Perfectly competitive retailers of the home intermediate goods bundle maximize

$$p_{H,t}Y_{H,t} - \int_0^1 p_{H,t}(h)Y_{H,t}(h)dh,$$

subject to

$$Y_{H,t} = \left[\int_0^1 Y_{H,t}^{\frac{1}{1+\mu_{H,t}}}(h)dh\right]^{1+\mu_{H,t}}.$$

Optimality conditions are

$$Y_{H,t}(h) = \left[\frac{P_{H,t}(h)}{P_{H,t}}\right]^{-\frac{1+\mu_{H,t}}{\mu_{H,t}}} Y_{H,t}, \quad \text{(A.38)}$$

together with a zero profit condition

$$P_{H,t}^{-\frac{1}{\mu_{H,t}}} = \int_0^1 P_{H,t}(h)^{-\frac{1}{\mu_{H,t}}} dh. \quad \text{(A.39)}$$

Similarly, for all other intermediates bundles,

$$Y_{F,t}(h) = \left[\frac{P_{F,t}(h)}{P_{F,t}}\right]^{-\frac{1+\mu_{F,t}}{\mu_{F,t}}} Y_{F,t}, \quad \text{(A.40)}$$

$$P_{F,t}^{-\frac{1}{\mu_{F,t}}} = \int_0^1 P_{F,t}(h)^{-\frac{1}{\mu_{F,t}}} dh, \quad \text{(A.41)}$$

$$Y_{F,t}^*(h) = \left[\frac{P_{F,t}^*(h)}{P_{F,t}^*}\right]^{-\frac{1+\mu_{F,t}^*}{\mu_{F,t}^*}} Y_{F,t}^*, \quad \text{(A.42)}$$

$$(P_{F,t}^*)^{-\frac{1}{\mu_{F,t}^*}} = \int_0^1 P_{F,t}^*(h)^{-\frac{1}{\mu_{F,t}^*}} dh, \quad \text{(A.43)}$$

$$Y^*_{H,t}(h) = \left[\frac{P^*_{H,t}(h)}{P^*_{H,t}}\right]^{-\frac{1+\mu^*_{H,t}}{\mu^*_{H,t}}} Y^*_{H,t}, \quad \text{(A.44)}$$

$${P^*_{H,t}}^{-\frac{1}{\mu^*_{H,t}}} = \int_0^1 P^*_{H,t}(h)^{-\frac{1}{\mu^*_{H,t}}} dh. \quad \text{(A.45)}$$

A.5 Intermediate Good Retailers

A retailer of an intermediate good variety at home that can reset its price at time t chooses $P^o_{H,t}$ to maximize

$$\mathbb{E}_t \sum_{i=0}^{\infty} (\theta_p)^i \Lambda_{t,t+i} \left(\frac{P^o_{H,t} \prod_{j=t}^{t+i-1} (1+\pi_{H,j})^{\iota_p}}{P_{t+i}} - MC_{t+i} \right) Y_{H,t+i}(h),$$

where

$$Y_{H,t+i}(h) = \left[\frac{P^o_{H,t} \prod_{j=t}^{t+i-1} (1+\pi_{H,j})^{\iota_p}}{P_{H,t+i}}\right]^{-\frac{1+\mu_{ht}}{\mu_{ht}}} Y_{H,t+i}.$$

The optimal reset price satisfies

$$\mathbb{E}_t \sum_{i=0}^{\infty} (\theta_p)^i \Lambda_{t,t+i} \frac{1}{\mu_{H,t+i}} \left(\frac{P^o_{H,t} \prod_{j=t}^{t+i-1} (1+\pi_{H,j})^{\iota_p}}{P_{t+i}} - (1+\mu_{H,t+i}) MC_{t+i} \right) = 0,$$

or equivalently, if we let $p^o_{H,t} = \frac{P^o_{H,t}}{P_t}$,

$$\mathbb{E}_t \sum_{i=0}^{\infty} (\theta_p)^i \Lambda_{t,t+i} \frac{1}{\mu_{H,t+i}} \left(p^o_{H,t} \frac{\prod_{j=t}^{t+i-1} (1+\pi_{H,j})^{\iota_p}}{\prod_{j=t+1}^{t+i} (1+\pi_j)} - (1+\mu_{H,t+i}) MC_{t+i} \right) = 0. \quad \text{(A.46)}$$

A similar problem for retailers of the home variety abroad yields

$$\mathbb{E}_t \sum_{i=0}^{\infty} \left(\theta^x_p\right)^i \Lambda_{t,t+i} \frac{1}{\mu^*_{H,t+i}} \left(p^{o*}_{H,t} \frac{\prod_{j=t}^{t+i-1} (1+\pi^*_{H,j})^{\iota_p}}{\prod_{j=t+1}^{t+i} (1+\pi^*_j)} RER^{-1}_{t+i} - (1+\mu^*_{H,t+i}) MC_{t+i} \right) = 0, \quad \text{(A.47)}$$

where $p^o_{H,t} = \frac{P^{*o}_{H,t}}{P^*_t}$. Analogous problems abroad yield:

$$\mathbb{E}_t \sum_{i=0}^{\infty} (\theta_p)^i \Lambda^*_{t,t+i} \frac{1}{\mu^*_{F,t+i}} \left(p^{*o}_{F,t} \frac{\prod_{j=t}^{t+i-1} (1+\pi^*_{F,j})^{\iota_p}}{\prod_{j=t+1}^{t+i} (1+\pi^*_j)} - (1+\mu^*_{F,t+i}) MC^*_{t+i} \right) = 0, \quad \text{(A.48)}$$

$$\mathbb{E}_t \sum_{i=0}^{\infty} \left(\theta^x_p\right)^i \Lambda_{t,t+i} \frac{1}{\mu_{F,t+i}} \left(p^o_{F,t} \frac{\prod_{j=t}^{t+i-1} (1+\pi_{F,j})^{\iota_p}}{\prod_{j=t+1}^{t+i} (1+\pi_j)} RER_{t+i} - (1+\mu_{F,t+i}) MC^*_{t+i} \right) = 0. \quad \text{(A.49)}$$

The evolution of price varieties is then given by

$$p_{H,t}(h) = \begin{cases} p_{H,t-1}(h)\frac{(1+\pi_{H,t-1})^{\gamma_p}}{(1+\pi_t)} & \text{with probability } \theta_p, \\ p^o_{H,t} & \text{with probability } 1-\theta_p, \end{cases} \tag{A.50}$$

$$p^*_{H,t}(h) = \begin{cases} p^*_{H,t-1}(h)\frac{(1+\pi^*_{H,t-1})^{\gamma_p}}{(1+\pi^*_t)} & \text{with probability } \theta^x_p, \\ p^{*o}_{H,t} & \text{with probability } 1-\theta^x_p, \end{cases} \tag{A.51}$$

$$p^*_{F,t}(h) = \begin{cases} p^*_{F,t-1}(h)\frac{(1+\pi^*_{F,t-1})^{\gamma_p}}{(1+\pi^*_t)} & \text{with probability } \theta_p, \\ p^{*o}_{F,t} & \text{with probability } 1-\theta_p, \end{cases} \tag{A.52}$$

$$p_{F,t}(h) = \begin{cases} p_{F,t-1}(h)\frac{(1+\pi_{F,t-1})^{\gamma_p}}{(1+\pi_t)} & \text{with probability } \theta^x_p, \\ p^o_{F,t} & \text{with probability } 1-\theta^x_p. \end{cases} \tag{A.53}$$

A.6 Intermediate Good Producers

Perfectly competitive producers choose capital and labor to maximize period by period profits given by

$$MC_tY_t - \frac{W_t}{P_t}N_t - r^K_t\bar{K}_t,$$

subject to

$$Y_t = e^{\zeta^A_t}\bar{K}^{\alpha}_t(N_t)^{(1-\alpha)}.$$

Optimality conditions are

$$(1-\alpha)MC_t\frac{Y_t}{N_t} = \frac{W_t}{P_t}, \tag{A.54}$$

$$\alpha MC_t\frac{Y_t}{\bar{K}_t} = r^K_t. \tag{A.55}$$

Similarly, abroad they are

$$(1-\alpha)MC^*_t\frac{Y^*_t}{N^*_t} = \frac{W^*_t}{P^*_t}, \tag{A.56}$$

$$\alpha MC^*_t\frac{Y^*_t}{\bar{K}^*_t} = r^{k*}_t. \tag{A.57}$$

A.7 Capital Good Producers

Capital good producers choose $(I_s, \bar{K}_s)$ to maximize

$$\mathbb{E}_t\sum_{i=0}^{\infty}\Lambda_{t,t+i}\left[Q_{t+i}e^{\zeta^I_{t+i}}I_{t+i}\left[1-S\left(\frac{I_{t+i}}{I_{t+i-1}}\right)\right]-p^I_{t+i}I_{t+i}\right].$$

Optimality conditions are

$$Q_t \left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) = p_t^I + Q_t e^{\zeta_t^I} \frac{I_t}{I_{t-1}} S'\left(\frac{I_t}{I_{t-1}}\right) - \mathbb{E}_t \Lambda_{t,t+1} Q_{t+1} e^{\zeta_{t+1}^I} \left(\frac{I_{t+1}}{I_t}\right)^2 S'\left(\frac{I_{t+1}}{I_t}\right), \tag{A.58}$$

$$Q_t^* \left(1 - S\left(\frac{I_t^*}{I_{t-1}^*}\right)\right) = p_t^{I*} + Q_t^* e^{\zeta_t^{I*}} \frac{I_t^*}{I_{t-1}^*} S'\left(\frac{I_t^*}{I_{t-1}^*}\right) - \mathbb{E}_t \Lambda_{t,t+1}^* Q_{t+1}^* e^{\zeta_{t+1}^{*I}} \left(\frac{I_{t+1}^*}{I_t^*}\right)^2 S'\left(\frac{I_{t+1}^*}{I_t^*}\right). \tag{A.59}$$

B Equilibrium Conditions

Market clearing conditions for all goods are given by

$$Y_t = e^{\zeta_t^A} \bar{K}_t^{\alpha} (N_t)^{(1-\alpha)}, \tag{A.60}$$

$$Y_t^* = e^{\zeta_t^{A*}} \bar{K}_t^{*\alpha} (N_t^*)^{(1-\alpha)}, \tag{A.61}$$

$$Y_t = \int Y_{H,t}(j)dj + \frac{n^*}{n} \int Y_{H,t}^*(j)dj, \tag{A.62}$$

$$Y_t^* = \int Y_{F,t}^*(j)dj + \frac{n}{n^*} \int Y_{F,t}(j)dj, \tag{A.63}$$

$$C_{H,t} + I_{H,t} = Y_{H,t}, \tag{A.64}$$

$$C_{H,t}^* + I_{H,t}^* = Y_{H,t}^*, \tag{A.65}$$

$$C_{F,t} + I_{F,t} = Y_{F,t}, \tag{A.66}$$

$$C_{F,t}^* + I_{F,t}^* = Y_{F,t}^*, \tag{A.67}$$

$$C_t + Ge^{\zeta_t^G} + \frac{\left(e^{\xi(u_t-1)} - 1\right)}{\xi} K_{t-1} = C_t^d, \tag{A.68}$$

$$C_t^* + Ge^{\zeta_t^{G*}} + \frac{\left(e^{\xi(u_t^*-1)} - 1\right)}{\xi} K_{t-1}^* = C_t^{*d}, \tag{A.69}$$

$$K_t - (1-\delta)K_{t-1} = e^{\zeta_t^I} I_t \left[1 - S\left(\frac{I_t}{I_{t-1}}\right)\right], \tag{A.70}$$

$$K_t^* - (1-\delta)K_{t-1}^* = e^{\zeta_t^{*I}} I_t^* \left[1 - S\left(\frac{I_t^*}{I_{t-1}^*}\right)\right], \tag{A.71}$$

$$\bar{K}_t = K_t u_t, \tag{A.72}$$

$$\bar{K}_t^* = K_t^* u_t^*, \tag{A.73}$$

$$B_{H,t} + B_{H,t}^* = 0, \tag{A.74}$$

$$B_{F,t}^* = 0, \tag{A.75}$$

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_R} \left[\left(\frac{\prod_{s=0}^{3}(1+\pi_{t-s})^{0.25}}{e^{\zeta_t^{\pi}}(1+\bar{\pi})}\right)^{\varphi_\pi} \left(\frac{Y_t}{Y_t^{flex}}\right)^{\varphi_Y}\right]^{1-\varphi_R} e^{\zeta_t^{R})}, \tag{A.76}$$

$$\frac{R_t^*}{R} = \left(\frac{R_{t-1}^*}{R}\right)^{\varphi_R} \left[\left(\frac{\prod_{s=0}^{3}(1+\pi_{t-s}^*)^{0.25}}{e^{\zeta_t^{\pi*}}(1+\bar{\pi})}\right)^{\varphi_\pi} \left(\frac{Y_t^*}{Y_t^{*flex}}\right)^{\varphi_Y}\right]^{1-\varphi_R} e^{\zeta_t^{R*}}, \tag{A.77}$$

$$\frac{b_{H,t}^*}{R_t RER_t e^{\zeta_t^{UIP}} \Psi\left(\frac{\bar{b}_{H,t}^*}{Y_t^* RER_t}\right)} = \frac{b_{H,t-1}^*}{\pi_t RER_t} + \frac{p_{F,t}}{RER_t} Y_{F,t} - p_{H,t}^* Y_{H,t}^*. \tag{A.78}$$

Let $\mathcal{Q}_t$ and $\mathcal{Q}_t^*$ denote the equilibrium allocations in the home and foreign economies:

$$\mathcal{Q}_t = \left\{ \begin{array}{cc} C_t, B_{H,t}, \{n_t(i)\}, N_t, K_t, \bar{x}_t, \phi_t, \psi_t, u_t, & \text{Workers' and bankers' choices} \\ C_{H,t}, C_{F,t}, C_t^d, I_{H,t}, I_{F,t}, I_t, \{Y_{H,t}(j)\}, Y_{H,t}, \{Y_{F,t}(j)\}, Y_{F,t}, \bar{K}_t, Y_t & \text{Final and intermediate goods} \end{array} \right\}$$

$$\mathcal{Q}_t^* = \left\{ \begin{array}{cc} C_t^*, B_{F,t}^*, B_{H,t}^*, \{n_t^*(i)\}, N_t^*, K_t^*, \bar{x}_t^*, \phi_t^*, \psi_t^*, u_t^* & \text{Workers' and bankers' choices} \\ C_F^*, C_H^*, C_t^{*d}, I_F^*, I_H^*, I_t^*, \{Y_{F,t}^*(j)\}, Y_{F,t}^*, \{Y_{H,t}^*(j)\}, Y_{H,t}^*, \bar{K}_t^*, Y_t^* & \text{Final and intermediate goods} \end{array} \right\}$$

Let $\mathcal{P}_t$ and $\mathcal{P}_t^*$ denote time series for prices in the home and foreign economies:

$$\mathcal{P}_t = \left\{p_{H,t}(j)\}, p_{H,t}^o, p_{H,t}, \{p_{F,t}(j)\}, p_{F,t}^o, p_{F,t}, \{\{w_t(i)\}, w_t^o, W_t, MC_t, \pi_t, R_t, R_t^d, p_t^I, r_t^k, \hat{r}_t^k, Q_t\right\},$$

$$\mathcal{P}_t^* = \left\{p_{F,t}^*(j)\}, p_{F,t}^{o*}, p_{F,t}^*, \{p_{H,t}^*(j)\}, p_{H,t}^{o*}, p_{H,t}^*, \{\{w_t^*(i)\}, w_t^{o*}, W_t^*, MC_t^*, \pi_t^*, R_t^*, R_t^{d*}, p_t^{I*}, r_t^{k*}, \hat{r}_t^{k*}, Q_t^*\right\}.$$

Equations (A.1) - (A.78) determine the equilibrium allocations $\{\mathcal{Q}_t, \mathcal{Q}_t^*\}$ and prices $\{\mathcal{P}_t, \mathcal{P}_t^*, RER_t\}$, given the exogenous shocks.

C Data

This appendix describes the data used in this paper. Unless otherwise noted, all series are at quarterly frequency and seasonally adjusted by the corresponding agency. All relevant series are in per capita terms to be consistent with the model definition. All series are obtained through Haver unless otherwise specified.

C.1 United States

National Accounts Data

We source nominal GDP (usecon'gdp), nominal personal consumption expenditures (usecon'c), nominal gross private investment (usecon'f), nominal imports of goods and services (usecon'm), nominal exports of goods and services (usecon'x), from the Bureau of Economic Analysis.

We convert GDP and its components to per capita terms using the "Resident Working Age Population: 15-64 years" (usecon'pop15wj) from the Census Bureau. We employ the implicit price deflator (usna'dgdp) to express all variables in real terms.

Interest Rates and Prices

Nominal policy rate: We convert the "Federal Open Market Committee: Fed Funds Target Rate" (usecon'ffedtar) monthly series to quarterly averages. For periods with a binding effective lower bound, we replace the short rate with the series estimated by Krippner (2020).

Exchange rate: We obtain the series "Total Foreign Real Exchange Rate, using Broad Dollar weights" (usitproj'rer.broad). We then save this data as the world exchange rate. The data come from the Federal Reserve Board.

Consumer price index: We use the seasonally adjusted series "CPI-U: All Items" (usecon'pcu), with reference period 1982-1984, from the Bureau of Economic Analysis.

Long-run inflation expectations: These data are taken from the survey of professional forecasters conducted by the Federal Reserve Bank of Philadelphia and represent year-over-year CPI inflation over the next 10 years.

Wages and Hours Worked

Real per capita wages: We use both the implicit price deflator (usna'dgdp) and quarterly CPI (usecon'pcu) to contruct two series of real wages from the seasonally adjusted series "Non-farm Business Sector: Compensation Per Hour" (usecon'lxnfc).

Total hours worked: We obtain seasonally adjusted average weekly hours (usecon'lrpriva) and seasonally adjusted total employees (usecon'lanagra) from the Bureau of Labor Statistics. After converting both series into quarterly data, we take their product.

Hours gap: As in Campbell et al. (2017), we construct the hours gap as the cyclical component in total hours worked. The trend is constructed as the sum of trends in (log) hours per-worker, (log) labor force participation, and (log) employment rate. These trends are obtained from the Federal Reserve Board FRB/US model, which can be downloaded from https://www.federalreserve.gov/econres/us-models-about.htm.

Real exchange rate: Data on the real foreign exchange rate come from an index constructed using trade-weighted exchange rates obtained from Bloomberg.

C.2 Foreign

For the Foreign bloc, we constructed trade-weighted aggregates for the following 34 countries/blocs: Argentina, Australia, Brazil, Bulgaria, Canada, Colombia, Chile, China, Croatia, the Czech Republic, Denmark, the Euro Area, Hong Kong, Hungary, India, Indonesia, Israel, Japan, Malaysia, Mexico, New Zealand, the Philippines, Poland, Romania, the Russian Federation, Saudi Arabia, Singapore, South Africa, South Korea, Sweden, Taiwan, Thailand, Turkey, and the United Kingdom. Our sample of countries represents about 85 % of PPP-adjusted world GDP in 2019.

The underlying data are obtained from Haver Analytics and the statistical agencies of each country as detailed below. For China, data on real GDP, real consumption, and real investment are obtained at annual frequency from the World Development Indicators (WDI) and linearly interpolated to quarterly observations.

Below is an example for the Euro Area where we use Haver to access the following databases: Eurostat, United Nations, EABCN, ECB.

National Accounts Data

We source the quarterly and seasonally adjusted data from Eurostat. The nominal components of GDP—consumption, fixed investment, imports, and exports—are similarly sourced from Eurostat, with a quarterly frequency and seasonally adjusted.

In order to deflate nominal GDP and its components, we use the implicit price deflator for GDP from Eurostat. This series is indexed relative to 2015=100 and seasonally adjusted. To extend our data sample, we also collect real GDP, real consumption, and real investment directly from the EABCN. This information is then used to supplement missing values.

Data on the working age population (the portion of the population aged 15-64) come from the United Nations and Haver Analytics. They are reported at an annual frequency and are seasonally adjusted.

Interest Rates and Consumer Prices

We collect two interest rate series: money market interest rates, and deposit rates. Neither series is seasonally adjusted, and each is reported at a monthly frequency, which we use to find the quarterly average. Day-to-day money market interest rates come from the Eurostat, while the other series comes from the ECB. For periods with a binding effective lower bound, we replace the short rate with the series estimated by Krippner (2020).

The inflation series for EA is constructed using GDP deflators from EA countries obtained from Haver Analytics.

C.3 Data Transformations

This section describes basic transformations to all relevant series and for all countries. In addition, we include any other adjustment, and we make explicit how we treat some missing observations in our data set.

Real GDP and its components are calculated by deflating the nominal GDP by the implicit price deflator for GDP. We also deflate earnings data by the GDP deflator to construct real wages. Additionally, we normalize all real series to per capita terms by dividing them by the working age population 15-64.

To measure inflation, we construct the quarterly and annualized growth rates for consumer prices. For the day to day money market interest rate, any missing values are substituted with the corresponding values from the deposit rate series within the same quarter. All growth rates are constructed as log changes from the previous quarter. Annual rates are constructed as *4 × quarterly growth rates*.

C.4 Aggregation

We construct the foreign aggregate by computing trade-weighted averages of real per capita GDP growth, real per capita consumption growth, real per capita fixed investment growth, real per capita import growth, real per capita export growth, real per capita hours worked, real per capita wage growth, the nominal policy rate, the nominal deposit interest rate, 10 year government yields, and CPI inflation.