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

Martin Bodenstein, Pablo Cuba Borda, Nils Gornemann, Ignacio Presno, Andrea Prestipino, Albert Queralto, and Andrea Raffo

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Abstract

We develop a two-country macroeconomic model that we fit to a set of aggregate prices and quantities for the U.S. and the rest of the world. In addition to a standard array of shocks, the model includes time variation in agents' preference for safe bonds. We allow for a component of this time variation to be common across countries and biased toward dollar-denominated safe assets, and refer to this component as global flight to safety (GFS). We find that GFS shocks are the most important shocks driving world business cycles, and are also important drivers of activity in the U.S. and especially abroad. An adverse GFS shock lowers global GDP and inflation, widens global corporate credit spreads, and appreciates the dollar. These effects are very close to those obtained from a structural VAR which uses the excess bond premium (Gilchrist and Zakrajšek, 2012) as proxy for global flight to safety.

JEL classification: E32, F30, H22

Keywords: Econometrics and economic theory; International economics; Macroeconomic activity.

*Bodenstein: Federal Reserve Board (martin.r.bodenstein@frb.gov); Cuba Borda: Federal Reserve Board (pablo.a.cubaborda@frb.gov); Gornemann: Federal Reserve Board (nils.m.gornemann@frb.gov); Presno: Federal Reserve Board (ignacio.presno@frb.gov); Prestipino: Federal Reserve Board (andrea.prestipino@frb.gov); Queralto: Federal Reserve Board (albert.queralto@frb.gov); Raffo: Federal Reserve Bank of Minneapolis (andrea.raffo@mpls.frb.org). We thank Hess Chung, Chris Erceg, Matteo Iacoviello, Leonardo Melosi, and seminar participants at the Federal Reserve Board for their comments at different stages of this project. The authors are grateful to the many talented research assistants who supported the project over the years: Jay Faris, Thomas Kaupas, Mike McHenry, Alexander Mechanick, Dawson Miller, Daniel Molon, Dylan Munson, and Mikaël Scaramucci. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System, or of any other person associated with the Federal Reserve System.

1 Introduction

Two of the most influential recent developments in the international macroeconomics literature have centered on the role of global factors in shaping developments in individual economies, on the one hand, and on the special role of the U.S. dollar in the global financial system—including its role as a safe haven during periods of global stress—on the other. Among the most well-known examples of the former view is the work by Miranda-Agrippino and Rey (2020, 2022), who show that a single global factor, dubbed global "risk aversion," accounts for a large fraction of the variance in risky asset prices and capital flows around the globe. The special role of the dollar, in turn, rests on the view of U.S. Treasuries as the world's safe assets par excellence, which are seen as providing particularly valuable safety and liquidity services to investors (Krishnamurthy and Vissing-Jorgensen, 2012; Maggiori, 2017; Gopinath and Stein, 2021). In this view, U.S. Treasuries' role as a safe haven plays an important role in shaping dollar exchange rate fluctuations (Jiang, Krishnamurthy, and Lustig, 2021; Kekre and Lenel, 2021; Jiang, Krishnamurthy, Lustig, and Sun, 2021).

To date, however, much of the work exploring the topics above has been empirical, and related modeling efforts have generally been mostly qualitative and have not attempted to draw implications for macroeconomic fluctuations more broadly.[1] This relatively narrow focus contrasts with traditional international business cycle studies—going back to Backus, Kehoe, and Kydland (1992), with the papers by Lubik and Schorfheide (2005) or by Eichenbaum, Johannsen, and Rebelo (2021) as more recent examples—which focus on quantitatively accounting for fluctuations in a large set of aggregate prices and quantities. In this strand of literature, however, the role of global factors has been relatively unexplored, with the focus much more centered on the role of country-specific shocks; and the models considered have generally not featured a special role of the dollar or of any other currency.

Our goal in this paper is to quantitatively assess the macroeconomic importance and transmission of shifts in global sentiment—which we refer to as global "flight-to-safety" shocks—and the associated role of dollar assets as a safe haven, as in the recent literature highlighted in the first paragraph, within the context of a model aimed at accounting for business cycles more gen-

[1] See section 5 of Miranda-Agrippino and Rey (2022) for an overview of models featuring a special role for dollar safe assets and for models aimed at capturing the effects of shifts in global risk aversion.

erally. To that end, we develop a two-country macroeconomic model that we fit, using Bayesian methods, to a standard set of aggregate variables for the U.S. and the rest of the world. A key feature of our model is time variation in agents' preference for safe bonds, aimed at capturing flight-to-safety shocks. Importantly, we allow for a component of these flight-to-safety shocks to be common across countries, capturing shifts in global risk aversion, as well as biased toward safe assets denominated in dollars, capturing the "specialness" of these assets. The presence of this global component is motivated by literature exemplified by Miranda-Agrippino and Rey (2020), and by evidence such as that in Figure 1, showing a strong association between global sentiment (proxied here by Gilchrist and Zakrajšek, 2012's excess bond premium) and world GDP growth.

In addition, we allow for financial shocks and portfolio costs to play a role in exchange-rate determination, following a set of recent influential papers (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2022; Maggiori, 2022; Du and Schreger, 2022). We also include a set of standard shocks and nominal and real rigidities commonly adopted in closed-economy estimated DSGE models such as Smets and Wouters (2007), Justiniano, Primiceri, and Tambalotti (2010), and Christiano, Motto, and Rostagno (2014). Our approach is to "let the data speak" on key model features—including on the role of country-specific versus global flight-to-safety shocks, and on the extent to which global flight-to-safety is biased toward safe dollar assets—by allowing the parameters governing these features to be fully determined by the data. The use of an estimated model complements recent work by Kekre and Lenel (2021), who also focus on flight-to-safety (including implications for activity), but who rely on a calibrated model instead.[2]

Our central finding is that global flight-to-safety (GFS henceforth) shocks are key drivers of fluctuations in aggregate economic activity. These shocks explain almost forty percent of the variation in world GDP growth, far more than any other shock category, and are also key drivers of fluctuations in activity in the U.S. and particularly abroad. GFS shocks are indeed dollar-biased: they raise the utility value of dollar safe bonds by substantially more than that of foreign safe bonds—supporting the view of safe dollar assets as a safe haven and helping quantify its magnitude. Global and foreign factors, taken together, account for a considerable fraction of

[2]There are other important differences in the modeling approaches, as well as in the overall focus. For example, Kekre and Lenel (2021) focus on the role of the U.S. as insurer of the rest of the world, an issue we do not address here.

the variance of U.S. GDP growth, hours, and other variables. In contrast to arguments made by Miranda-Agrippino and Rey (2020), however, we do not find a significant role of U.S. monetary shocks (or of any other U.S.-specific shock, for that matter) in driving foreign developments or in generating international co-movement, which our estimates indicate is largely driven by GFS shocks. Further, adverse GFS shocks are associated with lower U.S. (and foreign) interest rates, not higher.

We also propose a structural VAR to identify the effects of global flight-to-safety shocks on a set of global macroeconomic and financial variables, using the EBP as proxy for these shocks. The transmission of GFS shocks obtained from our macroeconomic model and from the VAR model agree to a remarkable extent. According to both models, the typical quarterly GFS shock triggers a rise in U.S. corporate borrowing spreads of about 10 basis points, a rise in foreign spreads of 15 basis points, an appreciation of the dollar of 0.5 percent, and a decline in global inflation of 0.1 percentage points. The effects on activity are substantial, with the model-based estimates somewhat larger than the VAR-based ones: thus, the typical GFS shock leads both U.S. and foreign GDP to decline around 0.25 percent at the trough, with 90 percent confidence bands ranging between 0.1 and 0.4, and the model-based estimates close to the upper end of that range.

Returning to the question of the determinants of fluctuations in the dollar exchange rate, in our last application we use our estimated model to decompose historical movements in the broad real dollar exchange rate through the lens of our model's version of the uncovered interest parity (UIP) condition—a topic that has received renewed interest in recent literature (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2022; Fukui et al., 2023). This condition permits decomposing dollar fluctuations into (i) a component driven by expected interest rate differentials; (ii) a component associated with the dollar bias of GFS shocks; and (iii) a component driven by financial shocks and portfolio frictions. Component (i) captures the conventional UIP channel (linking the level of the exchange rate to current and future expected interest rate differentials), while components (ii) and (iii) are associated with deviations from UIP. We find that the role of the GFS shock, though modest overall, is decisive during global downturns such as the global financial crisis. The financial shock plus portfolio friction component (capturing mechanisms emphasized by Gabaix and Maggiori, 2015) has considerable importance overall; but some notable episodes of dollar appreciation, such as the large appreciation between 2014 and 2016, are not associated with UIP deviations of any kind, and instead reflect a widening of expected interest rate paths in the U.S. relative to the rest of the world.

The remainder of the paper is organized as follows. Section 2 describes the model. Section 3 summarizes the data and estimation results. Section 4 documents the role of GFS shocks in our estimated model. Section 5 presents our structural VAR model. Section 6 focuses on the drivers of historical dollar movements. Section 7 concludes.

2 Model

We consider an economy consisting of a home (H) country, the U.S., 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 capture the data (Christiano et al., 2005; Smets and Wouters, 2007; Eichenbaum et al., 2021). A less-standard feature is that we allow for time variation in agents' preferences for safe bonds, as we discuss below—capturing the "flight-to-safety" shocks that are an important focus of our analysis. Importantly, these flight-to-safety shocks may be biased toward dollar-denominated assets. We also allow for frictions in financial intermediation within each country, following Gertler and Karadi (2011). 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

We turn here to the optimization problem facing households in each country. We assume that international financial markets are incomplete: the only internationally traded asset is a dollar-denominated safe bond, consistent with the evidence in Maggiori et al. (2020).[3] In addition to the standard set of frictions and rigidities—including habit formation in consumption, adjustment costs in investment and in import shares, and rigidities in price and wage setting—we assume that households derive utility from their holdings of safe assets, motivated by the liquidity and safety services of these assets, as in Krishnamurthy and Vissing-Jorgensen (2012). In addition, we allow for shocks to this preference for safety. These shocks have two

[3] Maggiori et al. (2020) document a strong dollar bias in global investors' portfolios.

important features: First, a component of these shocks is allowed to be common across countries. Second, this common component is allowed to impact dollar-denominated and foreign currency-denominated safe bonds asymmetrically—allowing the model to capture a special role for dollar-denominated safe assets.

2.1.1 Households at Home

A continuum of households each consist 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 institutions. 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

[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.

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 preferences. Both ζ_t^{RP} and ζ_t^{GFS} act as shifters of 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). As will become clear below, the distinction between ζ_t^{RP} and ζ_t^{GFS} is that ζ_t^{RP} shifts U.S. households' preference for safety but not foreign households', while 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" (GFS henceforth) 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 as well as safe bonds denominated in the foreign currency, and therefore they effectively act as "arbitrageurs" across safe bonds in different currencies. Like at home, households abroad also 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 *. Letting $B_{H,t}^*$ 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

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

The first and last terms in equation (4) are analogous to those in the domestic household's objective (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 due to fluctuations in a risk-premium shock specific to the foreign country, denoted ζ_t^{RP*}, as well as due to 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, with the degree of asymmetry 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, highlighted in much recent literature in international finance, that safe dollar-denominated bonds issued by the U.S. are particularly valuable in flight-to-safety episodes.[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} that 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., 2005) or as a 'financial" shock (Itskhoki and Mukhin, 2021, 2022).

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 only reset their nominal wage 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

[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. (2021), among many others.

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^{GFS}_t, ζ^{RP}_t, ζ^{RP*}_t, and ζ^{UIP}_t) 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.

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, respectively, are the following:[6]

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

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

where $c_1 \equiv b/(1+b)$ and $c_2 \equiv (1-b)/(1+b)$. As equations (7)-(8) make clear, higher values of the country-specific risk-premium shocks, ζ^{RP}_t and ζ^{RP*}_t, by raising the value of saving relative to consuming in the respective country, depress consumption spending and therefore aggregate demand in that country. In turn, increases in the global flight-to-safety shock ζ^{GFS}_t depress consumption spending in both countries simultaneously. In addition, these shocks also raise the cost of funding for banks, which ultimately pushes up the cost of capital—depressing investment spending as well.

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:

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

[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.

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 due to the presence of the portfolio cost χ_t, with higher portfolio costs of dollar-denominated assets associated with a weaker dollar.

As made clear by the preceding discussion, our model allows for a broad set of possibilities in how fluctuations in both countries' economic activity and in the real exchange rate can be driven by the various risk shocks. Thus, activity can be impacted by either the country-specific risk premium shocks or by the global flight-to-safety shock; and movements in the exchange rate (beyond those driven by interest rate differentials) can be impacted by both the GFS shock and the standard UIP shock. Our approach relies on "letting the data speak" to determine which of these sources of fluctuations are most important. We assume similar priors for ζ_t^{GFS}, ζ_t^{RP}, and ζ_t^{RP*}, and let the data determine whether the country-specific or the common risk shock is most important; and, we assume a flat prior for the parameter γ that is symmetric and centered at zero, thus letting the data determine the extent to which the GFS shock is associated with UIP deviations.

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

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

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

and ζ_t^w is a wage markup shock. Letting 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 its own net worth, x_t, and deposits from other families to purchase capital K_t.[8] Letting d_t denote real deposits, i.e. $d_t \equiv \frac{D_t}{P_t}$, 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.[9]

Following Gertler and Kiyotaki (2010) and Gertler and Karadi (2011), we assume that there is an agency problem between bankers and depositors. In particular, after raising deposits and making loans to firms, a banker can divert a proportion of these loans, κ and transfer them back to its 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. Letting V_t be the value to a banker of operating the bank honestly, the incentive compatibility constraint is:

$$V_t \geq e^{\zeta_t^\kappa + \overline{\zeta}_t^\kappa} \kappa Q_t K_t \tag{15}$$

where ζ_t^κ is an exogenous disturbance to the tightness of the banking friction affecting home banks only, and $\overline{\zeta}_t^\kappa$ is a similar disturbance affecting home and foreign banks simultaneously.

In our calibration, the incentive constraint (15) is binding and bankers in equilibrium will

[8] 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.

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

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. Letting $\Lambda_{t,t+i} \equiv \beta^i (C_{t+i} - bC_{t+i-1})^{-1}/(C_t - bC_{t-1})^{-1}$ denote 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:

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

This form of adjustment costs is common in the open-economy DSGE literature, for example Erceg et al. (2005) or Eichenbaum et al. (2021), and it allows capturing 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

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

subject to 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.[10]

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

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

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 composite 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 that are buffeted by a transitory shock $\zeta_t^{\mu_j}$ and a highly

[10]Our model of the final consumption and investment goods sector follows closely Erceg et al. (2005).

persistent one $\overline{\zeta}_t^{\mu_j}$.

The home intermediate good bundle is supplied by perfectly competitive retailers at home that 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

There are two types of retailers both in the home and in the foreign country: 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 it price is indexed to previous-period inflation with exponent $\iota_p \in [0,1]$. Letting MC_t be the price of the homogeneous intermediate good and $\pi_{H,t} \equiv \frac{P_{H,t}-P_{H,t-1}}{P_{H,t-1}}$ the rate of inflation of the domestic good bundle at home, a domestic retailer that resets his 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[11]

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

Similarly, exporting retailers cannot reset their price with probability θ_p^x which we allow 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, i.e. local currency pricing.[12] 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

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

2.5.2 Producers of the intermediate good

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

$$Y_t = e^{\zeta^A_t} \bar{K}^\alpha_t N^{1-\alpha}_t \tag{29}$$

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

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

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

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, given by

$$MC_t Y_t - w_t N_t - r_t^K \bar{K}_t \tag{32}$$

subject to production function (29).

2.6 Capital goods producers

Capital goods 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:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_R} \left[\left(\pi_t - e^{\zeta_t^\pi}\bar{\pi}\right)^{\varphi_\pi} \left(\frac{Y_t}{Y_t^{flex}}\right)^{\varphi_Y}\right]^{1-\varphi_R} e^{\zeta_t^R} \tag{36}$$

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 size 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 and estimate it with Bayesian methods using DYNARE.[13] 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

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

function under the data listed below to arrive at their posterior distribution. To approximate the posterior we first found the posterior mode and then explored the posterior with the Metropolis-Hastings algorithm.[14] To ensure convergence, we generated multiple chains of length 100,000 of which we dropped the first 50 percent of observations. We allow for 5 percent *iid* measurement error in the foreign series in the estimation, both to deal with true measurement error in the series as well as noise generated by our data aggregation approach (discussed next).

3.2 Data

We use 21 quarterly time series. All quantity series are measured in per capita units. Our data set starts as early as 1973. However, given data availability constraints, several of the individual time series start later. While we use previous data if available to form initial conditions, our estimation sample starts in 1985.

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 foreign country series in a given quarter, using real exchange rate weights discussed in Appendix C.[15] We 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. To ensure sufficient coverage, we start the first five series in 1985 and the corporate spread series in 2002, coding them as missing prior to those dates.

For the U.S. we use data for the same series as for the rest of the world, and include each series in the estimation as soon as it becomes available. In addition, we add data on the 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), as a measure of the cyclical component of total hours worked. This measure excludes low-frequency movements in the data that are not

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

[15] This means that our effective country weights change over time, both as the weights themselves change and as data for more countries becomes available.

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

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] 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 selected the prior values of parameters that are also present in closed economy models in line with earlier research. 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 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. (2005), 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

[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).

[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.

pricing frictions of imports we choose the same priors as for the domestic pricing frictions, for simplicity.

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 suggests a higher elasticity at most horizons than often assumed in international business cycle models. Focusing on the posterior mean, the values of these parameters imply a long-run trade elasticity of 2.5 and a short run one of 0.5, compared with 2 and 0.4, respectively, under our prior. Fourth, consistent with the high volatility of import and export prices in our data set, we find prices for imported goods to be less sticky than for domestically sold goods, consistent with calibrated open-economy DSGE models like SIGMA (Erceg et al., 2005).

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]:

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

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

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

The full list of shocks in our model is as follows. Starting with the home economy, in addition to the global flight-to-safety and risk premium shocks ζ_t^{GFS}, ζ_t^{RP}, 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, $\bar{\zeta}_t^k$.

The foreign economy is buffeted by an identical set of shocks, with the exception that we do not include a wage markup shock abroad. The reason is that our dataset does not include hours or wages for the foreign bloc, complicating 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 prices and quantities. These shocks include time variation in U.S. home bias—through the shocks ζ_t^ω—which works to shift the weight of the domestic good relative to the foreign good in the domestic consumption and investment baskets. The shock $\zeta_t^{\omega*}$ generates analogous fluctuations in the foreign economies. 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. Several observations are worth noting. First, the posterior distributions of shock variances and autocorrelations are much less dispersed than the prior distributions. Second, the U.S.-specific shocks are generally more persistent than the foreign shocks. Third, the GFS shock is estimated to be highly persistent.

4 Flight to Safety and Global Business Cycles

This section explores the drivers of global fluctuations in our estimated model. We begin by considering variance and historical decompositions of the data, with an emphasis on the role of the various risk-related shocks, and on the GFS shock in particular. We then present estimated impulse responses to these shocks to shed light on their transmission.

4.1 Historical Decompositions

A key finding from our analysis is that the global flight-to-safety (GFS) shock is the central driver of global GDP growth. Figure 2 illustrates this finding. The blue line in this figure shows world GDP growth in the data. This line is interpretable as the outcome of simulating our model assuming *all* estimated shocks took place (and given the filter's estimate of the initial condition). The red solid line shows global GDP growth conditional on *only* the GFS shock occurring (given the same initial condition). The key observation is that the red dashed line tracks the data remarkably well. The major downturns in global growth observed in the data—including the global financial crisis and the slowdowns in the early 2000s and in the early 1990s—are all associated with the GFS shock. The GFS shock accounts not only for the bulk of the decline in growth during the GFC, but also for the post-GFC slow recovery: observe that if it only the GFS shock had been present, post-GFC growth would have been even lower than it actually was.

Table 4 complements this finding by showing 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 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.

As Table 4 makes clear, the GFS shock accounts for the bulk of fluctuations in world GDP growth, explaining nearly 37 percent of such fluctuations—far more than any other shock or group of shocks. The same shock also explains an even larger share of the variability of global consumption and global policy rates, and accounts for a sizable share of fluctuations in global investment and credit spreads as well. The GFS shock accounts, however, for only a small portion of exchange rate fluctuations; but, as we show later, this shock does play a significant role in explaining deviations from UIP—particularly during severe global downturns like the GFC.

We make the following additional observations from Table 4. Both the U.S. and the Foreign country-specific risk-premium shocks play an overall minor role in accounting for fluctuations in world aggregates. The UIP shock explains a sizeable portion of exchange rate fluctuations (almost 44 percent, on a first-difference basis), but plays no role in explaining any other world aggregate (in line with the "exchange rate disconnect" literature); still, contrary to the "disconnect" hypothesis, other fundamental shocks also play a role in accounting for exchange rate fluctuations—particularly the shocks to home bias in households' preferences. Global inflation is largely driven by the inflation target shocks and, to a lesser extent, by the set of markup shocks. Fluctuations in global investment growth are driven to a large extent by investment efficiency shocks. Finally, the banking friction shocks are important in explaining movements in global credit spreads, but matter little for other global variables.

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 separately, as we show in Figure 3. In the Foreign bloc (right panel), the model simulation conditional on GFS shocks only tracks the actual data particularly well. In the U.S., the association between data and GFS-shock-only simulation appears less strong, especially at the higher frequency; but the GFS shock does account for a considerable part of the major slowdowns in U.S. growth in the sample, including in the early 1990s, early 2000s, and the GFC, as well as some of the growth gyrations in the 1970s and 1980s.

We next turn to variance decompositions of U.S. and Foreign variables separately. In Table 5 we perform the same variance decomposition as in Table 4 for the U.S. variables in our estimation sample. A key highlight is, again, that the GFS shock plays an important role in U.S. business cycles: it accounts for about 15 percent of U.S. GDP growth fluctuations, and about a third of fluctuations in hours and in the policy rate. A second key observation is that adding up global and foreign factors together (first and second columns) explains an even higher fraction of U.S. business cycles: almost a quarter of fluctuations in U.S. GDP growth, and even more of fluctuations in hours. Still, home-grown factors remain important. In particular, the U.S.-specific risk premium shock plays a central role as well, both for GDP and for other U.S. variables, as others have found.[21] Turning to trade, the U.S. home bias shocks are important

[21]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.

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, we turn to the variance decomposition of the Foreign variables in our sample, in Table 6. The GFS shock is, again, key, accounting for about a third of fluctuations in GDP and consumption growth, as well as in the policy rate. Second in importance in explaining GDP growth fluctuations are the foreign monetary and TFP shocks. We also highlight that U.S.-specific shocks (which are bundled together in the second column) matter little for overall developments in the Foreign bloc—in contrast to the U.S. case, in which Foreign-specific shocks do have a material role.

Table 7 provides some information to help understand why the model's estimation assigns a large role to the GFS shock. The top part of the table shows correlations of world GDP growth with other world aggregates, and the bottom part shows pair-wise correlations between variables in the U.S. and abroad. The first column shows the corresponding values in the data, the second column shows the values of these moments in a model simulation (including all shocks), and the third column shows the values in a model simulation with the GFS shock only. In the data, world GDP growth is positively correlated with global investment and consumption growth and with global inflation and policy rates, and is negatively correlated with credit spreads and with the (first-differenced) dollar exchange rate. From the third column, the GFS shock implies a set of correlations that are broadly consistent with those in the data. Thus, the presence of this shock pushes the model in the direction of matching these moments in the data. Of course, the model including all shocks does not necessarily match each of these moments, as the estimation implicitly targets *all* moments in the data and not just those shown in Table 7.

Turning to the bottom part of the table, in the data there is a considerable degree of comovement between variables in the U.S. and in the rest of the world, for each of the variables shown. The GFS shock implies a very high degree of comovement across the two country blocs, thus helping push the model closer to this dimension of the data as well.

4.2 Transmission of Key Shocks

We turn here to discussing how the various risk-related shocks in the model transmit through the global economy. Figure 4 shows the impulse responses to one-standard-deviation innovations to the GFS shock (thick red lines), the U.S.-specific risk premium shock (thin blue lines), and the UIP shock (yellow dash-dotted lines lines). A one-standard-deviation GFS shock depresses the level of U.S. and foreign GDP simultaneously and persistently, by almost the same amount—about 0.4 percent. The lower activity is associated with lower inflation, particularly in the U.S., and thus triggers an easing of monetary policy globally (not shown). Corporate bond spreads rise globally, and the rise is more pronounced in Foreign than in the U.S.—spreads rise 0.15 percentage points abroad and about 0.10 percentage points in the U.S. The dollar appreciates by 0.5 percent on impact and then slowly returns to its pre-shock path. This dollar appreciation helps explain the larger drop in U.S. inflation compared to Foreign.

It is interesting to highlight that while the size of the decline in GDP is virtually identical across country blocks, there are differences in its composition (Figure 5): Abroad, the shock depresses consumption, and particularly investment, more than in the U.S., consistent with the larger increase in foreign credit spreads. At the same time, the associated dollar appreciation contributes to depressing the trade balance in the U.S. (bottom right panel of Figure 5), 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., with the dollar appreciating, foreign borrowing spreads rising more than in the U.S., and foreign absorption falling more than in the U.S.

Turning to the other shocks shown in Figure 4, a one-standard-deviation U.S.-specific risk premium shock induces similar dynamics of U.S. GDP and the U.S. policy rate as the GFS shock, and a larger spike in U.S. credit spreads. The shock does not, however, have any material spillovers to the foreign block: foreign GDP barely moves. In addition, unlike the GFS shock, a rise in the U.S. risk premium triggers a dollar *depreciation*, which occurs due to the lower expected path of U.S. real rates relative to foreign rates triggered by the U.S. weakness. Finally, a one-standard-deviation UIP shock leads to a significant move in the exchange rate (about 1.8 percent), but has a relatively small effect on U.S. and foreign GDP. In addition, GDP moves in opposite directions in the U.S. and abroad in response to this shock, as a weaker dollar benefits U.S. GDP through net exports, but hurts foreign GDP.

5 Flight to Safety: A VAR Analysis

The previous section discussed how our estimated model uncovers the GFS shock as the single most important driver of fluctuations in global GDP growth. In our estimated model, a positive innovation to the GFS shock triggers a decline in both U.S. and foreign GDP, a rise in credit spreads in both countries (with a larger increase abroad), and a substantial appreciation of the dollar. In this section we complement that analysis by showing here that the effects of the GFS shock aligns closely with direct empirical evidence obtained from a structural VAR model in which we proxy for global flight to safety with an indicator for global sentiment, the excess bond premium (EBP; Gilchrist and Zakrajšek, 2012).

5.1 The Excess Bond Premium and Global Sentiment

Gilchrist and Zakrajšek (2012) show that the EBP, an indicator that measures risk appetite in U.S. corporate bond markets that is not directly attributable to expected risk of default, is a good predictor of future economic activity in the U.S. Because of the global importance of the U.S. financial sector, the EBP is a natural candidate to proxy for global sentiment, as has been emphasized in the literature (for example, Obstfeld and Zhou, 2023). To confirm that the EBP is a good indicator for global risk appetite, we show in this section that the EBP is a strong predictor of several popular measures of global investor sentiment. In particular, we test the predictive content of changes in the EBP for subsequent movements in other proxies for global sentiment by estimating the following regression:

$$X_{t+h} - X_{t-1} = \alpha + \sum_{i=1}^{p} \beta^i \Delta X_{t-i} + \gamma \Delta EBP_t + \varepsilon_{t+h}, \tag{41}$$

where X_{t+h} denotes the value of the variable of interest h-periods into the future. We compute the predictive content of the EBP for six proxies of global risk aversion: (1) Miranda-Agrippino and Rey (2022)'s "global financial cycle" factor, which captures the common statistical component driving world risky asset prices and international credit flows; (2) the VIX index, which measures the option-implied volatility in the S&P 500; (3) Londono and Wilson (2018)'s "global volatility" index, a market-value-weighted average of the equity option-implied volatility of risky asset prices in advanced economies; (4) Du et al. (2018)'s 1-year U.S. treasury premium, a measure of the non-pecuniary benefits (the "convenience yield") of holding U.S. government bonds relative to comparable default-free and liquid government bonds of G-10 countries; (5) emerging markets' sovereign credit spreads in foreign currency bonds (FC); (6) emerging markets sovereign spreads in local currency bonds (LC).

Table 8 shows the results from estimating equation (41). The columns correspond to each of the proxies of global risk, and the rows report the estimates of the parameter of interest, γ, for horizons $h = \{3, 6, 12\}$ months. For the VIX and global volatility, the estimation sample covers the period 1990m1-2023m2. The GFC factor's last available observation is 2019m4. We construct monthly averages of the U.S. treasury premium from 1990m1-2021m3. For emerging markets data on sovereign spreads we restrict our sample to the period 2003m1-2021m3.

Our results show significant predictive ability of the EBP on all our proxies of global sentiment. For example, at the three-month horizon ($h = 3$), a one-percentage-point increase in the EBP predicts a 0.3 percentage point decline in global risk appetite as measured by the GFC factor (column 1). Similarly, the same increase in the EBP is also associated associated with increased volatility with a 9 percent increase in the VIX (column 3) and 6 percent increase in global volatility (column 4). An increase in the EBP also results in a higher treasury premium of 10 basis points (column 5), consistent with increased demand for for U.S. treasuries relative to other safe assets.

To provide additional evidence that the EBP is a good proxy for global sentiment, we explore the response of sovereign government debt in emerging markets. The last two columns in Table 8 present results from estimating our forecasting regression in Equation (41) for two measures of emerging markets' sovereign risk. Column (5) shows results for FC credit spreads, measured using JP Morgan Global Emerging Market Bond Index (EMBI Global). Column (6) shows results using Du and Schreger (2016)'s 5-year LC credit spread, constructed as the spread of local currency bonds over synthetic cross-currency swaps of risk-free U.S. treasuries.

We find that a 1 percentage point increase in the EBP forecasts substantial increases (of more than 100 basis points) in emerging markets FC sovereign spreads at all future horizons, but it has no predictive power for LC sovereign spreads. This result is consistent with Du and

Schreger (2016) that shows that although LC borrowing is subject to sizeable default risk, LC debt is less exposed to global risk factors and exhibit lower international co-movement relative for FC sovereign debt in emerging markets.

5.2 VAR Evidence

Having established that the EBP is a useful proxy to capture shifts in global sentiment, we estimate a monthly VAR that includes the EBP, 5-year BBB corporate bond spreads in the U.S. and foreign economies, the trade-weighted broad real dollar index, total PCE inflation for the U.S., headline CPI inflation for the foreign economies, and monthly estimates of U.S. and foreign real GDP. The dollar index and GDP series are detrended before estimation [22]. Our estimation sample covers the period 2001:8 – 2022:12. To identify global risk shocks in the VAR, we impose a recursive contemporaneous causal structure with variables in the order listed above. This structure imposes that the only shock that can affect the EBP contemporaneously is the "global sentiment" shock. We take this global sentiment shock to be the counterpart in the VAR of the GFS shock in our model.

Figure 6 displays the response of key financial and macroeconomic variables to an innovation in global risk sentiment. The thin solid line is the median impulse response to a global risk sentiment shock in the VAR. The gray area represents the associated 95 percent confidence interval. The response of U.S. variables, including the broad real dollar, is shown in the top row. In the VAR a shock to global sentiment increases corporate borrowing spreads by about 10 basis points, and borrowing costs remain elevated for several quarters. The heightened financial stress is accompanied with a persistent contraction in economic activity. Real GDP declines about 0.25 percentage point within the first year and headline inflation falls by 0.1 percentage point within the first year. The broad real dollar index appreciates 0.5 percent on impact in response to higher global risk and the dollar strengths persistently for nearly two years after the shock. The bottom row of Figure 6 shows the response of foreign variables. Corporate borrowing spreads in the rest of the world increase by more than in the United States and remain above baseline for several quarters. The median response of foreign GDP and foreign

[22] For the dollar index we fit a log-linear trend. GDP is detrended relative to a non-parametric moving average trend as in Cuba-Borda et al. (2018)

inflation are similar to those in the U.S.[23]

In Figure 6 we also compare the estimated VAR responses with the response to a global flight-to-safety, ζ_t^{GFS}, shock in our estimated DSGE model. The thick solid line depicts the impulse response function in the DSGE model calculated using the mean of the posterior distribution from Table 2 and Table 3. As described in Section 4, the GFS shock simultaneously depresses GDP, lower inflation and increases borrowing costs globally. In addition, increased global risk increases the the demand for dollar denominated bonds globally and appreciates the real exchange rate in the U.S.

The responses in the DSGE model are remarkably close to those of the VAR. In both models we find that find that shifts in global risk sentiment can have a sizable adverse effect on economic activity, global inflation, increased excess returns on risky assets and an appreciation of the U.S. dollar. In the DSGE model the response of U.S. and foreign GDP is more protracted than in the VAR. In our DSGE model, the global flight-to-safety shock is estimated indirectly through the joint dynamics of real activity variables, inflation, borrowing costs and dollar movements. The VAR relies on a different identification strategy and uses the EBP as a direct measure of global sentiment to infer the transmission of these shocks. The VAR evidence provides external validation for the role of global flight-to-safety shocks, as well as their transmission through the asymmetric demand for safe assets present in our DSGE model.

6 Dollar Fluctuations and Uncovered Interest Parity

In this section, we turn to a historical analysis of the dollar exchange rate, through the lens of our model's version of the uncovered interest rate parity condition. The UIP condition is the basis of much theoretical and empirical analysis of exchange rate determination, and has been the subject of an enormous literature (see Engel, 2014 for a survey). Given the well-documented empirical limitations of the "pure" version of UIP—linking expected exchange rate changes solely to current interest rate differentials—it has long been common in the international macroeconomics literature to append an exogenous disturbance to the UIP equation, with the goal of capturing exchange rate fluctuations driven by factors other than the expected path of

[23] Akinci, Kalemli-Özcan, and Queralto (2022) have shown VAR evidence indicating similar effects on spreads and the dollar of an increase in the VIX, another popular indicator of global sentiment.

interest rate differentials, such as risk premiums (e.g. Erceg et al., 2005). Recent well-known contributions have provided foundations for these UIP deviations, by relying on imperfections in financial markets (Gabaix and Maggiori, 2015; Itskhoki and Mukhin, 2021; see also the survey in Maggiori, 2022).[24] Some of this work, for example Itskhoki and Mukhin (2022), focuses on providing foundations for a shock with similar features as the "pure" UIP shock ζ_t^{UIP} in our model. Other recent work, like Jiang et al. (2021) and Kekre and Lenel (2021), has focused on the exchange-rate implications of the convenience yield of dollar assets—as captured by the asymmetric effects of the GFS shock ζ_t^{GFS} in our model.[25]

Our approach, by virtue of relying on an estimated structural model, is able to make two contributions to the aforementioned recent literature. First, by considering the historical evolution of the dollar exchange rate through the lens of the model, we can determine whether dollar fluctuations in any given historical episode were linked to interest rate differentials, as in the "pure" version of UIP, or to deviations from it. And second, in historical episodes in which the model indicates a significant UIP deviation was present, we can use the model to assess whether such deviation was mostly driven by pure UIP shocks ζ_t^{UIP}—as stressed in the work of Itskhoki and Mukhin (2021)—or by heightened preference for dollar safety—as emphasized by Jiang et al. (2021) and Kekre and Lenel (2021). Our analysis reveals that even if GFS shocks explain little of the unconditional variance of exchange rates, they play a decisive role in accounting for UIP deviations in specific historical episodes, such as the global financial crisis.

With that perspective in mind, we begin by iterating equation (9) forward to obtain

$$rer_t = \mathbb{E}_t\big[\sum_{i=0}^{\infty}(\hat{r}_{t+i}^{real} - \hat{r}_{t+i}^{real*})\big] + \gamma\overline{\zeta}_t^{GFS} + \overline{\zeta}_t^{UIP} - \overline{\chi}_t, \tag{42}$$

[24]See Akinci and Queralto (2023) for a related study focused on emerging markets.

[25]In very recent work, Fukui, Nakamura, and Steinsson (2023) also allow for two distinct exogenous UIP disturbances, with different implications for economic activity and other variables.

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

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

$$\overline{\zeta}_t^{UIP} \equiv \mathbb{E}_t\big[\sum_{i=0}^{\infty} \zeta_{t+i}^{UIP}\big] = \frac{1}{(1-\rho_{UIP})}\zeta_t^{UIP}, \quad (44)$$

$$\overline{\chi}_t \equiv \mathbb{E}_t\big[\sum_{i=0}^{\infty} \chi_{t+i}\big] \quad (45)$$

are the forward-cumulated versions of ζ_t^{GFS}, ζ_t^{UIP}, and χ_t, respectively.[26] From equation (42), 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 of dollar portfolio costs ($\overline{\chi}_t$).

Figure 7 shows the value of the broad real dollar since 1990 (in four-quarter percent change, the black line), along with the variation explained by each of the components on the right-hand side of equation (42), shown by the colored bars.[27] A couple of 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).

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 8, 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 8, the interest differential component explains the *entirety* of the dollar appreciation between 2014 and 2016: the model assigns a minimal role

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

[27] 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).

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 by the blue bars in panel B of Figure 8 is driven by movements in the expected path of U.S. rates, or by movements the path of foreign rates, or both. To address this question, in Figure 9 we show the expected sum of future short rates in each country block separately: the black solid line shows the U.S. path,

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

and the blue dashed line shows its foreign counterpart

$$\hat{r}^*_{long,t} \equiv \mathbb{E}_t \sum_{i=0}^{\infty} \hat{r}_{t+i}^{real*}. \tag{47}$$

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. Starting around 2015, $\hat{r}_{long,t}$ rises sharply, while $\hat{r}^*_{long,t}$ remains close to its 2014 value. Thus, through the lens of the model, starting 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—triggering a sharp appreciation of the dollar.

Despite the important role played by the interest rate differential and the flight-to-safety shock in selected periods, the model attributes a substantial part of the fluctuations in UIP deviations to the "pure" UIP shock and to the portfolio cost. One example is the roughly 8 percent depreciation of the dollar between early 2017 and early 2018, which the model sees as resulting largely from downward movements in this component—with the interest differential component exerting influence in the opposite direction (in this period the U.S. policy interest rate was rising steadily, while the foreign rate was roughly flat).

7 Conclusion

We have developed and 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 *global flight-to-safety* shocks emerge as the single most important drivers of fluctuations in world GDP, explaining a considerable fraction of fluctuations in activity in the U.S. and especially abroad. A global flight-to-safety shock depresses global activity and inflation, widens corporate borrowing spreads, and appreciates the dollar, consistent with VAR-based estimates. Our results contribute to recent literature exploring the role of global factors in economic fluctuations and the role of dollar assets as a safe haven, by helping quantify these roles and assess their overall importance.

Our findings suggest that the importance of global factors in driving macroeconomic outcomes in individual countries may be greater than previously thought. A large role for global factors in driving business cycles would have 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.

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

Table 2: Estimated Structural Parameters: Prior and Posterior Distributions

		Prior			Posterior	
		Distr.	**Mean**	**SD**	**Mean**	**[10%, 90%]**
Preferences, Technology, & Banking Friction						
b	Habits	B	0.6	0.125	0.61	[0.58, 0.64]
η	Inverse Frisch	G	2	0.5	4.24	[3.52, 4.89]
θ	Home/foreign subst. elast.	B	2	0.33	1.74	[1.55, 1.94]
γ	GFS shock dollar bias	N	0	5	0.30	[0.15, 0.45]
ξ	capital utilization cost	G	2	1	4.06	[3.12, 5.01]
ψ	Investment adj. cost	G	5	2	10.31	[8.94, 12.04]
ψ_i	Trade adj. cost	B	10	2	4.08	[2.94, 5.30]
χ	Portfolio cost	G	0.008	0.005	0.02	[0.02, 0.03]
ϕ	Steady-state leverage ratio	B	8	0.75	7.07	[5.99, 8.06]
σ	Banker survival	B	0.95	0.013	0.91	[0.90, 0.92]
$100{*}e$	Banker endowment	IG	0.5	1	0.25	[0.16, 0.37]
Pricing						
θ_p	Dom. price rigidity	B	0.75	0.05	0.81	[0.78, 0.84]
θ_p^x	Trade price rigidity	B	0.75	0.05	0.65	[0.61, 0.68]
θ_w	Wage rigidity	B	0.75	0.05	0.91	[0.89, 0.93]
ι_p	Dom. price indexation	B	0.5	0.15	0.29	[0.22, 0.36]
ι_p^x	Trade price indexation	B	0.5	0.15	0.38	[0.25, 0.52]
ι_w	Wage indexation	B	0.5	0.15	0.10	[0.05, 0.14]
Monetary Policy						
φ_π	Taylor rule infl.	B	1.5	0.15	1.27	[1.18, 1.36]
φ_y	Taylor rule gap	B	0.1	0.033	0.21	[0.19, 0.23]
φ_r	Taylor rule lagged r	B	0.6	0.1	0.66	[0.61, 0.71]

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	0.09	[0.083, 0.097]
σ_G	IG	0.01	0.05	0.019	[0.017, 0.020]
σ_I	IG	0.01	0.05	0.046	[0.038, 0.057]
σ_N	IG	0.01	0.05	0.031	[0.024, 0.038]
$100\sigma_{RP}$	IG	0.1	1	0.118	[0.121, 0.162]
σ_{μ_H}	IG	0.01	0.05	0.013	[0.011, 0.015]
σ_A	IG	0.01	0.05	0.005	[0.004, 0.005]
σ_κ	IG	0.005	0.05	0.011	[0.008, 0.014]
$100\sigma_{\bar{\pi}}$	IG	0.01	0.1	0.045	[0.041, 0.049]
ρ_R	B	0.4	0.125	0.723	[0.671, 0.777]
ρ_G	B	0.6	0.125	0.919	[0.894, 0.944]
ρ_I	B	0.6	0.125	0.916	[0.880, 0.947]
ρ_N	B	0.6	0.125	0.420	[0.323, 0.514]
ρ_{RP}	B	0.6	0.1	0.967	[0.955, 0.977]
ρ_{μ_H}	B	0.6	0.125	0.973	[0.964, 0.981]
ρ_A	B	0.6	0.125	0.973	[0.923, 0.969]
ρ_κ	B	0.6	0.125	0.978	[0.965, 0.989]
$\rho_{\bar{\pi}}$	B	0.995	0.002	0.997	[0.996, 0.998]
θ_{μ_H}	B	0.5	0.125	0.455	[0.366, 0.537]
Foreign Shocks					
$100\sigma_{UIP}$	IG	0.1	5	0.203	[0.153, 0.258]
$100\sigma_{R*}$	IG	0.1	0.1	0.124	[0.099, 0.148]
σ_{G*}	IG	0.01	0.05	0.010	[0.009, 0.011]
σ_{I*}	IG	0.01	0.05	0.070	[0.056, 0.086]
$100\sigma_{RP*}$	IG	0.1	1	0.065	[0.036, 0.102]
$\sigma_{\mu_{F*}}$	IG	0.01	0.05	0.014	[0.011, 0.018]
σ_{A*}	IG	0.01	0.05	0.012	[0.010, 0.015]
$\sigma_{\kappa*}$	IG	0.005	0.05	0.011	[0.008, 0.014]
ρ_{R*}	B	0.4	0.125	0.673	[0.604, 0.737]
ρ_{UIP}	B	0.6	0.125	0.941	[0.916, 0.966]
ρ_{G*}	B	0.6	0.125	0.846	[0.798, 0.898]
ρ_{I*}	B	0.6	0.125	0.353	[0.226, 0.481]
ρ_{RP*}	B	0.6	0.1	0.571	[0.445, 0.715]
$\rho_{\mu_{F*}}$	B	0.6	0.125	0.690	[0.611, 0.777]
ρ_{A*}	B	0.6	0.125	0.698	[0.614, 0.780]
$\rho_{\kappa*}$	B	0.6	0.125	0.708	[0.559, 0.828]
$\theta_{\mu_{F*}}$	IG	0.5	0.125	0.392	[0.294, 0.501]
Trade Shocks					
$\sigma_{\mu_{H*}}$	IG	0.01	0.05	0.051	[0.042, 0.062]
$\sigma_{\mu^P_{H*}}$	IG	0.01	0.05	0.020	[0.005, 0.028]
σ_{μ_F}	IG	0.01	0.05	0.011	[0.007, 0.014]
$\sigma_{\mu^P_F}$	IG	0.01	0.05	0.013	[0.011, 0.016]
σ_ω	IG	0.01	0.05	0.009	[0.008, 0.012]
$\sigma_{\omega*}$	IG	0.01	0.05	0.003	[0.003, 0.004]
$\rho_{\mu_{H*}}$	B	0.6	0.125	0.631	[0.496, 0.764]
$\rho_{\mu^P_{H*}}$	B	0.995	0.002	0.994	[0.991, 0.996]
ρ_{μ_F}	B	0.6	0.125	0.532	[0.350, 0.698]
$\rho_{\mu^P_F}$	B	0.995	0.002	0.995	[0.993, 0.997]
ρ_ω	B	0.6	0.125	0.913	[0.887, 0.937]
$\rho_{\omega*}$	B	0.6	0.125	0.900	[0.866, 0.930]
$\theta_{\mu_{H*}}$	B	0.5	0.125	0.627	[0.512, 0.733]
θ_{μ_F}	B	0.5	0.125	0.515	[0.382, 0.659]
$\theta_{\mu^P_F}$	B	0.5	0.125	0.392	[0.294, 0.501]
Global Shocks					
$100\sigma_{GFS}$	IG	0.1	1	0.141	[0.121, 0.162]
$\sigma_{G\kappa}$	IG	0.005	0.05	0.005	[0.003, 0.007]
ρ_{GFS}	B	0.6	0.125	0.967	[0.958, 0.974]
$\rho_{G\kappa}$	B	0.6	0.125	0.770	[0.680, 0.851]

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	36.6	2.4	0.4	0	16.8	15	4.7	0.7	0	0.4	6.2	16.8
World consumption growth	40.7	2.6	0.6	0	21.2	2	5.2	0.9	0	0.2	1.8	24.6
World investment growth	24.1	1.6	0.1	0	6.6	0.7	7.7	0.2	0	4.8	46.6	7.7
World spread	23.6	1.6	0.3	0	10.2	0.7	1.6	0.4	0	52	3.3	6.5
World inflation	2.2	0.1	0	0	0.3	0.1	16.9	72.4	0	0	0.7	9
World policy rate	45.9	2.1	0	0	7.8	0.2	2	37.5	0	0	0.2	6.1
Real exchange rate growth	2.8	5.4	0	43.8	11.3	0.5	9.5	0.6	20	0.1	0.6	5.6

Note: The table shows the variance decomposition of world variables, based on model simulations of length 500,000, drawing shock innovations from their assumed Gaussian distributions.

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. In-vestment**	**U.S. TFP and labor supply**
U.S. GDP growth	14.8	8	0.1	4.3	14.6	8.3	23.9	3.7	0.4	0.3	6.7	15
U.S. consumption growth	10	11	8.7	2.5	32.7	8.6	4.4	2.5	0.4	0.3	3.1	15.9
U.S. investment growth	1.6	4.4	7.8	2	19.4	1.4	0.3	4.5	0	4.4	51.9	2.8
U.S. spread	5.3	0.7	3.3	0.3	20.8	4.7	1.4	2.1	0.3	47.1	11.2	3.6
U.S. inflation	1.5	15.6	6.7	2	1.2	1	0.1	13	49.6	0.1	2.3	11.9
U.S. policy rate	29.4	0.7	0.6	0.5	15.4	4.9	0.5	5.1	38.4	0.1	0.3	5.8
U.S. hours	34.1	8.6	1	4.6	20.8	4.9	3.2	5.4	0.1	0.6	10.7	4.9
U.S. real exchange rate growth	2.8	23.1	43.8	13.5	5.5	4.9	0.4	3.5	0.3	0.1	0.5	1.9
U.S. import growth	1.4	3.7	2.5	62.9	6.8	1.4	0.5	4.5	0.1	1.1	13.2	2.3
U.S. export growth	5.9	47.9	25.1	9.4	4.2	2.4	0.3	2.1	0.2	0.1	1.1	1.4

Note: The table shows the variance decomposition of U.S. variables, based on model simulations of length 500,000, drawing shock innovations from their assumed Gaussian distributions.

Table 6: Variance Decomposition, Foreign Variables

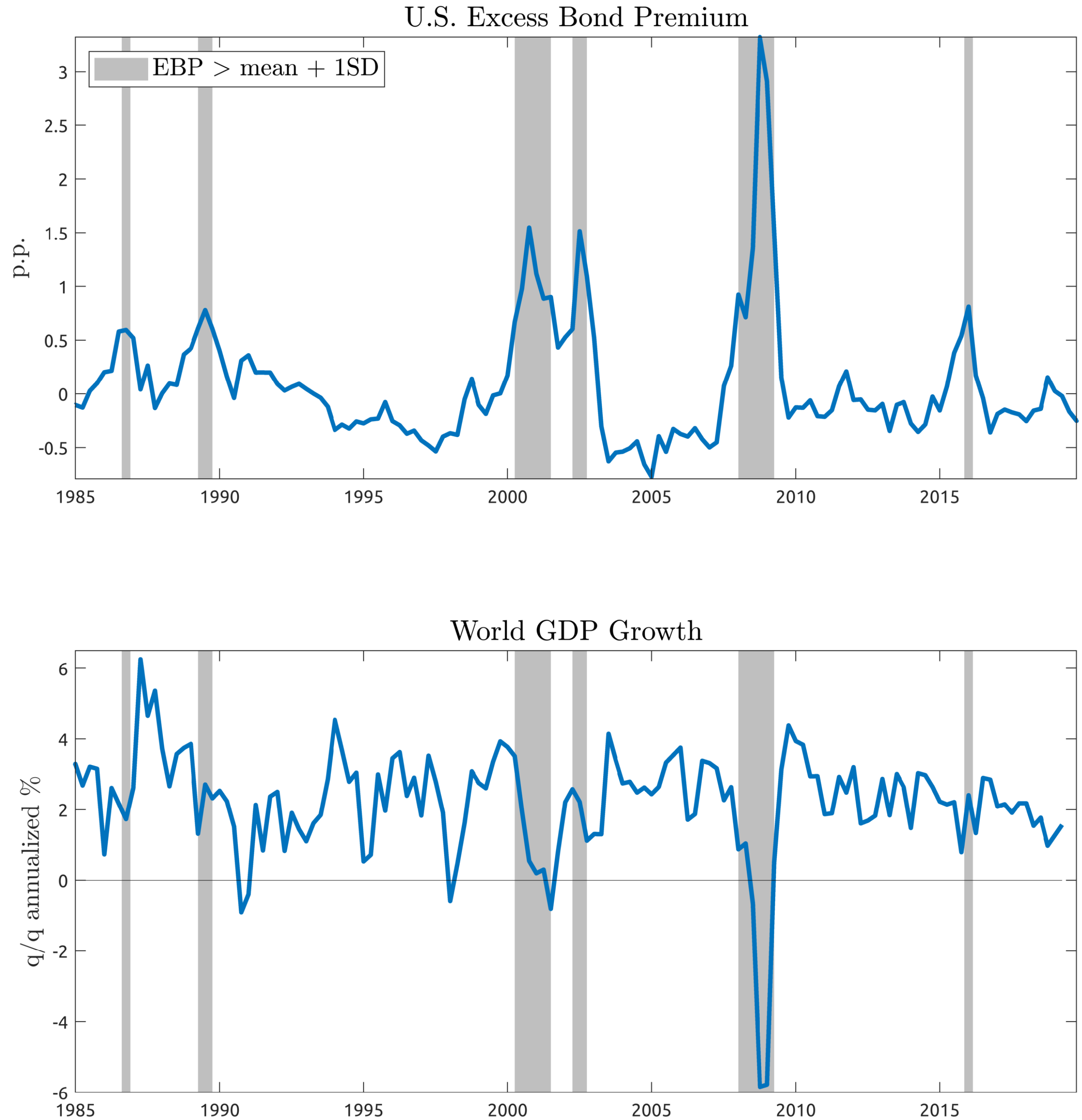
	Global flight-to-safety	**All U.S. shocks**	**UIP**	**Foreign home bias**	**Foreign risk premium**	**Foreign monetary**	**Foreign government**	**Foreign markup**	**Foreign inflation target**	**Foreign banking friction**	**Foreign Invest-ment**	**Foreign TFP**
Foreign GDP growth	30	1.2	0	1.4	0.6	21.1	15	5.2	0.8	0.3	5.1	19
Foreign consumption growth	34.5	2	1.9	0.3	0.9	23.8	1.3	5.8	1	0	0.8	27.5
Foreign investment growth	25.5	4.6	3.5	0.3	0.2	7.5	0.4	3.8	0.2	4.7	43.7	6.2
Foreign spread	19.9	1.1	0.8	0	0.4	12.2	0.5	1.5	0.5	54.8	2.4	6.7
Foreign inflation	1.3	1	1.1	0.2	0	0.4	0	13.8	71	0	0.3	6.8
Foreign policy rate	33.2	0.2	0.1	0.1	0	9.7	0.2	1.9	45.7	0	0.1	6.7

Note: The table shows the variance decomposition of Foreign varibles, based on model simulations of length 500,000, drawing shock innovations from their assumed Gaussian distributions.

Table 7: Correlations, Data and Model

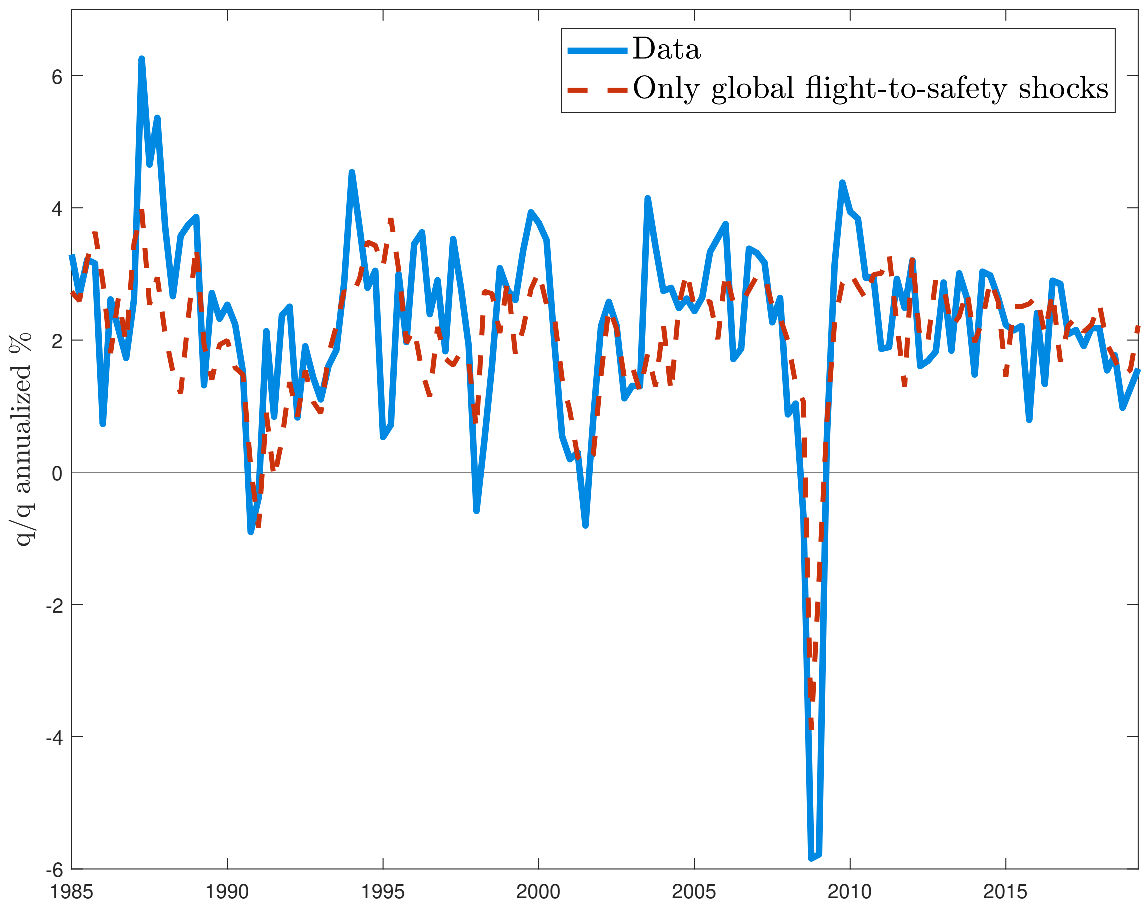
	Data	**Model**	**Model, GFS shock only**
Correlation of world GDP growth with:			
World consumption growth	0.679	0.816	0.983
World investment growth	0.795	0.676	0.878
World spread	-0.673	-0.428	-0.737
World inflation	0.418	-0.105	0.604
World policy rate	0.132	-0.145	-0.053
Change in dollar exchange rate	-0.290	0.038	-0.774
Correlations between U.S. and Foreign:			
GDP growth	0.469	0.242	0.999
Consumption growth	0.245	0.107	0.985
Investment growth	0.363	-0.018	0.967
Spread	0.810	0.071	0.978
Inflation	0.405	-0.029	0.684
Policy rate	0.845	0.345	0.999

Figure 1: U.S. Excess Bond Premium and World GDP Growth



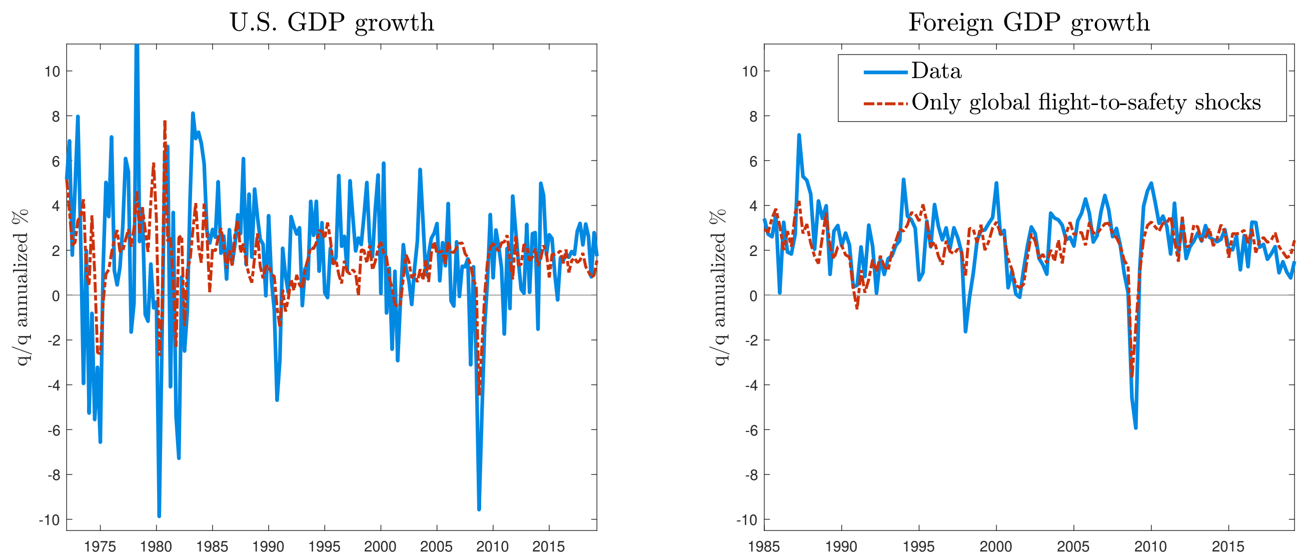
Note: The top panel shows the excess bond premium (Gilchrist and Zakrajšek, 2012), and the bottom panel shows world GDP growth, both at the quarterly frequency. Gray shaded areas indicate periods in which the excess bond premium is one standard deviation above the mean.

Figure 2: The Role of the GFS Shock in World GDP Growth



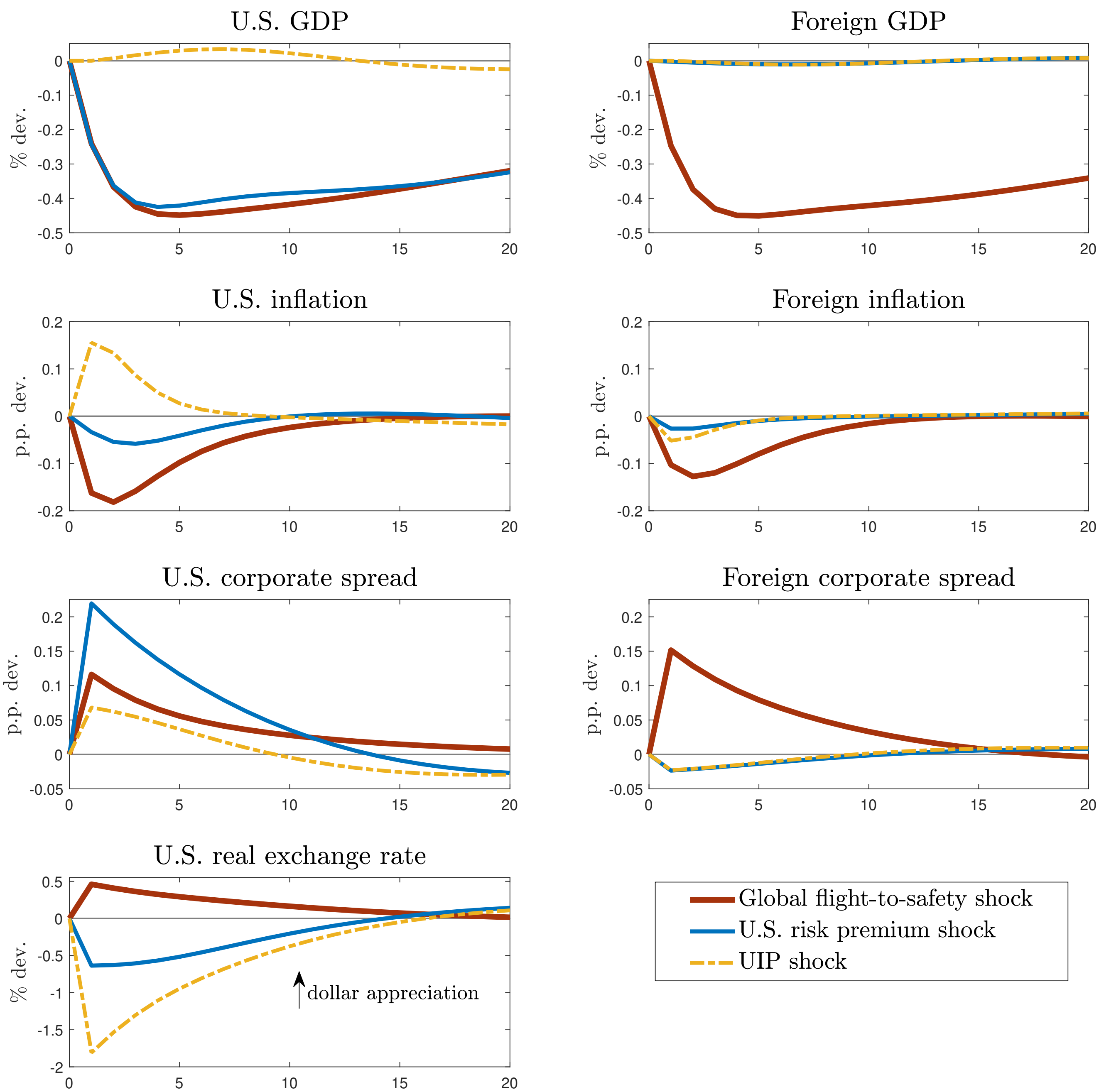
Note: World GDP growth in the data (blue solid line) and in the model with GFS shocks only (red dashed line).

Figure 3: The Role of the GFS Shock in U.S. and Foreign GDP Growth



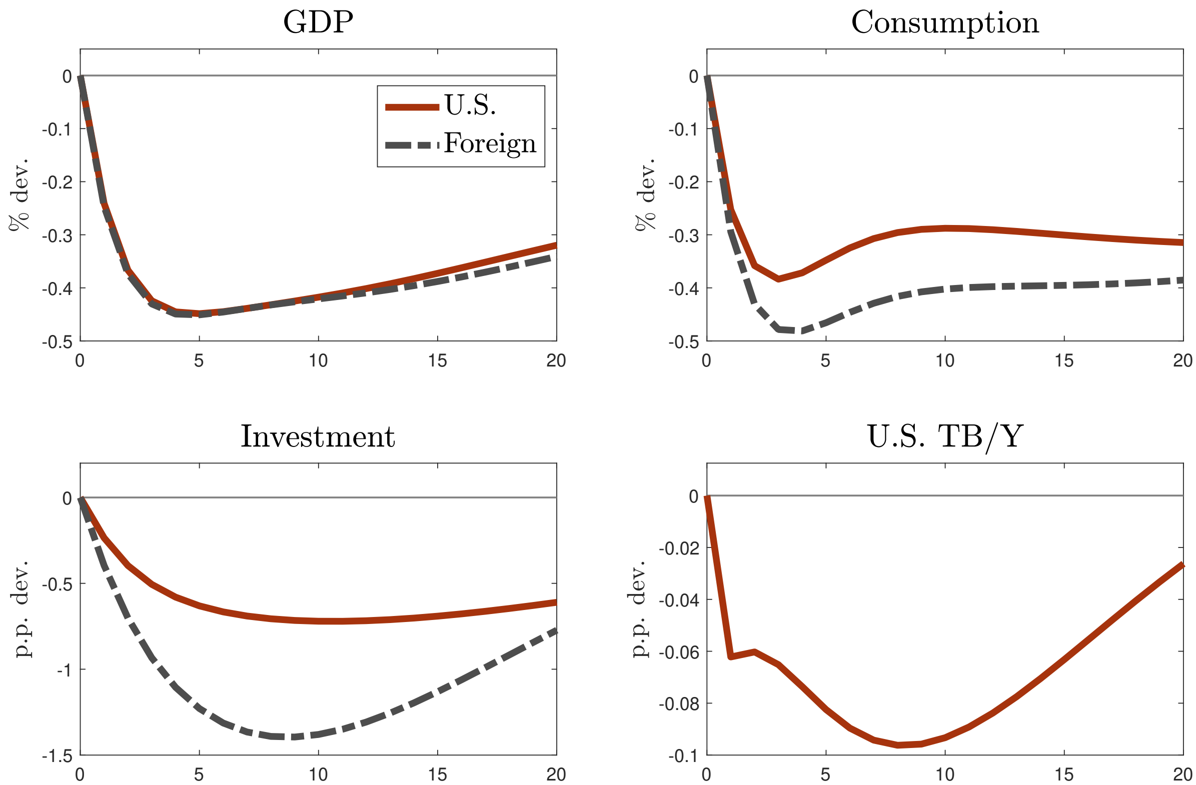
Note: U.S. (left panel) and Foreign (right panel) GDP growth in the data (blue solid line) and in the model with GFS shocks only (red dashed line).

Figure 4: 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 thin line), and UIP shock (yellow dash-dotted line).

Figure 5: Global Flight-to-Safety Shock in the Model: Impulse Responses



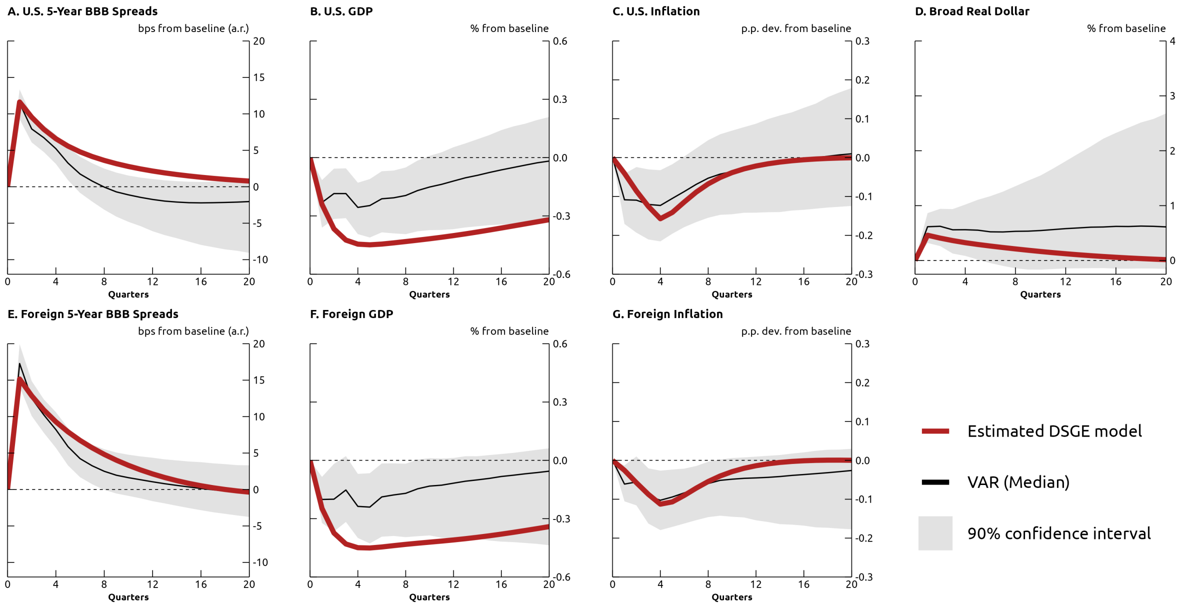
Note: Effects of a one-standard-deviation global flight-to-safety shock in the model, on the U.S. (red solid line) and on Foreign (gray dash-dotted line).

Table 8: EBP and Global Risk Proxies

	Global Financial Factor	VIX	Global Volatility	1-Year U.S. Treasury Premium	Foreign Currency Sovereign Risk	Local Currency Sovereign Risk
$h = 3$	-0.78^{***}	8.92^{***}	6.56^{***}	0.10^{***}	1.37^{***}	0.05
	(0.19)	(1.69)	(2.01)	(0.04)	(0.25)	(0.11)
$h = 6$	-0.94^{***}	8.06^{***}	4.99^{**}	0.11^{**}	1.41^{***}	0.09
	(0.23)	(2.02)	(2.53)	(0.04)	(0.33)	(0.08)
$h = 12$	-1.01^{***}	7.67^{***}	4.84	0.09	1.12^{**}	-0.10
	(0.28)	(2.45)	(3.17)	(0.06)	(0.48)	(0.11)

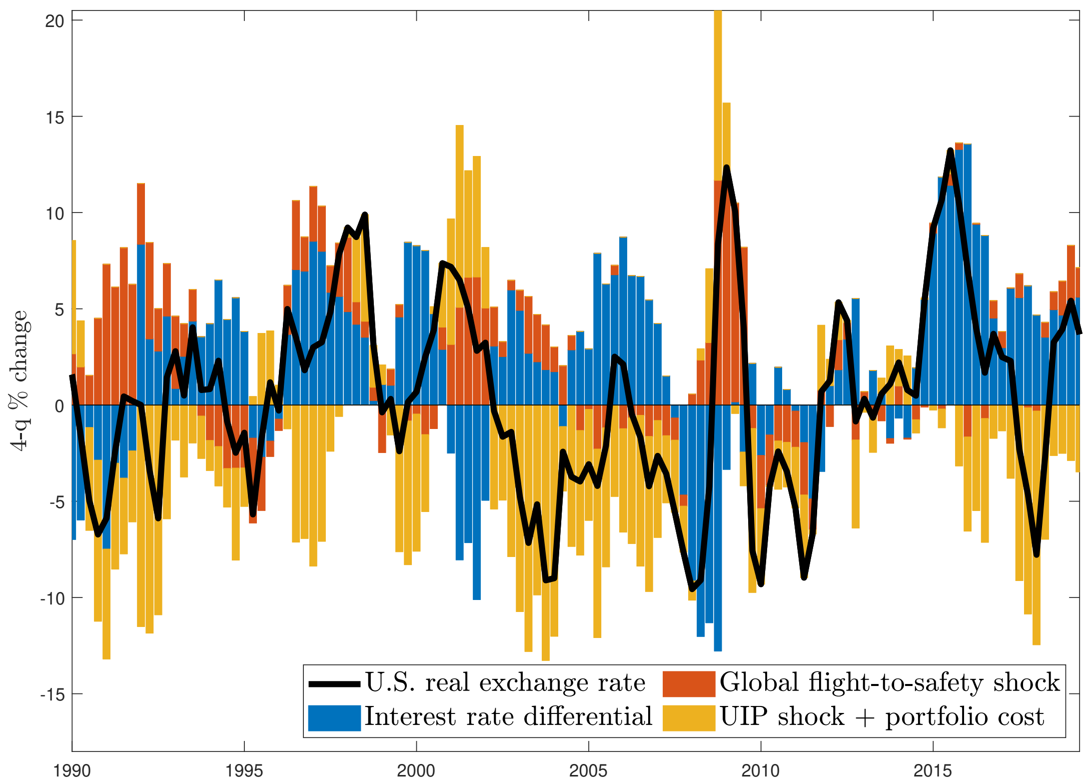
Note: The optimal number of lags (p) in each regression is determined by AIC criteria. Robust standard errors, *p<0.1; **p<0.05; ***p<0.01

Figure 6: Effects of global risk shock from identified VAR



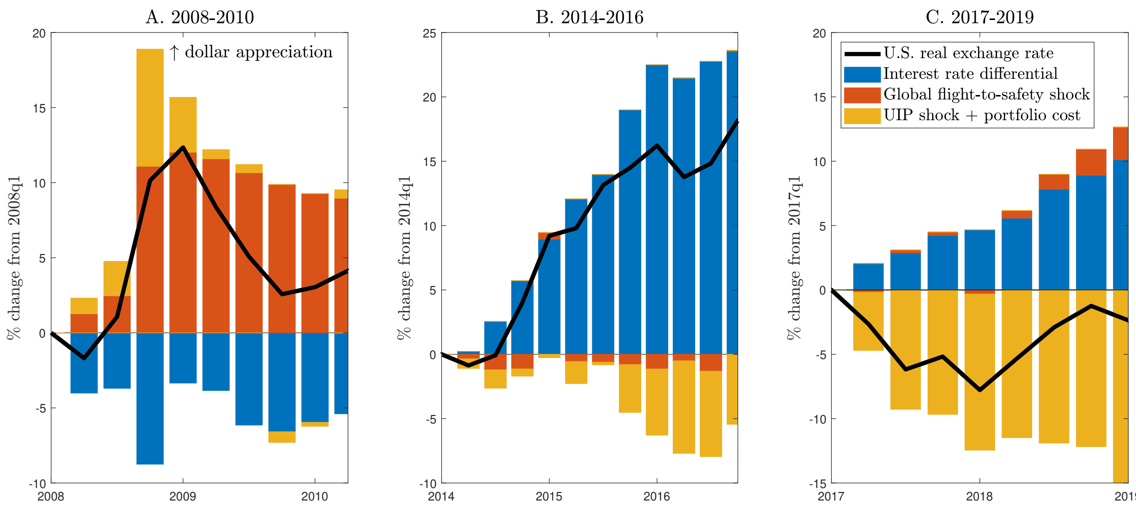
Note: In the VAR we report end-of-quarter values obtained from monthly responses to a 1 standard deviation shock to global risk sentiment proxied with the EBP. The solid black line corresponds to the median response in the VAR. Confidence bands are obtained by bootstrapping. The shaded gray areas denote the 95 percent confidence interval. The thick blue line depicts the response to a GFS shock in the estimated DSGE model.

Figure 7: Drivers of exchange rate movements



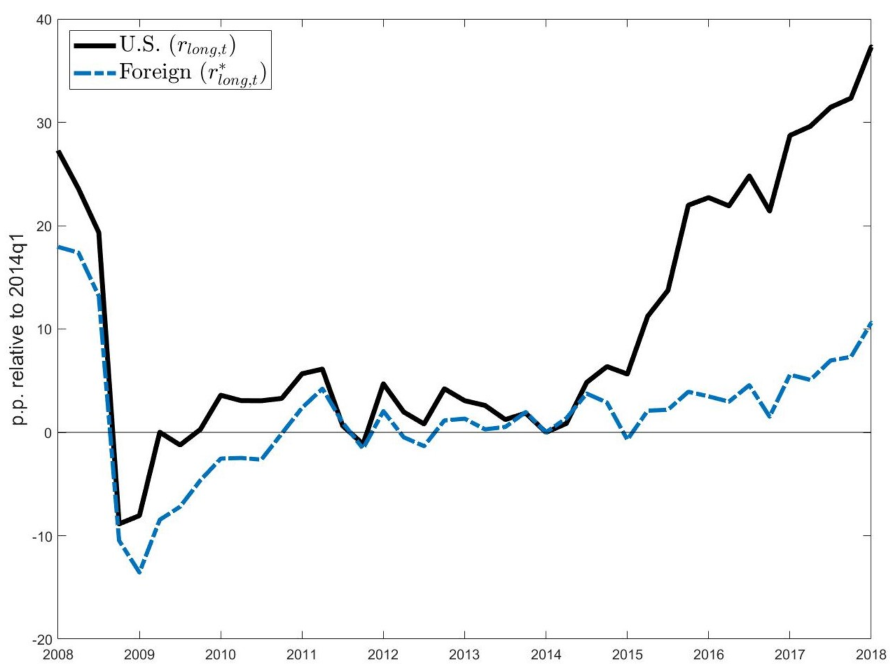
Note: The figure plots broad real dollar and its three components from decomposition (42) in 4-quarter percent changes. The black solid line shows the broad real dollar, the blue bars correspond to the interest rate differential, the red bars correspond to the flight-to-safety shock, and the yellow bars correspond to the UIP shock plus the portfolio cost.

Figure 8: Drivers of exchange rate movements: Three episodes



Note: The three panels plot the broad real dollar and its three components from decomposition (42) for the periods 2008-10, 2014-16 and 2017-19, as 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 9: 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 (46) and (47) 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 his lifetime utility given by

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

subject to

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

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

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

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 his lifetime utility given by

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

subject to

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

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

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

Optimality Conditions:

Consumption, C_t^*:

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

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

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

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

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

Deposits, D_t^*:

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

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

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

Labor, $n_t^*(i)$:

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

Wage evolution $w_t^*(i)$:

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

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:

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

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

$$\frac{V_t}{x_t} \geq e^{\zeta_t^\kappa + \bar{\zeta}_t^\kappa} \kappa \phi_t$$

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

$$\psi_t = e^{\zeta_t^\kappa + \bar{\zeta}_t^\kappa} \kappa \phi_t \tag{A.15}$$

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

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 total startup net worth that the family transfers to new bankers and net worth of bankers that survive from the previous period.

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

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

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

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

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

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

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

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 is 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

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

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

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

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

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

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

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

$$-\beta\mathbb{E}_t\Lambda_{t,t+1}\frac{p_{t+1}^I}{p_t^I}\left[(1-e^{\zeta_{t+1}^\omega}\omega_I)\left(\frac{C_{t+1}^d}{C_{F,t+1}}\right)\right]^{\frac{1}{\theta}} C_{F,t+1}\left(1-\psi_{t+1}^{M,C}\right)^{-\frac{1}{\theta}}\frac{\partial\psi_{t+1}^{M,I}}{\partial I_{F,t}} \quad \text{(A.30)}$$

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

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

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

Optimality conditions for foreign producers are given by

$$p_{F,t}^* = \left[e^{\zeta_t^{*\omega}}\omega^*\left(\frac{C_t^{*d}}{C_{F,t}^*}\right)\right]^{\frac{1}{\theta}} - \left[(1-e^{\zeta_t^{*\omega}}\omega^*)\left(\frac{C_t^{*d}}{C_{H,t}^*}\right)\right]^{\frac{1}{\theta}} C_{H,t}^*\left(1-\psi_t^{*M,C}\right)^{-\frac{1}{\theta}}\frac{\partial\psi_t^{*M,C}}{\partial C_{F,t}^*}$$

$$-\beta\mathbb{E}_t\Lambda_{t,t+1}^*\left[(1-e^{\zeta_{t+1}^{*\omega}}\omega^*)\left(\frac{C_{t+1}^{d*}}{C_{H,t+1}^*}\right)\right]^{\frac{1}{\theta}} C_{H,t+1}^*\left(1-\psi_{t+1}^{*M,C}\right)^{-\frac{1}{\theta}}\frac{\partial\psi_{t+1}^{*M,C}}{\partial C_{F,t}^*} \quad \text{(A.33)}$$

$$p_{H,t}^* = \left[(1-e^{\zeta_t^{\omega*}}\omega^*)\left(\frac{C_t^{d*}}{C_{H,t}^*}\right)\right]^{\frac{1}{\theta}} - \left[(1-e^{\zeta_t^{\omega*}}\omega^*)\left(\frac{C_t^{d*}}{C_{H,t}^*}\right)\right]^{\frac{1}{\theta}} C_{H,t}^*\left(1-\psi_t^{M,C*}\right)^{-\frac{1}{\theta}}\frac{\partial\psi_t^{M,C*}}{\partial C_{H,t}^*}$$

$$-\beta\mathbb{E}_t\Lambda_{t,t+1}^*\left[(1-e^{\zeta_{t+1}^{*\omega}}\omega^*)\left(\frac{C_{t+1}^{*d}}{C_{H,t+1}^*}\right)\right]^{\frac{1}{\theta}} C_{H,t+1}^*\left(1-\psi_{t+1}^{*M,C}\right)^{-\frac{1}{\theta}}\frac{\partial\psi_{t+1}^{*M,C}}{\partial C_{H,t}^*} \quad \text{(A.34)}$$

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

$$-\beta\mathbb{E}_t\Lambda_{t,t+1}^*\frac{p_{t+1}^{I*}}{p_t^{I*}}\left[(1-e^{\zeta_{t+1}^{*\omega}}\omega_I^*)\left(\frac{I_{t+1}^*}{I_{H,t+1}^*}\right)\right]^{\frac{1}{\theta}} I_{H,t+1}^*\left(1-\psi_{t+1}^{*M,I}\right)^{-\frac{1}{\theta}}\frac{\partial\psi_{t+1}^{*M,I}}{\partial I_{F,t}^*} \quad \text{(A.35)}$$

$$\frac{p^*_{H,t}}{p^{I*}_t} = \left[(1-e^{\zeta^{\omega*}_t}\omega^*_I)\left(\frac{I^*_t}{I^*_{H,t}}\right)\right]^{\frac{1}{\theta}} - \left[(1-e^{\zeta^{\omega*}_t}\omega^*_I)\left(\frac{I^*_t}{I^*_{H,t}}\right)\right]^{\frac{1}{\theta}} I^*_{H,t}\left(1-\psi^{M,I*}_t\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{M,I*}_t}{\partial I^*_{H,t}}$$
$$-\beta\mathbb{E}_t\frac{p^{I*}_{t+1}}{p^{I*}_t}\Lambda^*_{t,t+1}\left[(1-e^{\zeta^{*\omega}_{t+1}}\omega^*_I)\left(\frac{C^{*d}_{t+1}}{C^*_{H,t+1}}\right)\right]^{\frac{1}{\theta}} C^*_{H,t+1}\left(1-\psi^{*M,C}_{t+1}\right)^{-\frac{1}{\theta}}\frac{\partial\psi^{*M,I}_{t+1}}{\partial I^*_{H,t}} \quad \text{(A.36)}$$

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

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:

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

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

$$Y^*_{F,t}(h) = \left[\frac{P^*_{F,t}(h)}{P^*_{F,t}}\right]^{-\frac{1+\mu^*_{F,t}}{\mu^*_{F,t}}} Y^*_{F,t} \quad \text{(A.42)}$$

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

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

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

A.5 Intermediate Goods 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, letting $p^o_{H,t} = \frac{P^o_{H,t}}{P_t}$,

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

A similar problem for retailers of the home variety abroad yields:

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

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

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

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

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 Goods Producers

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

$$MC_t Y_t - W_t N_t - r^K_t \bar{K}_t$$

subject to

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

Optimality conditions are:

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

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

Similarly abroad:

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

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

A.7 Capital goods producers

Capital goods 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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_R}\left[\left(\pi_t - e^{\zeta_t^{\pi}}\bar{\pi}\right)^{\varphi_\pi}\left(\frac{Y_t}{Y_t^{flex}}\right)^{\varphi_Y}\right]^{1-\varphi_R} e^{\zeta_t^R)} \tag{A.76}$$

$$\frac{R_t^*}{R} = \left(\frac{R_{t-1}^*}{R}\right)^{\varphi_R}\left[\left(\pi_t^* -^{\zeta_t^{\pi *}}\bar{\pi}\right)^{\varphi_\pi}\left(\frac{Y_t^*}{Y_t^{*flex}}\right)^{\varphi_Y}\right]^{1-\varphi_R} e^{\zeta_t^{R*}} \tag{A.77}$$

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

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.

Nominal interest rate: We use the "10-Year Treasury Bond Yield at Constant Maturity" (g10'n111rg10) monthly series converted to quarterly averages. Source: Haver Analytics.

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. Source: Federal Reserve Board.

Consumer price index: We use the seasonally adjusted series "CPI-U: All Items" (usecon'pcu) with reference period 1982-84 from the Bureau of Economic Analysis. Source: Haver Analytics.

Long-run inflation expectations: taken from the survey of professional forecasters conducted by the Federal Reserve Bank of Philadelphia and represents 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 "Nonfarm 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 comes 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 country/blocs: Argentina, Australia, Brazil, Bulgaria, Canada, Colombia, Chile, China, Croatia, Czech Republic, Denmark, Euro Area, Hong Kong, Hungary, India, Indonesia, Israel, Japan, Malaysia, Mexico, New Zealand, Philippines, Poland, Romania, Russian Federation, Saudi Arabia, Singapore, South Africa, South Korea, Sweden, Taiwan, Thailand, Turkey, and United Kingdom. Our sample of countries represents about 85 % of PPP-adjusted world GDP in 2019.

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

In order to deflate nominal GDP and its components we use the implicit price deflator for GDP from the 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.

Working Age Population 15-64 comes from the United Nations and Haver Analytics. It is reported at an annual frequency and is seasonally adjusted.

Interest Rates and Consumer Prices

We collect three interest rate series: money market interest rates, 10-year government bond yields, and deposit rates. All 3 series are not seasonally adjusted and are reported at a monthly frequency which we use to find the quarterly average. Day-to-Day Money Market Interest Rates comes from the Eurostat, while the other two series come from the ECB.

Harmonized Index of Consumer Prices (HICP) comes from the EABCN. It is indexed relative to 1996=100.

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 it 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* $\times$ *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, nominal policy rate, nominal deposit interest rate, 10 year government yields, CPI inflation inflation.