Technical Appendix: "International Business Cycle and Financial Intermediation"

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Technical Appendix: "International Business Cycle and Financial Intermediation"[*]

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Abstract

The paper extends a standard two-country international real business cycle model to include financial intermediation by banks of loans and government bonds. The paper contributes an explanation for both the United States relative to the Euro-area, and the United States relative to China, of cross-country correlations of loan rates, deposit rates, and the loan premia. It shows a type of financial retrenchment for the United States relative to both Europe and China following a negative bank productivity shock, such as during the 2008 crisis. After 2008, results suggest that the Euro-area has been more financially integrated with the United States, and China less financially integrated.

Keywords: International Real Business Cycles, Trade, Financial Intermediation, Credit Spread, Bank Productivity, 2008 Crisis

JEL: E13, E32, E44, F41

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A Appendix

A.1 Calibration Table

Parameters	Description	Country H	Country F	
		US	Euro Area	China
Preferences				
θ_i	Elasticity of substitution	1.51	1	1
A_i	Weight of leisure	1.8	1.8	1.8
β_i	Subjective discount factor	0.99	0.99	0.99
Goods Production				
A_{Gi}	Goods sector productivity level	1	1	1
α_i	Share of capital in output	0.36	0.30	0.30
δ_i	Depreciation rate of capital	0.025	0.025	0.025
ρ_G^i	Persistence of TFP shock	0.96	0.96	0.96
$\sigma_{G,i}^2$	Variance of TFP shock	0.007	0.007	0.007
Banking Sector				
A_{Qi}	Bank sector productivity level	1.84	1.5	1.5
κ_i	Share of labor in loan prod.	0.10	0.10	0.10
ρ_Q^i	Persistence of bank prod. shock	0.963	0.963	0.963
$\sigma_{Q,i}^2$	Variance of bank prod. shock	0.00076	0.00076	0.00076
Open Economy and Gov't				
η_i	CES b/w home and foreign goods	0.60	0.40	0.40
ν_i	Openness parameter	0.25	0.25	0.25
γ_i	Home bias parameter	0.84	0.09	0.09
n	Population parmaeter	0.37	0.63	0.63
χ_{Dij}	Country premium on deposits	0.01	0.012	0.012
χ_{Qij}	Country premium on loans	0.01	0.0119	0.0121
χ_{Bij}	Country premium on bonds	0.01	0.0119	0.0121
$\gamma_{gov,i}$	Share of gov't expenditure	0.20	0.40	0.40
$\rho_{gov,i}^i$	Persistence of gov't exp. shock	0.80	0.80	0.80
$\sigma_{gov,i}^2$	Variance of gov't exp. shock	0.01	0.01	0.01

Table 1: Model calibration parameter values.

A.2 Data Description

All data used in this paper is of quarterly frequency The data covers the period from 1996Q1 until 2015Q4 except for Euro-area loan rates which are 2003Q1-2015Q4. Variables are not seasonally adjusted and are in percents except the deposit and loan series for the US.

US:

Deposits: Deposits, All Commercial Banks (Series ID: DPSACBM027SBOG),from the Board of Governors of the Federal Reserve System; release H.8: Assets and Liabilities of Commercial Banks in the United States (Seasonally adjusted; in billions of US Dollars).

Loans: Loans and Leases in Bank Credit, All Commercial Banks (Series ID: LOANS), from the Board of Governors of the Federal Reserve System; release H.8: Assets and Liabilities of Commercial Banks in the United States (Seasonally adjusted; in billions of US Dollars).

The Lending Rate:.Bank Prime Loan Rate (Series ID: MPRIME) from the Federal Reserve Economic Data (FRED), Federal Reserve Bank of St Louis.

The Deposit Rate:.3-Months Treasury Bill: Secondary Market rate (Series ID: TB3MS), from the Board of Governors of the Federal Reserve System; release H.15: Selected Interest Rates.

Loan Premium: constructed as the difference between the lending and deposit rates.

Euro-area:

The Lending Rate: Bank Interest Rates - Loans to Corporations with an Original Maturity of up to one year - Euro area (Series ID: MIR.M.U2.B.A20.F.R.A.2240.EUR.O), from European Central Bank, Statistical Data Warehouse.

The Deposit Rate: 3-Months or 90-day Rates and Yields: Interbank Rates for the Euro Area (Series ID: IR3TIB01), from OECD, Main Economic Indicators.

Loan Premium: constructed as the difference between the lending and deposit rates.

All data series for calculating cross-country correlations are filtered with a **?** filter at the business cycle frequency to be consistent with the simulation based moment output of Dynare (**?**).

China:

Data for the financial variables of China are from the dataset of **?**. The variables used for China are[1]

The Lending Rate: the People's Bank of China benchmark 1-year lending rate.

The Deposit Rate: the People's Bank of China benchmark 1-year deposit rate.

Loan Premium: constructed as the difference between the lending and deposit rates.

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[1]The detailed methodology of the construction of the lending and deposit rates are described in **?**.
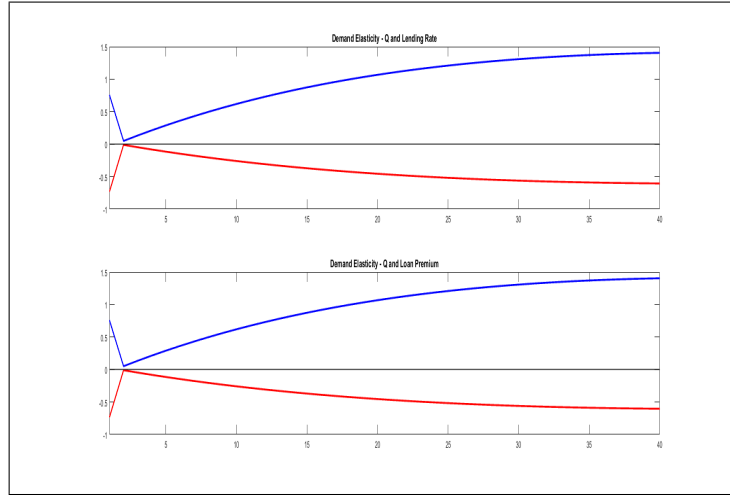
A.3   Impulse Responses

Figure A1. Responses of loan demand elasticity measures for the US (Home country - blue solid) and Euro area (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.
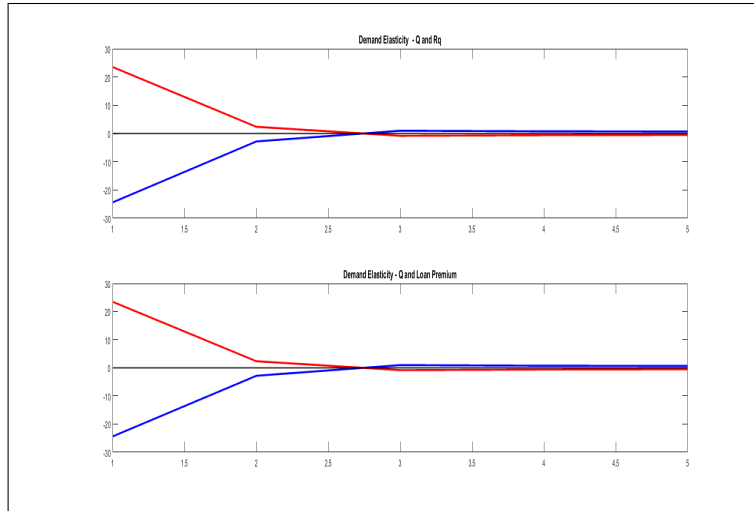

Figure A2. Responses of loan demand elasticity measures for the US (Home country - blue solid) and China (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

Figure A3. Impulse responses of key financial variables to a 1% positive Home country bank productivity shock for the US (Home country - blue solid) and the Euro area (Foreign country - red solid) calibration.
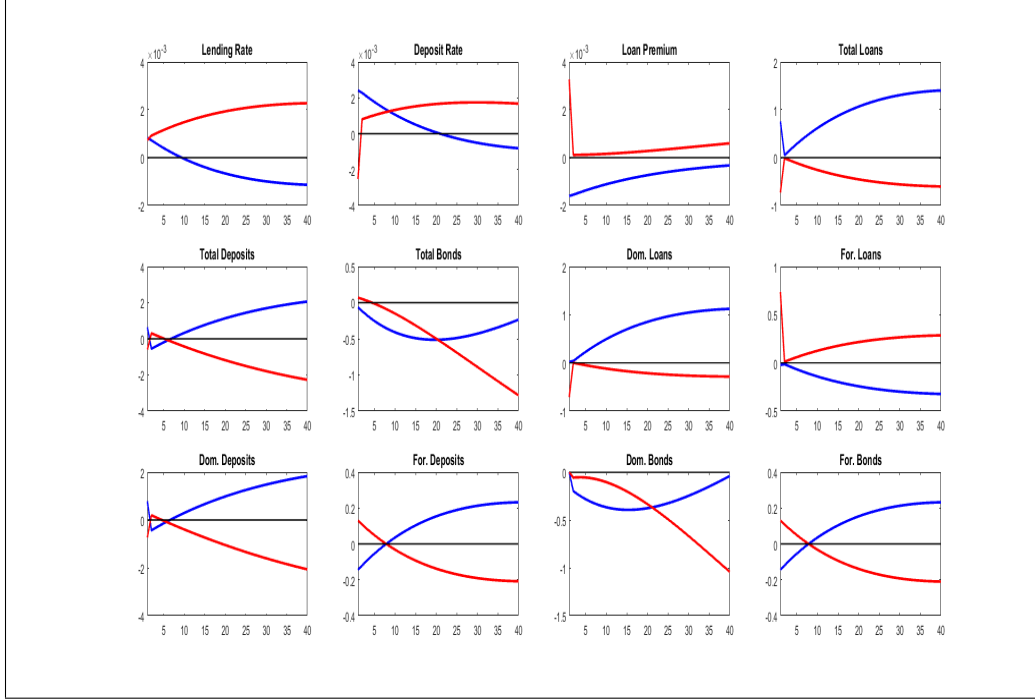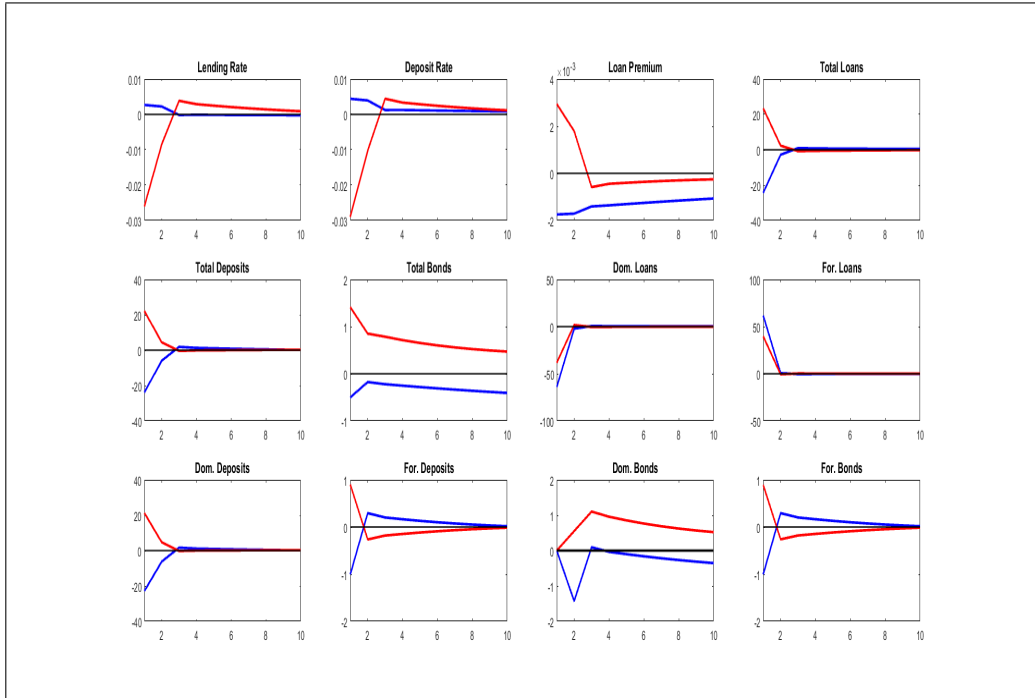

Figure A4. Impulse responses of key financial variables to a 1% positive Home country bank productivity shock for the US (Home country - blue solid) and the China (Foreign country - red solid) calibration.
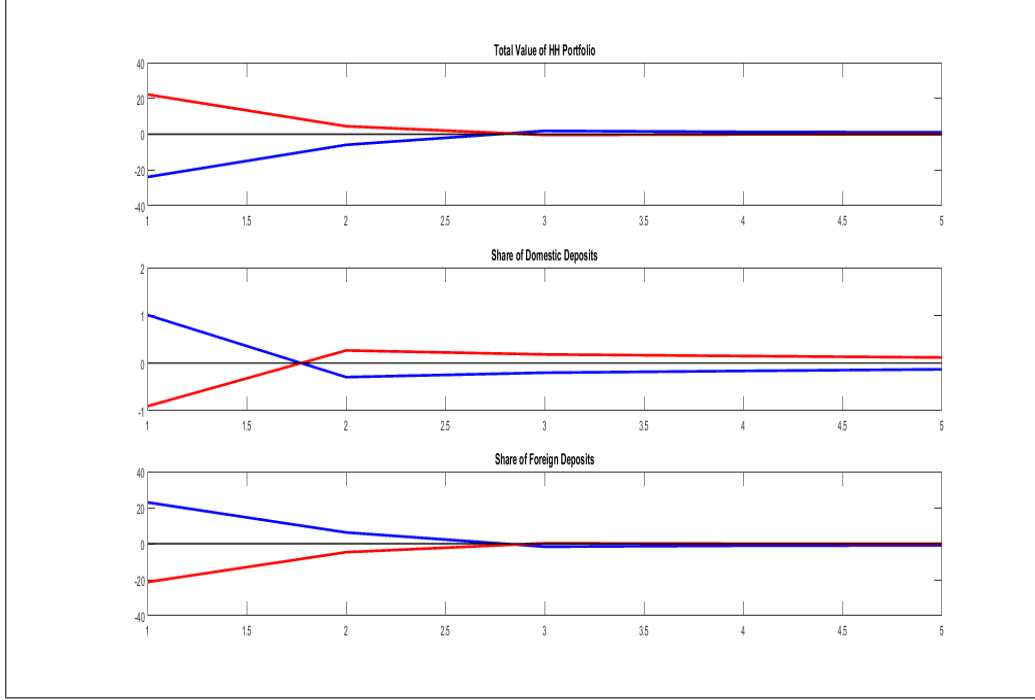
Figure A5. Impulse responses of the total and the shares of domestic and foreign deposits in the household's portfolio for the US (Home country - blue solid) and China (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.
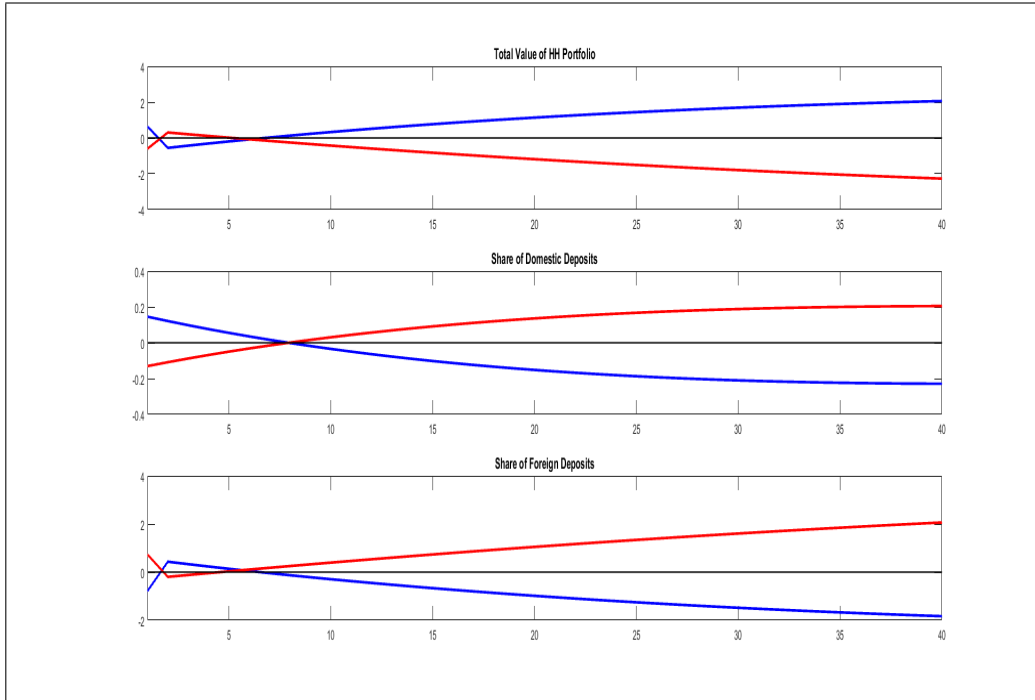

Figure A6. Impulse responses of the total and the shares of domestic and foreign deposits in the household's portfolio for the US (Home country - blue solid) and Euro area (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

Figure A7. Impulse responses of the total value and the shares of assets in the bank's portfolio for the US (Home country - blue solid) and Euro area (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.
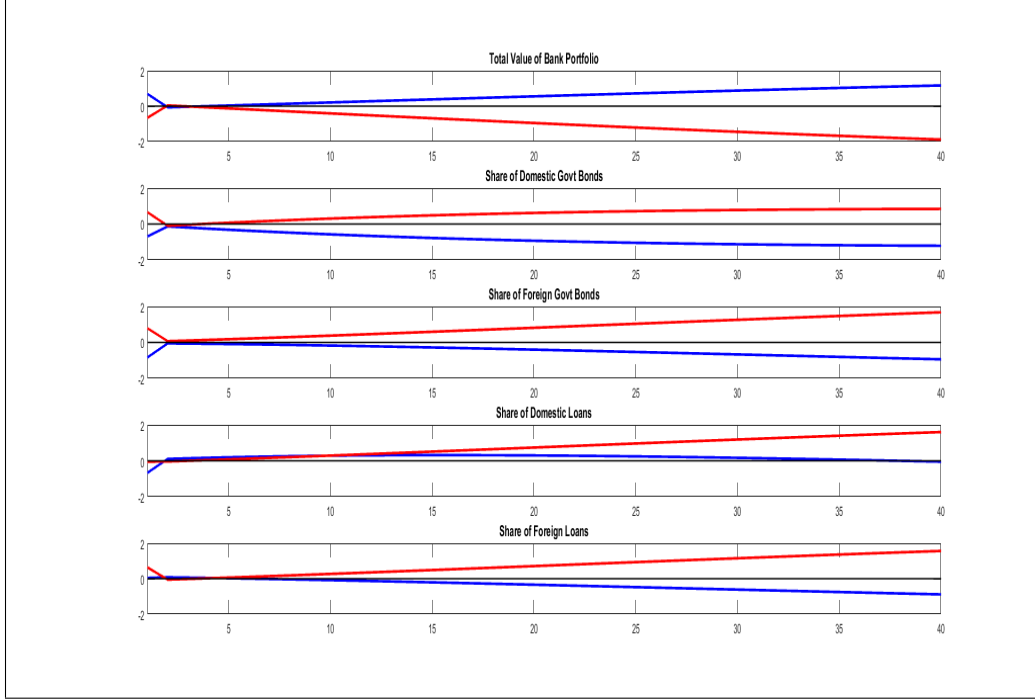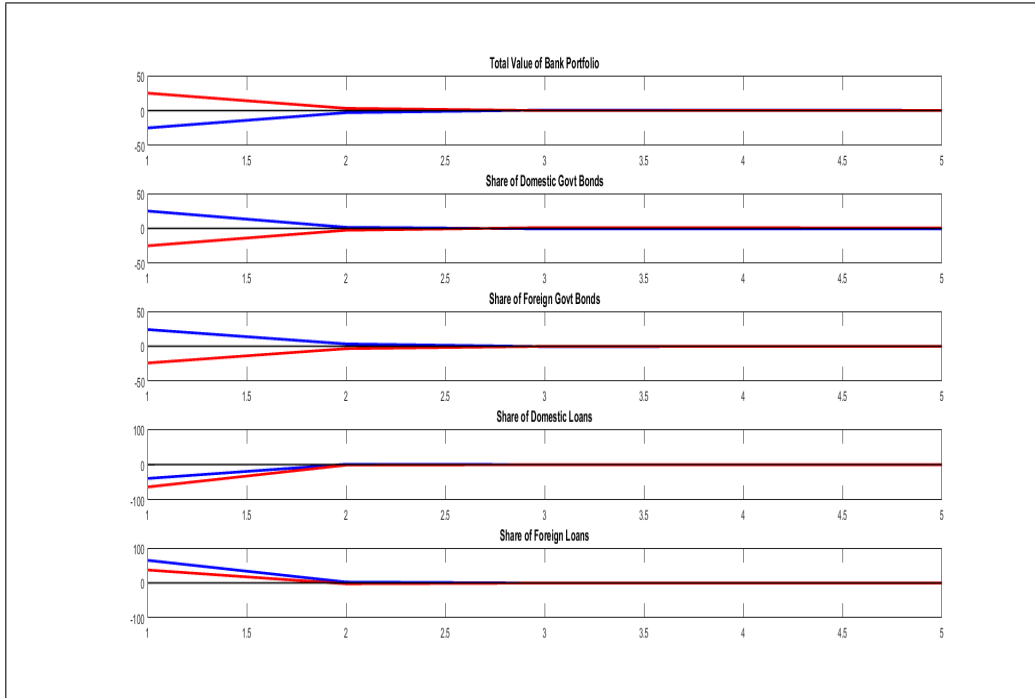

Figure A8. Impulse responses of the total value and the shares of assets in the bank's portfolio for the US (Home country - blue solid) and China (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.
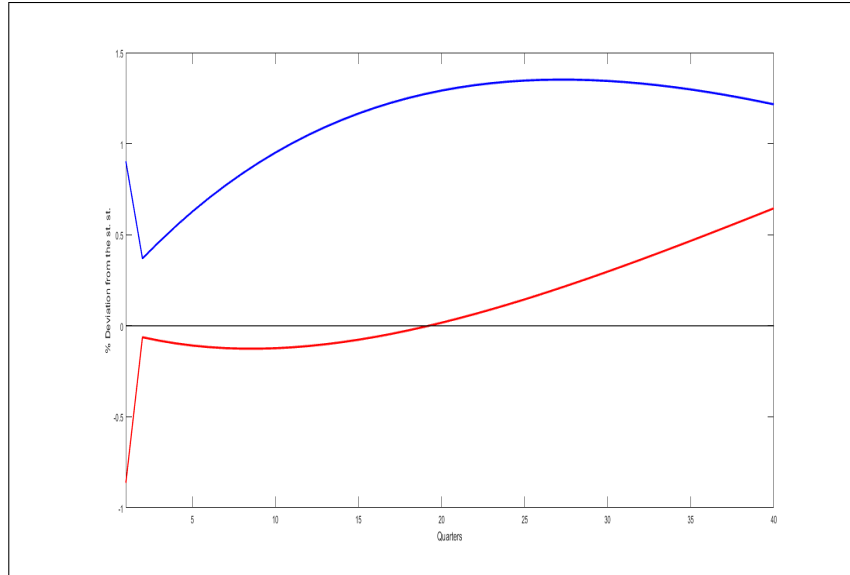
A.9. The impulse responses of the ratio of total loans to total government bond holdings in the bank's portfolio, to 1 percent positive home country banking productivity shock (US - blue solid; Euro area - red solid).
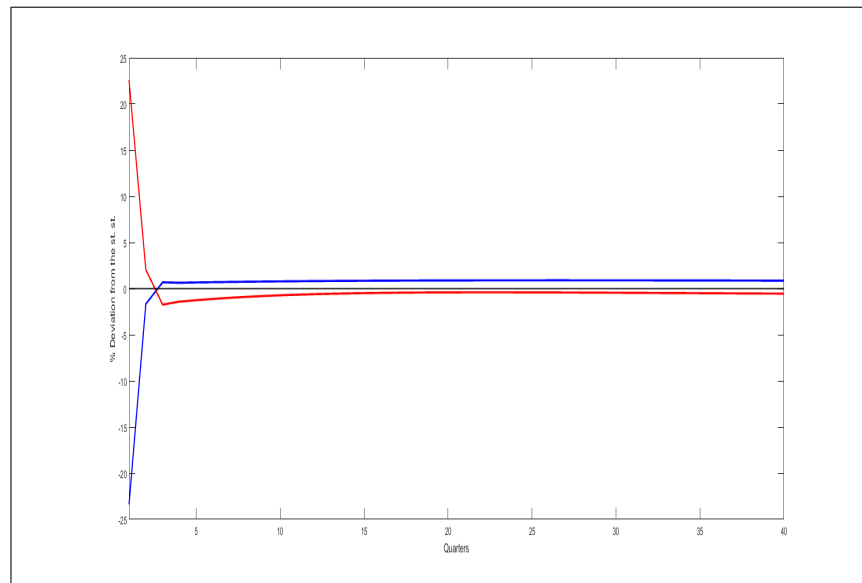
A. 10. The impulse responses of the ratio of total loans to total government bond holdings in the bank's portfolio, to 1 percent positive home country banking productivity shock (US - blue solid; China - red solid).

B   Technical Appendix: Model Details

In this section the model optimization problem and the equilibrium conditions are presented in detail. First, for the Home country and then for the Foreign country for each agent and/or sector.

B.1   The Home Country Household

For the home country consider the budget constraint in footnote 7. In this case $i = H$ and also apply the calibration assumption that no adjustment cost is paid for changing domestic asset positions, i.e. $\chi_{DHH} = 0$, to get

$$
\begin{aligned}
P_{CH,t}C_{H,t} &= P_{CH,t}w_{H,t}(l_{H,t} + l_{QH,t}) + P_{CH,t}(1 + R_{DH,t})D_{HH,t} \\
&\quad + P_{CF,t}(1 + R_{DF,t})D_{HF,t} + P_{CH,t}\tau_{H,t} - P_{CH,t}D_{HH,t+1} \\
&\quad - P_{CF,t}D_{HF,t+1} + P_{CH,t}\frac{\chi_{DHF}}{2}\left(\frac{P_{CF,t}}{P_{CH,t}}D_{HF,t+1}\right)^2.
\end{aligned}
\tag{1}
$$

Next normalize the budget constraint with the domestic consumption good price, $P_{CH,t}$, and use the definition of the real exchange rate, $RER_t \equiv P_{CF,t}/P_{CH,t}$, to get

$$
\begin{aligned}
C_{H,t} &= w_{H,t}t(l_{H,t} + l_{QH,t}) + (1 + R_{DH,t})D_{HH,t} + RER_t(1 + R_{DF,t})D_{HF,t} + \tau_{H,t} \\
&\quad - D_{HH,t+1} - RER_t D_{HF,t+1} + \frac{\chi_{DHF}}{2}\left(RER_{t+1}D_{HF,t+1}\right)^2.
\end{aligned}
\tag{2}
$$

Then the household's problem in the Home country can be writen as

$$
\begin{aligned}
\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta_H^t &\Big\{ \frac{[C_{H,t}(1 - l_{H,t} - l_{HQ,t})^{a_H}]^{1-\theta_H}}{1 - \theta_H} \\
&+ \lambda_{H,t}\begin{bmatrix} w_{H,t}t(l_{H,t} + l_{QH,t}) + (1 + R_{DH,t})D_{HH,t} \\ + RER_t(1 + R_{DF,t})D_{HF,t} + \tau_{H,t} - D_{HH,t+1} \\ -D_{HH,t+1} - RER_t D_{HF,t+1} + \frac{\chi_{DHF}}{2}\left(RER_{t+1}D_{HF,t+1}\right)^2 - C_{H,t} \end{bmatrix} \Big\}.
\end{aligned}
\tag{3}
$$

The resulting first order conditions are the following:

$$
C_{H,t} : \quad \lambda_{H,t} = C_{H,t}^{-\theta_H} x_{H,t}^{a_H(1-\theta_H)};
\tag{4}
$$

$$
l_{H,t} : \quad \lambda_{H,t}w_{H,t} = A_H C_{H,t}^{1-\theta} x_{H,t}^{a_H(1-\theta_H)-1};
\tag{5}
$$

$$l_{QH,t}: \quad \lambda_{H,t}w_{H,t} = A_H C_{H,t}^{1-\theta_H} x_{H,t}^{a_H(1-\theta_H)-1}; \tag{6}$$

$$D_{HH,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}}{\lambda_{H,t}}(1+R_{DH,t+1}) = 1; \tag{7}$$

$$D_{HF,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}}{\lambda_{H,t}}\frac{RER_{t+1}}{RER_t}(1+R_{DF,t+1}) = 1 + \chi_{DHF}\left(RER_t D_{HF,t+1}\right); \tag{8}$$

Then by combining the first order conditions one obtains the following equilibrium conditions:

$$a_H C_{H,t} = w_{H,t} x_{H,t}; \tag{9}$$

$$1 = \beta_H E_t \left\{ \left(\frac{C_{H,t}}{C_{H,t+1}}\right)^{\theta_H} \left(\frac{x_{H,t+1}}{x_{H,t}}\right)^{a_H(1-\theta_H)} (1+R_{DH,t+1}) \right\}; \tag{10}$$

$$E_t \left(\frac{RER_{t+1}}{RER_t}\right) = E_t \left\{ \left[\frac{1+R_{DH,t+1}}{1+R_{DF,t+1}}\right](1+\chi_{DHF}RER_t D_{HF,t+1}) \right\}; \tag{11}$$

where equation (9) is the marginal rate of substitution (MRS) between consumption and leisure; equation (10) is the Euler condition with respect to domestic deposits; and equation (11) is the uncovered interest parity equation for the home country household.

B.2 The Foreign Country Household

For the Foreign country household $i = F$ and apply the calibration assumption that no adjustment cost is paid for changing domestic asset positions, i.e. $\chi_{DFF} = 0$, to get

$$\begin{aligned}
P_{CF,t}C_{F,t} = \ & P_{CF,t}w_{F,t}(l_{F,t} + l_{QF,t}) + P_{CF,t}(1+R_{DF,t})D_{FF,t} \\
& + P_{CH,t}(1+R_{DH,t})D_{FH,t} + P_{CF,t}\tau_{F,t} - P_{CF,t}D_{FF,t+1} \\
& - P_{CH,t}D_{FH,t+1} + P_{CF,t}\frac{\chi_{DFH}}{2}\left(\frac{P_{CH,t}}{P_{Cf,t}}D_{FH,t+1}\right)^2.
\end{aligned} \tag{12}$$

Normalizing the budget constraint with the domestic consumption good price, $P_{CF,t}$, and use the definition of the real exchange rate, RER_t, yields

$$C_{F,t} = w_{F,t}(l_{F,t} + l_{QF,t}) + (1 + R_{DF,t})D_{FF,t} + \frac{(1 + R_{DH,t})D_{FH,t}}{RER_t} \tag{13}$$

$$+\tau_{F,t} - D_{FF,t+1} - \frac{D_{FH,t+1}}{RER_t} + \frac{\chi_{DFH}}{2}\left(\frac{D_{FH,t+1}}{RER_t}\right)^2.$$

Then given that the Lagrange multiplier of the Foreign household's budget constraint is denoted by $\lambda_{F,t}$ one obtain the following first order conditions:

$$C_{F,t}: \quad \lambda_{F,t} = C_{F,t}^{-\theta_F} x_{F,t}^{a_F(1-\theta_F)}; \tag{14}$$

$$l_{F,t}: \quad \lambda_{F,t}w_{F,t} = a_F C_{F,t}^{1-\theta_F} x_{F,t}^{a_F(1-\theta_F)-1}; \tag{15}$$

$$l_{FQ,t}: \quad \lambda_{F,t}w_{F,t} = a_F C_{F,t}^{1-\theta_F} x_{F,t}^{a_F(1-\theta_F)-1}; \tag{16}$$

$$D_{FF,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}}{\lambda_{F,t}}(1 + R_{DF,t+1}) = 1; \tag{17}$$

$$D_{FH,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}}{\lambda_{F,t}} \frac{RER_t}{RER_{t+1}}(1 + R_{DH,t+1}) = 1 + \chi_{DFH}\left(\frac{D_{FH,t+1}}{RER_t}\right); \tag{18}$$

Then by combining the first order conditions one obtains the following equilibrium conditions:

$$a_F C_{F,t} = w_{F,t}x_{F,t}; \tag{19}$$

$$1 = \beta_F E_t\left\{\left(\frac{C_{F,t}}{C_{F,t+1}}\right)^{\theta_F}\left(\frac{x_{F,t+1}}{x_{F,t}}\right)^{a_F(1-\theta_F)}(1 + R_{DF,t+1})\right\}; \tag{20}$$

$$E_t\left\{\frac{RER_{t+1}}{RER_t}\left[1 + \chi_{DFH}\left(\frac{D_{FH,t+1}}{RER_t}\right)\right]\right\} = E_t\left[\frac{1 + R_{DH,t+1}}{1 + R_{DF,t+1}}\right]; \tag{21}$$

where equation (19) is the marginal rate of substitution between consumption and leisure; equation (20) is the Euler condition with respect to domestic deposits; and equation (21) is the uncovered interest parity equation for the foreign country

consumer.

B.3 The Home Country Intermediate Goods Producer

For the Home country intermediate goods producer consider the profit function, $\Pi_{GH,t}$, in footnote 9 with $i = H$ and applying the calibration assumption that no adjustment cost is paid for changing domestic asset positions, i.e. $\chi_{QHH} = 0$, to get

$$\Pi_{GH,t} = P_{XH,t}X_{H,t} - P_{CH,t}w_{H,t}l_{H,t} - P_{CH,t}i_{H,t} + P_{CH,t}Q_{HH,t+1} \tag{22}$$
$$+P_{CF,t}Q_{FH,t+1} - P_{CH,t}\frac{\chi_{QFH}}{2}\left(\frac{P_{CF,t}}{P_{CH,t}}Q_{FH,t+1}\right)^2$$
$$-P_{CH,t}(1 + R_{QH,t})Q_{HH,t} - P_{CF,t}(1 + R_{QF,t})Q_{FH,t}.$$

Normalizing the profit constraint with the domestic consumption good price, $P_{CH,t}$, using the definition of the real exchange rate, RER_t, and denoting the relative price $p_{XH,t} \equiv P_{XH,t}/P_{CH,t}$, yields

$$\pi_{GH,t} = \frac{\Pi_{GH,t}}{P_{CH,t}} = p_{XH,t}X_{H,t} - w_{H,t}l_{H,t} - i_{H,t} + Q_{HH,t+1} \tag{23}$$
$$+RER_tQ_{FH,t+1} - \frac{\chi_{QFH}}{2}\left(RER_tQ_{FH,t+1}\right)^2 - (1 + R_{QH,t})Q_{HH,t}$$
$$-(1 + R_{QH,t})Q_{HH,t} - RER_t(1 + R_{QF,t})Q_{FH,t}.$$

Next, consider the loan requirement constraint in the Model section, which after applying $i = H$ becomes

$$P_{CH,t}Q_{HH,t} + P_{CF,t}Q_{FH,t} = P_{CH,t}k_{H,t}. \tag{24}$$

Normaling the the above with the domestic consumption good price results in

$$Q_{HH,t} + RER_tQ_{FH,t} = k_{H,t}. \tag{25}$$

Then substituting the capital accumulation constraint, the production technology and the loan requirement constraint into (23) the intermediate goods producer's problem in the home country becomes

$$\max_{\{Q_{HH,t},\, Q_{FH,t+1},\, l_{H,t}\}_{t=0}^{\infty}} \pi_{HG,t} = E_0\left(\beta_H^t\lambda_{H,t}\right)\left\{ \begin{array}{c} p_{XH,t}A_He^{z_{H,t}}\left(Q_{HH,t} + RER_tQ_{FH,t}\right)^{\alpha_H}\left(l_{H,t}\right)^{1-\alpha_H} \\ -w_{H,t}l_{H,t} - Q_{HH,t}(\delta_H + R_{FQ,t}) \\ +(RER_t - RER_{t+1})Q_{FH,t+1} \\ -RER_tQ_{FH,t}(\delta_H + R_{QF,t}) \\ -\frac{\chi_{QFH}}{2}(RER_tQ_{FH,t+1})^2 \end{array} \right\}.$$

The resulting first order conditions are:

$$l_{H,t}: \quad \lambda_{H,t}(1-\alpha_H)A_H e^{z_{H,t}} \left[\frac{k_{H,t}}{l_{H,t}}\right]^{\alpha_H} = \lambda_{H,t} w_{H,t}; \tag{26}$$

$$Q_{HH,t}: \quad \lambda_{H,t}(R_{QH,t}+\delta_H) = \lambda_{H,t}\alpha_H p_{XH,t} A_H e^{z_{H,t}} \left(\frac{k_{H,t}}{l_{H,t}}\right)^{\alpha_H-1}; \tag{27}$$

$$Q_{FH,t+1}: \quad \beta_H E_t RER_{t+1}\lambda_{H,t+1} \left\{ \alpha_H p_{XH,t+1} A_H e^{z_{H,t+1}} \left(\frac{k_{H,t+1}}{l_{H,t+1}}\right)^{\alpha-1} - (\delta_H + R_{FQ,t+1}) \right\} = $$
$$\lambda_{H,t}(RER_{t+1}-RER_t) + \lambda_{H,t}RER_t\chi_{QFH}(RER_t Q_{FH,t+1}). \tag{28}$$

Next, by denoting the marginal product with respect to physical capital as $r_{H,t} = p_{XH,t}\alpha_H A_H e^{z_{H,t}} \left[\frac{k_{H,t}}{l_{H,t}}\right]^{\alpha_H-1}$, the full set of equilibrium conditions and constraints of the intermediate goods producer in the Home country are:

$$r_{H,t} = R_{QH,t} + \delta_H; \tag{29}$$

$$X_{H,t} = A_H e^{z_{H,t}} (k_{H,t})^{\alpha_H} (l_{H,t})^{1-\alpha_H}; \tag{30}$$

$$X_{H,t} = X_{HH,t} + X_{HF,t}; \tag{31}$$

$$i_{H,t} = k_{H,t+1} - (1-\delta_H)k_{H,t}; \tag{32}$$

$$k_{H,t} = Q_{HH,t} + RER_t Q_{FH,t}; \tag{33}$$

$$w_{H,t} = p_{XH,t}(1-\alpha)A_H e^{z_{H,t}} \left[\frac{k_{H,t}}{l_{H,t}}\right]^{\alpha_H}; \tag{34}$$

$$r_{H,t} = p_{XH,t}\alpha A_H e^{z_{H,t}} \left[\frac{k_{H,t}}{l_{H,t}}\right]^{\alpha_H-1}; \tag{35}$$

$$1 + \beta_H E_t \left\{ \left(\frac{C_{H,t}}{C_{H,t+1}} \right)^{\theta_H} \left(\frac{x_{H,t+1}}{x_{H,t}} \right)^{a_H(1-\theta_H)} \frac{RER_{t+1}}{RER_t} (R_{QH,t+1} - R_{QF,t+1}) \right\}$$

$$= E_t \left\{ \frac{RER_{t+1}}{RER_t} + \chi_{QFH}(RER_t Q_{FH,t+1}) \right\}; \qquad (36)$$

where equation (29) is obtained by using the first order conditions in (27) and using the definition of $r_{H,t}$. It equates the gross interest on domestic loans in the home country with the gross real return on physical capital net of depreciation. Equation (30) is the Cobb-Douglas production technology of the intermediate goods producer; equation (31) equates the sum of domestically and internationally sold intermediate goods to the total quantity produced; equation (32) is the physical capital law of motion; and equation (33) is the loan requirement constraint the firm faces. Equations (34) and (35) equate the marginal products to the real wage and the real return to physical capital. Lastly, by combining the first order conditions in (27) and (28) one obtains the home and foreign loan uncovered interest parity condition in equation (36).

B.4 The Foreign Country Intermediate Goods Producer

For the Foreign country intermediate goods producer consider the profit function, $\Pi_{GF,t}$, in footnote 9 with $i = F$ and applying the calibration assumption that no adjustment cost is paid for changing domestic asset positions, i.e. $\chi_{QFF} = 0$, to get

$$\Pi_{GF,t} = P_{XF,t} X_{F,t} - P_{CF,t} w_{F,t} l_{F,t} - P_{CF,t} i_{F,t} + P_{CF,t} Q_{FF,t+1} \qquad (37)$$

$$+ P_{CH,t} Q_{HF,t+1} - P_{CF,t} \frac{\chi_{QHF}}{2} \left(\frac{P_{CH,t}}{P_{CF,t}} Q_{HF,t+1} \right)^2$$

$$- P_{CF,t}(1 + R_{QF,t}) Q_{FF,t} - P_{CH,t}(1 + R_{QH,t}) Q_{HF,t}.$$

Normalizing the profit constraint with the domestic consumption good price, $P_{CF,t}$, using the definition of the real exchange rate, RER_t, and denoting the relative price $p_{XF,t} \equiv P_{XF,t}/P_{CH,t}$, yields

$$\pi_{GH,t} = \frac{\Pi_{GF,t}}{P_{CF,t}} = p_{XF,t} X_{F,t} - w_{F,t} l_{F,t} - i_{F,t} + Q_{FF,t+1} + \frac{Q_{HF,t+1}}{RER_t} \qquad (38)$$

$$- \frac{\chi_{QHF}}{2} \left(\frac{Q_{HF,t+1}}{RER_t} \right)^2 - (1 + R_{QF,t}) Q_{FF,t} - \frac{(1 + R_{QH,t}) Q_{HF,t}}{RER_t}.$$

Next, consider the loan requirement constraint, which after applying $i = F$ becomes

$$P_{CF,t} Q_{FF,t} + P_{CH,t} Q_{HF,t} = P_{CF,t} k_{F,t}. \qquad (39)$$

Normaling the the above with the domestic consumption good price results in

$$Q_{FF,t} + \frac{Q_{HF,t}}{RER_t} = k_{H,t}. \tag{40}$$

Then substituting the capital accumulation constraint, the production technology and the loan requirement constraint into (23) the intermediate goods producer's problem in the home country becomes

$$\max_{\{Q_{FF,t},\, Q_{HF,t+1},\, l_{F,t}\}_{t=0}^{\infty}} \pi_{FG,t} = E_0 \left(\beta_F^t \lambda_{F,t}\right) \left\{ \begin{array}{c} p_{XF,t} A_F e^{z_{F,t}} \left(Q_{FF,t} + \frac{Q_{HF,t}}{RER_t}\right)^{\alpha_F} (l_{F,t})^{1-\alpha_F} - w_{F,t} l_{F,t} \\ -Q_{FF,t}(\delta_F + R_{QF,t}) + \left(\frac{1}{RER_t} - \frac{1}{RER_{t+1}}\right) Q_{HF,t+1} \\ -\frac{Q_{HF,t}(\delta_H + R_{QH,t})}{RER_t} - \frac{\chi_{QHF}}{2}\left(\frac{Q_{HF,t+1}}{RER_t}\right)^2 \end{array} \right\}.$$

The resulting first order conditions are:

$$l_{F,t}: \quad \lambda_{F,t} p_{XF,t}(1-\alpha_F) A_F e^{z_{F,t}} \left[\frac{k_{F,t}}{l_{F,t}}\right]^{\alpha_F} = \lambda_{F,t} w_{F,t}; \tag{41}$$

$$Q_{FF,t}: \quad R_{QF,t} + \delta_F = \lambda_{F,t} p_{XF,t} \alpha_F A_F e^{z_{F,t}} \left[\frac{k_{F,t}}{l_{F,t}}\right]^{\alpha_F - 1}; \tag{42}$$

$$Q_{HF,t+1}: \quad \beta_F E_t \frac{1}{RER_{t+1}} \lambda_{F,t+1} \left\{ \alpha_F p_{XF,t+1} A_F \left(\frac{k_{F,t+1}}{l_{F,t+1}}\right)^{\alpha_F - 1} - (\delta_F + R_{QH,t+1}) \right\}$$
$$= \lambda_{F,t} \left(\frac{1}{RER_{t+1}} - \frac{1}{RER_t}\right) + \lambda_{F,t} \frac{1}{RER_t} \chi_{QHF} \left(\frac{Q_{HF,t+1}}{RER_t}\right). \tag{43}$$

Next, by denoting the marginal product with respect to physical capital as $r_{F,t} = p_{XF,t} \alpha_F A_F e^{z_{F,t}} \left[\frac{k_{F,t}}{l_{F,t}}\right]^{\alpha_F - 1}$, the full set of equilibrium conditions and constraints of the intermediate goods producer in the Home country are:

$$r_{F,t} = R_{QF,t} + \delta_F; \tag{44}$$

$$X_{F,t} = A_F e^{z_{F,t}} (k_{F,t})^{\alpha_F} (l_{F,t})^{1-\alpha_F}; \tag{45}$$

$$X_{F,t} = X_{FF,t} + X_{FH,t}; \tag{46}$$

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$$i_{F,t} = k_{F,t+1} - (1 - \delta_F)k_{F,t}; \tag{47}$$

$$k_{F,t} = Q_{FF,t} + \frac{Q_{HF,t}}{RER_t}; \tag{48}$$

$$w_{F,t} = p_{XF,t}(1 - \alpha_F)A_F e^{z_{F,t}} \left[\frac{k_{F,t}}{l_{F,t}}\right]^{\alpha_F}; \tag{49}$$

$$r_{F,t} = p_{XF,t}\alpha_F A_F e^{z_{F,t}} \left[\frac{k_{F,t}}{l_{F,t}}\right]^{\alpha_F - 1}; \tag{50}$$

$$1 + \beta_F E_t \left\{ \frac{RER_t}{RER_{t+1}} \left(\frac{C_{F,t}}{C_{F,t+1}}\right)^{\theta_F} \left(\frac{x_{F,t+1}}{x_{F,t}}\right)^{a_F(1-\theta_F)} [R_{QF,t+1} - R_{QH,t+1}] \right\}$$
$$= E_t \left\{ \frac{RER_t}{RER_{t+1}} + \chi_{QHF} \left(\frac{Q_{HF,t+1}}{RER_t}\right) \right\}; \tag{51}$$

where equation (44) is obtained by using the first order condition in (42) and using the definition of $r_{F,t}$. It equates the gross interest on domestic loans in the foreign country with the gross real return on physical capital net of depreciation. Furthermore, equation (45) is the Cobb-Douglas production technology of the intermediate goods producer; equation (46) equates the sum of domestically and internationally sold intermediate goods to the total produced; equation (47) is the physical capital law of motion; and equation (48) is the financing constraint that the firm faces. Equations (49) and (50) equate the marginal products to the real wage and the real return to physical capital. Lastly, by combining the first order conditions in (42) and (43) one obtains the home and foreign loan uncovered interest parity condition in equation (51).

B.5 The Home Country Final Good Producer

Nontradable final gooconsumption goods in the Home country are denoted by $Y_{H,t}$. Given parameteres $\gamma_H \in (0,1)$ and $\eta_H > 0$, these goods are competitively produced using domestic and foreign intermediate goods according to the following CES technology:

$$Y_{H,t} = \left[\gamma_H^{1/\eta_H} \left(X_{HH,t}\right)^{(\eta_H-1)/\eta_H} + (1 - \gamma_H)^{1/\eta_H} \left(X_{FH,t}\right)^{(\eta_H-1)/\eta_H}\right]^{\gamma_H/(\eta_H-1)}.$$

The final goods producer then minimizes its expenditures subject to the produc-

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tion technology

$$\min_{X_{HH,t},\ X_{FH,t}} P_{XH,t}X_{HH,t} + P_{XF,t}X_{FH,t}.$$

The optimal demand allocation across domestic and imported intermediate goods for a given level of $Y_{H,t}$ gives the demand equations:

$$X_{HH,t} = \gamma_H \left(\frac{P_{XH,t}}{P_{CH,t}}\right)^{-\eta_H} Y_{H,t} \tag{52}$$

$$X_{FH,t} = (1 - \gamma_H) \left(\frac{P_{XF,t}}{P_{CH,t}}\right)^{-\eta_H} Y_{H,t} \tag{53}$$

From the demands functions and the budget constraint of the competitive final goods producer, $P_{CH,t}Y_{H,t} = P_{XH,t}X_{HH,t} + P_{XF,t}X_{FH,t}$, which follows from the zero profit condition, the price of the home consumption good, $P_{CH,t}$, is given as follows:

$$P_{CH,t} = \left[\gamma_H(P_{XH,t})^{1-\eta_H} + (1 - \gamma_H)(P_{XF,t})^{1-\eta_H}\right]^{\frac{1}{1-\eta_H}}. \tag{54}$$

B.6 The Foreign Country Final Good Producer

Nontradable final gooconsumption goods in the Foreign country are denoted by $Y_{F,t}$. Given parameteres $\gamma_F \in (0,1)$ and $\eta_F > 0$, these goods are competitively produced using domestic and foreign intermediate goods according to the following CES technology:

$$Y_{F,t} = \left[\gamma_F^{1/\eta_F} \left(X_{FF,t}\right)^{(\eta_F-1)/\eta_F} + (1 - \gamma_F)^{1/\eta_F} \left(X_{HF,t}\right)^{(\eta_F-1)/\eta_F}\right]^{\gamma_F/(\eta_F-1)}.$$

The final goods producer then minimizes its expenditures subject to the production technology

$$\min_{X_{FF,t},\ X_{HF,t}} P_{XF,t}X_{FF,t} + P_{XH,t}X_{HF,t}.$$

The optimal demand allocation across domestic and imported intermediate goods for a given level of $Y_{F,t}$ gives the demand equations:

$$X_{FF,t} = \gamma_F \left(\frac{P_{XF,t}}{P_{CF,t}}\right)^{-\eta_F} Y_{F,t} \tag{55}$$

$$X_{HF,t} = (1 - \gamma_F) \left(\frac{P_{XH,t}}{P_{CF,t}}\right)^{-\eta_F} Y_{F,t} \tag{56}$$

From the demands functions and the budget constraint of the competitive final goods producer, $P_{CF,t}Y_{F,t} = P_{XF,t}X_{FF,t} + P_{XH,t}X_{HF,t}$, which follows from the zero

profit condition, the price of the foreign consumption good, $P_{CF,t}$, is given as follows:

$$P_{CF,t} = \left[\gamma_F (P_{XF,t})^{1-\eta_F} + (1-\gamma_F)(P_{XH,t})^{1-\eta_F} \right]^{\frac{1}{1-\eta_F}}. \tag{57}$$

B.7 Trade Openness

The mass of world population is normalized to unity. The Home country household then lies on the interval $(0, n)$, where $0 < n < 1$; the Foreign household on the interval $(n, 1)$. Then following De Paoli (2009), the parameter determining the share of foreign goods in final consumption good production in the Home country, $(1-\gamma_H)$, is assumed to be a function of the relative size of the foreign economy, $1-n$, and of the degree of openness, υ, more specifically, $1-\gamma_H = (1-n)\upsilon$. Similarly, for the foreign final goods producer, $\gamma_F = n\upsilon$.

B.8 The Home Country Financial Intermediary

For the Home country financial intermediary consider the profit function, $\Pi_{QH,t}$, in footnote *10* with $i = H$ and applying the calibration assumption that no adjustment cost is paid for changing domestic asset positions, i.e. $\chi_{BHH} = 0$, to get

$$
\begin{aligned}
\Pi_{QH,t} = {} & -P_{CH,t}Q_{HH,t+1} - P_{CF,t}Q_{HF,t+1} + (1+R_{QH,t})\left[P_{CH,t}Q_{HH,t} + P_{CF,t}Q_{HF,t}\right] \\
& + P_{CH,t}D_{HH,t+1} + P_{CF,t}D_{FH,t+1} - (1+R_{DH,t})\left[P_{CH,t}D_{HH,t} + P_{CF,t}D_{FH,t}\right] \\
& - P_{CH,t}w_{H,t}l_{QH,t} - P_{CH,t}B_{HH,t+1} - P_{CF,t}B_{FH,t+1} + (1+R_{H,t})P_{CH,t}B_{HH,t} \\
& + (1+R_{F,t})P_{CF,t}B_{FH,t} - P_{CH,t}\frac{\chi_{BFH}}{2}\left(\frac{P_{CF,t}}{P_{CH,t}}B_{FH,t+1}\right)^2.
\end{aligned}
\tag{58}
$$

Normalizing the profit constraint with the domestic consumption good price, $P_{CH,t}$, using the definition of the real exchange rate, RER_t, yields

$$
\begin{aligned}
\Pi_{QH,t} = {} & -Q_{HH,t+1} - RER_t Q_{HF,t+1} + (1+R_{QH,t})\left[Q_{HH,t} + RER_t Q_{HF,t}\right] \\
& + D_{HH,t+1} + RER_t D_{FH,t+1} - (1+R_{DH,t})\left[D_{HH,t} + RER_t D_{FH,t}\right] \\
& - w_{H,t}l_{QH,t} - B_{HH,t+1} - RER_t B_{FH,t+1} + (1+R_{H,t})B_{HH,t} \\
& + (1+R_{F,t})RER_t B_{FH,t} - \frac{\chi_{BFH}}{2}\left(RER_t B_{FH,t+1}\right)^2.
\end{aligned}
\tag{59}
$$

The Home country's bank faces the following balance sheet constraint:

$$Q_{HH,t} + RER_t Q_{HF,t} + B_{HH,t} + RER_t B_{FH,t} = D_{HH,t} + RER_t D_{FH,t}. \tag{60}$$

In this case unlike in Gillman (2011) deposits are not equal to loans, which allows for banks to have reserves held in the form of domestic or foreign bonds. Here, total deposits can be used for loan production, $D_{H,t}^{pr} = D_{HH,t} + RER_t D_{FH,t} - B_{HH,t} -$

$RER_tB_{FH,t}$, or having reserves in the form of bonds. Then it follows that deposits used in loan production equal loans, i.e. $D_{H,t}^{pr} = Q_{HH,t} + RER_tQ_{HF,t}$.

The production of loans by the home country bank is subject to the financial intermediation CRS technology that requires labor from the representative consumer in the home country, $l_{QH,t}$, and deposits allocated to loan production, $D_{H,t}^{pr}$. With $A_{HQ} > 0$ representing the home banking sector's steady state productivity level and $\kappa_H \in (0,1)$, the total loans issued by the home country bank is

$$Q_{H,t} = Q_{HH,t} + RER_tQ_{HF,t} = A_{QH}e^{z_{H,t}^Q}(l_{QH,t})^{\kappa_H}(D_{H,t}^{pr})^{1-\kappa_H}. \tag{61}$$

Then the home financial intermediary maximizes (59) subject to (60) and (61). Given that $\phi_{H,t}$ is the Lagrange multiplier associated with the loan production technology and $\theta_{H,t}$ is the multplier associated witht the balance sheet constraint, the resulting first order conditions are:

$$l_{QH,t}: \quad w_{H,t} = \phi_{H,t}\kappa_H A_{QH}e^{z_{H,t}^Q}\left[\frac{l_{QH,t}}{D_{H,t}^{pr}}\right]^{\kappa_H-1}; \tag{62}$$

$$D_{HH,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}}{\lambda_{H,t}}\left\{\begin{array}{c}(1+R_{DH,t+1})\\-\phi_{H,t+1}(1-\kappa_H)A_{QH}e^{z_{H,t+1}^Q}\left[\frac{l_{QH,t}}{D_{H,t}^{pr}}\right]^{\kappa_H}\\-\theta_{H,t+1}\end{array}\right\} = 1; \tag{63}$$

$$D_{FH,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}RER_{t+1}}{\lambda_{H,t}RER_t}\left\{\begin{array}{c}(1+R_{DH,t+1})\\-\phi_{H,t+1}(1-\kappa_H)A_{QH}e^{z_{H,t+1}^Q}\left[\frac{l_{QH,t}}{D_{H,t}^{pr}}\right]^{\kappa_H}\\-\theta_{H,t+1}\end{array}\right\} = 1; \tag{64}$$

$$Q_{HH,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}}{\lambda_{H,t}}\left\{(1+R_{QH,t+1})-\phi_{H,t+1}-\theta_{H,t+1}\right\} = 1; \tag{65}$$

$$Q_{HF,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}RER_{t+1}}{\lambda_{H,t}RER_t}\left\{(1+R_{QH,t+1})-\phi_{Ht+1}-\theta_{H,t+1}\right\} = 1; \tag{66}$$

$$B_{HH,t+1}: \quad \beta_H E_t \frac{\lambda_{H,t+1}}{\lambda_{H,t}}\left\{\begin{array}{c}(1+R_{H,t+1})\\-\phi_{Ht+1}(1-\kappa_H)A_{QH}e^{z_{H,t+1}^Q}\left[\frac{l_{QH,t}}{D_{H,t}^{pr}}\right]^{\kappa_H}\\-\theta_{H,t+1}\end{array}\right\} = 1. \tag{67}$$

$$B_{FH,t+1} \quad : \quad \beta_H E_t \frac{\lambda_{H,t+1} RER_{t+1}}{\lambda_{H,t} RER_t} \left\{ \begin{array}{c} (1 + R_{F,t+1}) \\ -\phi_{Ht+1}(1-\kappa_H) A_{QH} e^{z^Q_{H,t+1}} \left[\frac{l_{QH,t}}{D^{pr}_{H,t}} \right]^{\kappa_H} \\ -\theta_{H,t+1} \end{array} \right\}$$

$$= E_t \left\{ 1 + \chi_{BFH}(RER_t B_{FH,t+1}) \right\}. \tag{68}$$

Then the full set of equilibrium conditions and constraints of the financial intermediary in the Home country are:

$$Q_{HH,t} + RER_t Q_{HF,t} + B_{HH,t} + RER_t B_{FH,t} = D_{H,t} = D_{HH,t} + RER_t D_{FH,t}; \tag{69}$$

$$Q_{H,t} = A_{HQ} e^{z^Q_{H,t}} (l_{QH,t})^{\kappa_H} (D^{pr}_{H,t})^{1-\kappa_H}; \tag{70}$$

$$Q_{H,t} = Q_{HH,t} + RER_t Q_{HF,t}; \tag{71}$$

$$D^{pr}_{H,t} = D_{HH,t} + RER_t D_{FH,t} - B_{HH,t} - RER_t B_{FH,t}; \tag{72}$$

$$R_{QH,t} - R_{DH,t} = \frac{w_{H,t} l_{QH,t}}{Q_{H,t}}; \tag{73}$$

$$R_{DH,t} = R_{H,t}; \tag{74}$$

$$E_t \left\{ \frac{RER_{t+1}}{RER_t} + \beta_F \left(\frac{C_{H,t}}{C_{H,t+1}} \right)^{\theta_H} \left(\frac{x_{H,t+1}}{x_{H,t}} \right)^{a_H(1-\theta_H)} \frac{RER_{t+1}}{RER_t} [R_{F,t+1} - R_{H,t+1}] \right\}$$

$$= E_t \left\{ 1 + \chi_{BFH}(RER_t B_{FH,t+1}) \right\}. \tag{75}$$

Equation (69) is the balance sheet constraint of the Home country bank; (70) is loan production technology; (71) is the definition of total Home country bank issued loans; and (72) is the definition of deposits used in credit production. Equation (73) is the equilibrium condition that defines the loan interest spread in the Home country, where the spread is driven by the labor cost of producing a unit of loan. Equation (74) is a no arbitrage condition equating the rate on bonds to the rate on deposits. Lastly, equation (75) is the expectational uncovered interest parity equation.

B.9 The Foreign Country Financial Intermediary

For the Foreign country financial intermediary consider the profit function, $\Pi_{QF,t}$, in footnote 10 with $i = F$ and applying the calibration assumption that no adjustment cost is paid for changing domestic asset positions, i.e. $\chi_{BHH} = 0$, to get

$$
\begin{aligned}
\Pi_{QF,t} = {} & -P_{CF,t}Q_{FF,t+1} - P_{CH,t}Q_{FH,t+1} + (1 + R_{QF,t})\left[P_{CF,t}Q_{FF,t} + P_{CH,t}Q_{FH,t}\right] \\
& +P_{CF,t}D_{FF,t+1} + P_{CH,t}D_{HF,t+1} - (1 + R_{DF,t})\left[P_{CF,t}D_{FF,t} + P_{CH,t}D_{HF,t}\right] \\
& -P_{CF,t}w_{F,t}l_{QF,t} - P_{CF,t}B_{FF,t+1} - P_{CH,t}B_{HF,t+1} + (1 + R_{F,t})P_{CF,t}B_{FF,t} \\
& +(1 + R_{H,t})P_{CH,t}B_{HF,t} - P_{CF,t}\frac{\chi_{BHF}}{2}\left(\frac{P_{CH,t}}{P_{CF,t}}B_{HF,t+1}\right)^2 .
\end{aligned}
\tag{76}
$$

Normalizing the profit constraint with the domestic consumption good price, $P_{CF,t}$, using the definition of the real exchange rate, RER_t, yields

$$
\begin{aligned}
\Pi_{QF,t} = {} & -Q_{FF,t+1} - \frac{Q_{FH,t+1}}{RER_t} + (1 + R_{QF,t})\left[Q_{FF,t} + \frac{Q_{FH,t}}{RER_t}\right] \\
& +D_{FF,t+1} + \frac{D_{HF,t+1}}{RER_t} - (1 + R_{DF,t})\left[D_{FF,t} + \frac{D_{HF,t}}{RER_t}\right] \\
& -w_{F,t}l_{QF,t} - B_{FF,t+1} - \frac{B_{HF,t+1}}{RER_t} + (1 + R_{F,t})B_{FF,t} \\
& +\frac{(1 + R_{H,t})B_{HF,t}}{RER_t} - \frac{\chi_{BHF}}{2}\left(\frac{B_{HF,t+1}}{RER_t}\right)^2 .
\end{aligned}
\tag{77}
$$

The Foreign country's bank faces the following balance sheet and productive deposits constraints:

$$
Q_{FF,t} + \frac{Q_{FH,t}}{RER_t} + B_{FF,t} + \frac{B_{HF,t}}{RER_t} = D_{FF,t} + \frac{D_{HF,t}}{RER_t}
\tag{78}
$$

$$
D_{F,t}^{pr} = D_{FF,t} + \frac{D_{HF,t}}{RER_t} - B_{FF,t} - \frac{B_{HF,t}}{RER_t}
\tag{79}
$$

The production of loans by the foreign country bank is subject to the financial intermediation CRS technology that requires labor from the representative consumer in the home country, $l_{QF,t}$, and deposits allocated to loan production, $D_{F,t}^{pr}$. With $A_{QF,t}$ representing the home banking sector's exogenous productivity process and $\kappa_F \in (0,1)$, the total loans issued by the home country bank is

$$
Q_{F,t} = Q_{FF,t} + \frac{Q_{FH,t}}{RER_t} = A_{QF}e^{z_{F,t+1}^Q}(l_{QF,t})^{\kappa_F}(D_{F,t}^{pr})^{1-\kappa_F} .
\tag{80}
$$

Then the foreign financial intermediary maximizes (77) subject to (78) and (80). Given that $\phi_{F,t}$ is the Lagrange multiplier associated with the loan production technology and $\theta_{F,t}$ is the multiplier associated witht the balance sheet constraint, the resulting first order conditions are:

$$l_{QF,t}: \quad w_{F,t} = \phi_{F,t} \kappa_F A_{QF} e^{z^Q_{F,t}} \left[\frac{l_{QF,t}}{D^{pr}_{F,t}} \right]^{\kappa_F - 1}; \tag{81}$$

$$D_{FF,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}}{\lambda_{F,t}} \left\{ \begin{array}{c} (1+R_{DF,t+1}) \\ -\phi_{F,t+1}(1-\kappa_F)A_{QF}e^{z^Q_{F,t+1}}\left[\frac{l_{QF,t}}{D^{pr}_{F,t}}\right]^{\kappa_F} \\ -\theta_{F,t+1} \end{array} \right\} = 1; \tag{82}$$

$$D_{HF,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}RER_t}{\lambda_{F,t}RER_{t+1}} \left\{ \begin{array}{c} (1+R_{DF,t+1}) \\ -\phi_{F,t+1}(1-\kappa_F)A_{QF}e^{z^Q_{F,t+1}}\left[\frac{l_{QF,t}}{D^{pr}_{F,t}}\right]^{\kappa_F} \\ -\theta_{F,t+1} \end{array} \right\} = 1; \tag{83}$$

$$Q_{FF,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}}{\lambda_{F,t}} \{(1+R_{QF,t+1}) - \phi_{F,t+1} - \theta_{F,t+1}\} = 1; \tag{84}$$

$$Q_{FH,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}RER_t}{\lambda_{F,t}RER_{t+1}} \{(1+R_{QF,t+1}) - \phi_{Ft+1} - \theta_{F,t+1}\} = 1; \tag{85}$$

$$B_{FF,t+1}: \quad \beta_F E_t \frac{\lambda_{F,t+1}}{\lambda_{F,t}} \left\{ \begin{array}{c} (1+R_{F,t+1}) \\ -\phi_{Ft+1}(1-\kappa_F)A_{QF}e^{z^Q_{F,t+1}}\left[\frac{l_{QF,t}}{D^{pr}_{F,t}}\right]^{\kappa_F} \\ -\theta_{F,t+1} \end{array} \right\} = 1. \tag{86}$$

$$\begin{aligned} B_{HF,t+1} \quad : \quad & \beta_F E_t \frac{\lambda_{F,t+1}RER_t}{\lambda_{F,t}RER_{t+1}} \left\{ (1+R_{H,t+1}) - \phi_{Ft+1}(1-\kappa_F)A_{QF}e^{z^Q_{F,t+1}}\left[\frac{l_{QF,t}}{D^{pr}_{F,t}}\right]^{\kappa_F} - \theta_{F,t+1} \right\} \\ = \quad & 1 + \chi_{BHF} \frac{B_{HF,t+1}}{RER_t}. \end{aligned} \tag{87}$$

Then the full set of equilibrium conditions and constraints of the financial intermediary in the Foreign country are:

$$Q_{FF,t} + \frac{Q_{FH,t}}{RER_t} + B_{FF,t} + \frac{B_{HF,t}}{RER_t} = D_{FF,t} + \frac{D_{HF,t}}{RER_t}; \tag{88}$$

$$Q_{F,t} = A_{QF}e^{z_{F,t}^Q}(l_{QF,t})^{\kappa_F}(D_{F,t}^{pr})^{1-\kappa_F}; \tag{89}$$

$$Q_{F,t} = Q_{FF,t} + \frac{Q_{FH,t}}{RER_t}; \tag{90}$$

$$D_{F,t}^{pr} = D_{FF,t} + \frac{D_{HF,t}}{RER_t} - B_{FF,t} - \frac{B_{HF,t}}{RER_t}; \tag{91}$$

$$R_{QF,t} - R_{DF,t} = \frac{w_{F,t}l_{QF,t}}{Q_{F,t}}; \tag{92}$$

$$R_{DF,t} = R_{F,t}; \tag{93}$$

$$E_t\left\{\frac{RER_t}{RER_{t+1}} + \beta_F\left(\frac{C_{F,t}}{C_{F,t+1}}\right)^{\theta_F}\left(\frac{x_{F,t+1}}{x_{F,t}}\right)^{a_F(1-\theta_F)}\frac{RER_t}{RER_{t+1}}[R_{H,t+1} - R_{F,t+1}]\right\}$$
$$= E_t\left\{1 + \chi_{BFH}\frac{B_{HF,t}}{RER_t}\right\}. \tag{94}$$

Equation (88) is the balance sheet constraint of the Foreign country bank; (89) is loan production technology; (90) is the definition of total Foreign country bank issued loans; and (91) is the definition of deposits used in credit production. Equation (92) is the equilibrium condition that defines the loan interest spread in the Foreign country, where the spread is driven by the labor cost of producing a unit of loan. Equation (93) is a no arbitrage condition equating the rate on bonds to the rate on deposits. Lastly, equation (94) is the expectational uncovered interest parity equation.

B.10 The Home Country Government

The government in the Home country makes purchases, $P_{CH,t}G_{H,t}$, which are a constant share of output, $G_{H,t} = (\gamma_{H,gov})e^{z_{H,t}^{gov}}Y_{H,t}$, and which are financed solely by issuing real bonds that can be traded domestically and internationally. Then the government budget constraint is as follows:

$$\begin{aligned} P_{CH,t}G_{H,t} &= P_{CH,t}B_{HH,t+1} + P_{CF,t}B_{HF,t+1} \\ &\quad -(1+R_{H,t})\left[P_{CH,t}B_{HH,t} + P_{CF,t}B_{HF,t}\right]. \end{aligned} \tag{95}$$

Normalizing the government budget constraint with the domestic consumption good price, $P_{CH,t}$, and using the definition of the real exchange rate, RER_t, yields:

$$G_{H,t} = B_{HH,t+1} + RER_t B_{HF,t+1} - (1 + R_{H,t}) [B_{HH,t} + RER_t B_{HF,t}]. \tag{96}$$

B.11 The Foreign Country Government

The government in the Foreign country makes purchases, $P_{CF,t}G_{F,t}$, which are a constant share of output, $G_{F,t} = \left(\gamma_{F,gov}\right) e^{z^{gov}_{F,t}} Y_{F,t}$, and which are financed solely by issuing real bonds that can be traded domestically and internationally. Then the government budget constraint is as follows:

$$
\begin{aligned}
P_{CF,t}G_{F,t} &= P_{CF,t}B_{FF,t+1} + P_{CH,t}B_{FH,t+1} \\
&\quad -(1 + R_{F,t}) [P_{CF,t}B_{FF,t} + P_{CH,t}B_{FH,t}].
\end{aligned}
\tag{97}
$$

Normalizing the government budget constraint with the domestic consumption good price, $P_{CF,t}$, and using the definition of the real exchange rate, RER_t, yields:

$$G_{F,t} = B_{FF,t+1} + \frac{B_{FH,t+1}}{RER_t} - (1 + R_{F,t}) \left[B_{FF,t} + \frac{B_{FH,t}}{RER_t} \right].$$