

Lecture 2 Practical: The International Transmission of Financial Shocks

Summer School in International Finance
University of Oxford

September 2021

$$\Lambda_t = \frac{1}{C_t - h\bar{C}_{t-1}}$$

$$\Lambda_t = \beta \mathbb{E}_t[\Lambda_{t+1} \frac{R_t}{1 + \pi_{t+1}}].$$

$$\tilde{w}_t^{1+\nu_L\zeta} = \frac{\chi^{\nu_L}}{\nu_L - 1} \frac{F_{1t}^W}{F_{2t}^W}$$

$$F_{1t}^W = \ell_t^{1+\zeta} w_t^{\nu_L\zeta} + \beta \xi_w \mathbb{E}_t \left(\frac{w_{t+1}}{w_t} \right)^{\nu_L} (1 + \pi_{t+1})^{\nu_L(1+\zeta)} F_{1t+1}^W$$

$$F_{2t}^W = \Lambda_t \ell_t + \beta \xi_w \mathbb{E}_t \left(\frac{w_{t+1}}{w_t} (1 + \pi_{t+1}) \right)^{\nu_L} (1 + \pi_{t+1})^{-1} F_{2t+1}^W.$$

$$w_t = ((1 - \xi_w) \tilde{w}_t^{1-\nu_L} + \xi_w \left(\frac{w_{t-1}}{1 + \pi_t} \right)^{1-\nu_L})^{\frac{1}{1-\nu_L}}.$$

$$\Lambda_t^* = \frac{1}{C_t^* - h\bar{C}_{t-1}^*}$$

$$\Lambda_t^* = \beta \mathbb{E}_t[\Lambda_{t+1}^* \frac{R_t^*}{1 + \pi_{t+1}^*}].$$

$$(\tilde{w}_t^*)^{1+\nu_L\zeta} = \frac{\chi^{\nu_L}}{\nu_L - 1} \frac{F_{1t}^{W*}}{F_{2t}^{W*}}$$

$$F_{1t}^{W*} = (\ell_t^*)^{1+\zeta} (w_t^*)^{\nu_L\zeta} + \beta \xi_w \mathbb{E}_t \left(\frac{w_{t+1}^*}{w_t^*} \right)^{\nu_L} (1 + \pi_{t+1}^*)^{\nu_L(1+\zeta)} F_{1t+1}^{W*}$$

$$F_{2t}^{W*} = \Lambda_t^* \ell_t^* + \beta \xi_w \mathbb{E}_t \left(\frac{w_{t+1}^*}{w_t^*} (1 + \pi_{t+1}^*) \right)^{\nu_L} (1 + \pi_{t+1}^*)^{-1} F_{2t+1}^{W*}.$$

$$w_t^* = ((1 - \xi_w)(\tilde{w}_t^*)^{1-\nu_L} + \xi_w \left(\frac{w_{t-1}^*}{1 + \pi_t^*} \right)^{1-\nu_L})^{\frac{1}{1-\nu_L}}.$$

$$\phi_t^* = \frac{q_t^* z_t^* + b_t^*}{n_t^*}$$

$$\mathbb{E}_t(\Omega_{t,t+1}^* R_{Kt+1}^*) = \mathbb{E}_t(\Omega_{t,t+1}^* \frac{R_{Bt}^*}{1 + \pi_{t+1}^*})$$

$$\Omega_{t,t+1}^* = \mathbb{E}_t[\mathcal{M}_{t,t+1}^* (1 - \omega + \omega \kappa_{t+1}^*)]$$

$$\kappa_t^* = \theta^* \phi_t^*,$$

$$\phi_t^* = \frac{\mu_{1t}^*}{\theta^* - \mu_{0t}^*}$$

$$\mu_{0t}^* = \mathbb{E}_t[\Omega_{t,t+1}^*(R_{Kt+1}^* - \frac{R_t^*}{1 + \pi_{t+1}^*})]$$

$$\mu_{1t}^* = \mathbb{E}_t[\Omega_{t,t+1}^* \frac{R_t^*}{1 + \pi_{t+1}^*}]$$

$$q_t^* z_t^* + b_t^* = d_t^* + n_t^*.$$

$$n_t^* = (\omega + \xi_b^*)(R_{Kt}^* q_{t-1}^* z_{t-1}^* + \frac{R_{Bt-1}^*}{1 + \pi_t^*} b_{t-1}^*) - \omega \frac{R_{t-1}^*}{1 + \pi_t^*} d_{t-1}^*$$

$$\phi_t = \frac{q_t z_t}{n_t}$$

$$\kappa_t = \Theta(x_t) \phi_t$$

$$\Theta(x_t) = \theta \left(1 + \frac{\gamma_b}{2} x^2 \right)$$

$$x = \frac{s_t b_t^*}{q_t z_t}$$

$$q_t z_t = d_t + s_t b_t^* + n_t$$

$$n_t = (\omega + \xi_b) R_{Kt} q_{t-1} z_{t-1} - \omega \frac{R_{t-1}}{1 + \pi_t} d_{t-1} - \omega \frac{R_{Bt-1}^*}{1 + \pi_t^*} b_{t-1}^* s_t.$$

Action: Task 1

$$\mu_{Bt} = \mathbb{E}_t[\Omega_{t,t+1}(\frac{R_t}{1 + \pi_{t+1}} - \frac{R_{Bt}^*}{1 + \pi_{t+1}^*} \frac{s_{t+1}}{s_t})]$$

$$\mu_{Kt} = \mathbb{E}_t[\Omega_{t,t+1}(R_{Kt+1} - \frac{R_t}{1 + \pi_{t+1}})]$$

$$\mu_{Dt} = \mathbb{E}_t[\Omega_{t,t+1} \frac{R_t}{1 + \pi_{t+1}}]$$

$$\Omega_{t,t+1} = \mathbb{E}_t[\mathcal{M}_{t,t+1}(1 - \omega + \omega \kappa_{t+1})].$$

$$x_t = \frac{\sqrt{1 + \frac{1}{\gamma_b} \mu_t^2} - 1}{\mu_t},$$

$$\mu_t = \frac{\mu_{Bt}}{\mu_{Kt}}$$

$$\phi_t = \frac{\mu_{Dt}}{\Theta(x_t) - (\mu_{Kt} + \mu_{Bt} x_t)}$$

Home intermediate goods producers

$$q_t z_t = q_t k_t.$$

$$\begin{aligned}\frac{W_t}{P_t} &= (1 - \alpha) P_{mt} \frac{Y_t}{\ell_t} \\ R_{Kt} &= \frac{\alpha P_{mt} \frac{Y_t}{k_{t-1}} + (1 - \delta) q_t}{q_{t-1}} \\ P_{mt} &= \frac{(R_{Kt} q_{t-1} - (1 - \delta) q_t)^\alpha (w_t)^{1-\alpha}}{A_t \alpha^\alpha (1 - \alpha)^{1-\alpha}} \\ A_t &= (A_{t-1})^{\rho_A} \exp(e_{At}).\end{aligned}$$

Foreign intermediate goods producers

$$q_t^* z_t^* = q_t^* k_t^*.$$

$$\frac{W_t^*}{P_t^*} = (1 - \alpha) P_{mt}^* \frac{Y_t^*}{\ell_t^*}$$

$$R_{Kt}^* = \frac{\alpha P_{mt}^* \frac{Y_t^*}{k_{t-1}^*} + (1 - \delta) q_t^*}{q_{t-1}^*}.$$

$$P_{mt}^* = \frac{(R_{Kt}^* q_{t-1}^* - (1 - \delta) q_t^*)^\alpha (w_t^*)^{1-\alpha}}{A_t^* \alpha^\alpha (1 - \alpha)^{1-\alpha}}$$

$$A_t^* = (A_{t-1}^*)^{\rho_A} \exp(e_{At}^*).$$

$$q_t = 1 + \frac{\phi_K}{2} \left(\frac{l_t}{l_{t-1}} - 1 \right)^2 + \phi_K \left(\frac{l_t}{l_{t-1}} - 1 \right) \frac{l_t}{l_{t-1}} - \phi_K \mathbb{E}_t [\mathcal{M}_{t,t+1} \left(\frac{l_{t+1}}{l_t} - 1 \right) \frac{l_{t+1}^2}{l_t^2}].$$

$$k_t = l_t + (1 - \delta)k_{t-1}.$$

$$q_t^* = 1 + \frac{\phi_K}{2} \left(\frac{l_t^*}{l_{t-1}^*} - 1 \right)^2 + \phi_K \left(\frac{l_t^*}{l_{t-1}^*} - 1 \right) \frac{l_t^*}{l_{t-1}^*} - \phi_K \mathbb{E}_t [\mathcal{M}_{t,t+1}^* \left(\frac{l_{t+1}^*}{l_t^*} - 1 \right) \frac{(l_{t+1}^*)^2}{(l_t^*)^2}].$$

$$k_t^* = l_t^* + (1 - \delta)k_{t-1}^*.$$

Foreign final goods producers

$$\frac{\tilde{P}_t^*(f)}{P_{Ft}^*} = \frac{\varrho}{\varrho - 1} \frac{F_{1Ht}^*}{F_{2Ht}^*},$$

$$F_{1Ft}^* = \Lambda_t^* \mathcal{Y}_{Ft}^* P_{mt}^* + \beta \xi \mathbb{E}_t (1 + \pi_{Ft+1}^*)^\varrho F_{1Ft+1}^*$$

$$F_{2Ft}^* = \Lambda_t^* \mathcal{Y}_{Ft}^* \frac{P_{Ft}^*}{P_t^*} + \beta \xi \mathbb{E}_t (1 + \pi_{Ft+1}^*)^{\varrho-1} F_{2Ht+1}^*.$$

$$\xi (1 + \pi_{Ft}^*)^{\varrho-1} + (1 - \xi) \left[\frac{\tilde{P}_t^*(f)}{P_{Ft}^*} \right]^{1-\varrho} = 1.$$

$$\Delta_{Ft}^* = (1 - \xi) \left(\frac{\tilde{P}_t^*(f)}{P_{Ft}^*} \right)^{-\varrho} + \xi (1 + \pi_{Ft}^*)^\varrho \Delta_{Ft-1}^*$$

$$\frac{\tilde{P}_t^{PCP}(h)}{P_{Ht}} = \frac{\varrho}{\varrho - 1} \frac{F_{1Ht}}{F_{2Ht}},$$

$$F_{1Ht} = \Lambda_t \mathcal{Y}_{Ht} P_{mt} + \beta \xi \mathbb{E}_t (1 + \pi_{Ht+1})^\varrho F_{1Ht+1}$$

$$F_{2Ht} = \Lambda_t \mathcal{Y}_{Ht} \frac{P_{Ht}}{P_t} + \beta \xi \mathbb{E}_t (1 + \pi_{Ht+1})^{\varrho-1} F_{2Ht+1}$$

$$\frac{\tilde{P}_t^{PCP^*}(h)}{P_{Ht}^*} = \frac{p_{Ht}}{S_t p_{Ht}^*} \frac{\tilde{P}_t^{PCP}(h)}{P_{Ht}}$$

$$\frac{\tilde{P}_t^{LCP}(h)}{P_{Ht}} = \frac{\varrho}{\varrho - 1} \frac{F_{1Ht}^{LCP}}{F_{2Ht}^{LCP}}$$

$$F_{1Ht}^{LCP} = \Lambda_t \mathcal{Y}_{Ht} P_{mt} + \beta \xi \mathbb{E}_t (1 + \pi_{Ht+1})^\varrho F_{1Ht+1}^{LCP}$$

$$F_{2Ht}^{LCP} = \Lambda_t \mathcal{Y}_{Ht} \frac{P_{Ht}}{P_t} + \beta \xi \mathbb{E}_t (1 + \pi_{Ht+1})^{\varrho-1} F_{2Ht+1}^{LCP},$$

$$\frac{\tilde{P}_t^{LCP*}(h) S_t}{P_{Ht}^*} = \frac{\varrho}{\varrho - 1} \frac{F_{1Ht}^{LCP*}}{F_{2Ht}^{LCP*}},$$

$$F_{1Ht}^{LCP*} = \Lambda_t \mathcal{Y}_{Ht}^* P_{mt} + \beta \xi \mathbb{E}_t (1 + \pi_{Ht+1}^*)^\varrho F_{1Ht+1}^{LCP*}$$

$$F_{2Ht}^{LCP*} = \Lambda_t \mathcal{Y}_{Ht}^* \frac{P_{Ht}^*}{P_t^*} + \beta \xi \mathbb{E}_t \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} (1 + \pi_{Ht+1}^*)^{\varrho-1} \frac{1 + \pi_{t+1}^*}{1 + \pi_{t+1}} F_{2Ht+1}^{LCP*},$$

Home final goods producers

$$\xi(1 + \pi_{Ht})^{\varrho-1} + (1 - \xi)(\eta_F \left[\frac{\tilde{P}_t^{PCP}(h)}{P_{Ht}} \right]^{1-\varrho} + (1 - \eta_F) \left[\frac{\tilde{P}_t^{LCP}(h)}{P_{Ht}} \right]^{1-\varrho}) = 1$$

$$\xi(1 + \pi_{Ht}^*)^{\varrho-1} + (1 - \xi)(\eta_F \left[\frac{\tilde{P}_t^{PCP^*}(h)}{P_{Ht}^*} \right]^{1-\varrho} + (1 - \eta_F) \left[\frac{\tilde{P}_t^{LCP^*}(h)}{P_{Ht}^*} \right]^{1-\varrho}) = 1.$$

$$\Delta_{Ht} = (1 - \xi)[\eta_F \left(\frac{\tilde{P}_t^{PCP}(h)}{P_{Ht}} \right)^{-\varrho} + (1 - \eta_F) \left(\frac{\tilde{P}_t^{LCP}(h)}{P_{Ht}} \right)^{-\varrho}] + \xi(1 + \pi_{Ht})^{\varrho} \Delta_{Ht-1}$$

$$\Delta_{Ht}^* = (1 - \xi)[\eta_F \left(\frac{\tilde{P}_t^{PCP^*}(h)}{P_{Ht}^*} \right)^{-\varrho} + (1 - \eta_F) \left(\frac{\tilde{P}_t^{LCP^*}(h)}{P_{Ht}^*} \right)^{-\varrho}] + \xi(1 + \pi_{Ht}^*)^{\varrho} \Delta_{Ht-1}^*$$

$$p_H^{\epsilon-1} = a + (1-a)\mathcal{T}_t^{1-\epsilon},$$

$$(p_F^*)^{\epsilon-1} = a^* \left(\frac{\tilde{\Delta}_t}{\mathcal{T}_t} \right)^{1-\epsilon} + (1-a^*),$$

$$\tilde{\Delta}_t = \eta_F + (1-\eta_F) \frac{\mathcal{E}_t p_{Ht}^{LCP*}}{p_{Ht}^{LCP}}.$$

$$a p_H^{1-\epsilon} + (1-a) p_F^{1-\epsilon} = 1$$

$$a^* (p_F^*)^{1-\epsilon} + (1-a^*) (p_F^*)^{1-\epsilon} = 1$$

$$\frac{1 + \pi_{Ht}}{1 + \pi_t} = \frac{p_{Ht}}{p_{Ht-1}}.$$

$$\frac{1 + \pi_{Ft}^*}{1 + \pi_t^*} = \frac{p_{Ft}^*}{p_{Ft-1}^*}.$$

$$S_t^{1-\epsilon} = \frac{a^* \tilde{\Delta}_t^{1-\epsilon} + (1-a^*) \mathcal{T}_t^{1-\epsilon}}{a + (1-a) \mathcal{T}_t^{1-\epsilon}}.$$

The Home central bank:

$$R_t = R_{t-1}^\gamma (\bar{R}(1 + \pi_t)^{\theta_\pi})^{1-\gamma} \exp(e_{Rt}).$$

The Foreign central bank:

$$R_t^* = (R_{t-1}^*)^\gamma (\bar{R}^*(1 + \pi_t^*)^{\theta_\pi})^{1-\gamma} \exp(e_{Rt}^*).$$

Government spending:

$$\begin{aligned} \frac{G_t}{\bar{G}} &= \left(\frac{G_{t-1}}{\bar{G}} \right)^{\rho_G} \exp(e_{Gt}) \\ \frac{G_t^*}{\bar{G}^*} &= \left(\frac{G_{t-1}^*}{\bar{G}^*} \right)^{\rho_G} \exp(e_{Gt}^*). \end{aligned}$$

$$\mathcal{Y}_{Ht} = y_{Ht} + \frac{1-n}{n} y_{Ht}^*$$

$$\mathcal{Y}_{Ht}^* = \frac{1-n}{n} y_{Ht}^*$$

$$\mathcal{Y}_{Ft}^* = \frac{n}{1-n} y_{Ft} + y_{Ft}^*$$

$$y_{Ht} = a \left(\frac{P_{Ht}}{P_t} \right)^{-\epsilon} \left(C_t + I_t + G_t + \frac{\phi_K}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t \right)$$

$$y_{Ht}^* = a^* \left(\frac{P_{Ht}^*}{P_t^*} \right)^{-\epsilon} \left(C_t^* + I_t^* + G_t^* + \frac{\phi_K}{2} \left(\frac{I_t^*}{I_{t-1}^*} - 1 \right)^2 I_t^* \right).$$

$$y_{Ft} = (1-a) \left(\frac{P_{Ft}}{P_t} \right)^{-\epsilon} \left(C_t + I_t + G_t + \frac{\phi_K}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t \right)$$

$$y_{Ft}^* = (1-a^*) \left(\frac{P_{Ft}^*}{P_t^*} \right)^{-\epsilon} \left(C_t^* + I_t^* + G_t^* + \frac{\phi_K}{2} \left(\frac{I_t^*}{I_{t-1}^*} - 1 \right)^2 I_t^* \right).$$

Market Clearing

Market clearing for intermediate goods:

$$Y_t = \Delta_{Ht} y_{Ht} + \Delta_{Ht}^* \frac{1-n}{n} y_{Ht}^*$$

$$Y_t^* = \Delta_{Ft}^* \left(\frac{n}{1-n} y_{Ft} + y_{Ft}^* \right)$$

Budget constraint of the Home household:

$$y_t^d + \frac{R_{Bt-1}^* b_{t-1}^* S_t}{(1 + \pi_t^*)} = b_t^* S_t + \frac{P_{Ht}}{P_t} y_{Ht} + \frac{P_{Ht}^* S_t}{P_t^*} \frac{1-n}{n} y_{Ht}^*,$$

where

$$y_t^d = C_t + I_t + G_t + \frac{\phi_K}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 I_t.$$

Task 1

Action

Fill in the missing equations in the local banking sections in CFR_Model_AQ_ps.mod (starting from line 246)

Hints:

- Use 'lev' for ϕ_t , 'nw' for n_t , 'Thetax' for $\Theta(x_t)$, 'rer' for s_t , 'b_star' for b^* , 'xib' for ξ_b , 'rk' for R_{Kt} , 'rb_star' for R_{Bt} . Generally, you should be able to find the corresponding notations in the 'var' section (line 1-125) and the 'parameters' section (line 139-210) in the code.
- Variables are expressed in exponential [e.g. $\exp(\text{lev})$] in the code, why?
- I have coded 5 equations. Given the number of equations in the local banking sector, how many are left for you to code up?

Local banking sector

Task 2

Action

Fill in the missing codes in `IRFmatch_ps.mod`. In line 24, write codes to get the standard deviation of the empirical IRFs. In line 34, define `Var_IRF` as empirical IRFs, `invVarNorm` as the inverse of variance, and `logdetVarNorm` as the log-determinant of the variance.

Hints:

- In `IRFmatch_data`, 'irf' stores empirical IRFs, 'low' and 'upp' store the lower and upper bounds of the confidence bands respectively. The confidence bands are twice the estimated standard deviations.
- Function for inverse: $\text{inv}(X)$; Function for log-determinant: $\text{logdet}(X)$.

After you finish, rename `CFR_Model_AQ_ps.mod` and `IRFmatch_ps.mod` as `CFR_Model_AQ.mod` and `IRFmatch.mod`. Execute the code through `GO_CFR_AQ` to see whether it works.