Lecture 2 Practical: The International Transmission of Financial Shocks

Summer School in International Finance
University of Oxford

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Home household

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

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

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

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

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

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

Foreign household

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

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

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

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

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

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

Global banks

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

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

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

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

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

Global banks

$$\mu^*_{0t} = \mathbb{E}_t[\Omega^*_{t,t+1}(R^*_{Kt+1} - \frac{R^*_t}{1+\pi^*_{t+1}})]$$

$$\mu^*_{1t} = \mathbb{E}_t[\Omega^*_{t,t+1}\frac{R^*_t}{1+\pi^*_{t+1}}]$$

$$q^*_t z^*_t + b^*_t = d^*_t + n^*_t.$$

$$n^*_t = (\omega + \xi^*_b)(R^*_{Kt} q^*_{t-1} z^*_{t-1} + \frac{R^*_{Bt-1}}{1+\pi^*_t} b^*_{t-1}) - \omega \frac{R^*_{t-1}}{1+\pi^*_t} d^*_{t-1}$$

Local banks

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

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

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

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

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

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

Action: Task 1

Local banks

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

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

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

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

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

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

.

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

Home intermediate goods producers

$$q_t z_t = q_t k_t.$$

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

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

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

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

Foreign intermediate goods producers

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

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

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

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

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

Capital producers

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

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

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

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

Foreign final goods producers

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

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

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

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

Home PCP final goods producers

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

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

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

Home LCP final goods producers

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

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

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

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

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

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

Home final goods producers

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

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

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

$$\Delta^*_{Ht} = (1-\xi)[\eta_F(\frac{\widetilde{P}_t^{PCP*}(h)}{P^*_{Ht}})^{-\varrho} + (1-\eta_F)(\frac{\widetilde{P}_t^{LCP*}(h)}{P^*_{Ht}})^{-\varrho}] + \xi(1+\pi^*_{Ht})^{\varrho}\Delta^*_{Ht-1}$$

Prices

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

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

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

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

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

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

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

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

Governments

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:

$$\frac{G_t}{\bar{G}} = (\frac{G_{t-1}}{\bar{G}})^{\rho_G}\exp(e_{Gt})$$
$$\frac{G_t^*}{\bar{G}^*} = (\frac{G_{t-1}^*}{\bar{G}^*})^{\rho_G}\exp(e_{Gt}^*).$$

Market Clearing

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

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

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

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:

$$y^d_t + \frac{R^*_{Bt-1} b^*_{t-1} S_t}{(1+\pi^*_t)} = b^*_t S_t + \frac{P_{Ht}}{P_t} y_{Ht} + \frac{P^*_{Ht} S_t}{P^*_t} \frac{1-n}{n} y^*_{Ht},$$

where

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

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(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: $inv(X)$; Function for log-determinant: $logdet(X)$.

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.