Gone with the Wind:

Monetary and Financial Policies During Global Financial Cycles

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Research Question

Can we reconcile macro DSGE models with empirical facts of global financial cycles?

Evidence of Global Financial Cycles

- Work by Helene Rey
- Post-GFC "taper tantrum"
- "Fragile Five" and sudden stop shocks

Related Literature

Most relevant papers are: Aoki, Benigno and Kiyotaki (2016) (ABK), Christiano, Trabandt and Walentin (2011), Gertler and Karadi (2011), and Gertler and Kiyotaki (2010).

Framework of Aoki, Benigno, and Kiyotaki (2016)

- Small open economy NK model with financial markets.
- Banks receive domestic deposits and borrow from foreigners (in foreign currency).
  - "The Original Sin" by Eichengreen, Hausmann and Panizza (2007).
  - Bruno and Shin (2015): EMEs non-financial corporations' balance sheets are exposed to global monetary and financial conditions.

ABK Framework

- Banking sector of the model creates propagation mechanism.
- Policy problem for the central bank intensifies.

Model Overview

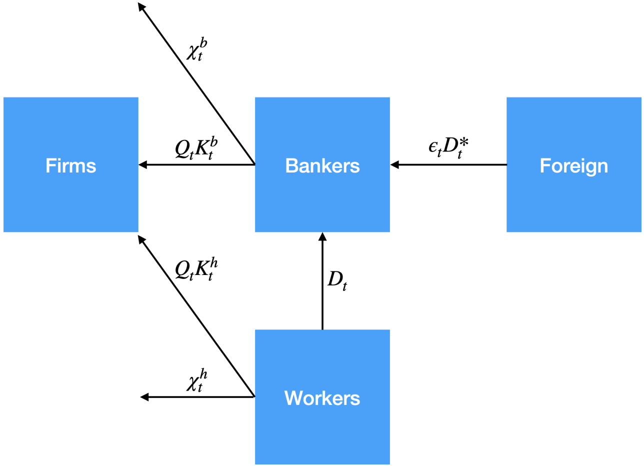


Figure 1: Flow of Funds in the ABK Model

Households

- Representative household consists of a continuum of workers and bankers.
- Each banker manages a bank until she retires w.p. $1 - \sigma$, and then brings back the net worth as dividend.
- Workers become new bankers, starting with γ assets from household.
- Household saves in home deposits and owns capital (with cost).

Household Problem

$$\max \ \mathbb{E}_t \left[\sum_{s=0}^{\infty} \beta^s \xi_{t+s}^h \ln \left(\xi_{t+s}^C C_{t+s} - \frac{\zeta_0}{1+\zeta} \xi_{t+s}^L L_{t+s}^{1+\zeta} \right) \right],$$

subject to:

$$C_t + Q_t K_t^h + \chi_t^h + D_t = w_t L_t + \mathrm{Profits}_t + (z_t + \lambda Q_t) K_{t-1}^h + \frac{R_{t-1} D_{t-1}}{\Pi_t}.$$

Bankers' Problem

- Each banker chooses capital, k_t, home real deposits, d_t, and foreign debt, d_t^* to maximise franchise value

$$V_t = \mathbb{E}_t \left\{ \Lambda_{t,t+j} \left[(1-\sigma) n_{t+1} + \sigma V_{t+1} \right] \right\},$$

subject to a balance sheet constraint and incentive constraint:

$$\left[1 + \tau_t^K + \frac{\varkappa^b}{2} x_t^2 \right] Q_t k_t = (1+\tau_t^N) n_t + d_t + (1-\tau_t^{D^*}) \epsilon_t d_t^*,$$
$$V_t \geq \Theta(x_t) Q_t k_t.$$

- Note the banker's flow of funds constraint:

$$n_t = (Z_t + \lambda Q_t) k_{t-1} - \frac{R_{t-1}}{\Pi_t} d_{t-1} - \epsilon_t \frac{R_{t-1}^*}{\Pi_t^*} d_{t-1}^*.$$

Timing of the Banker

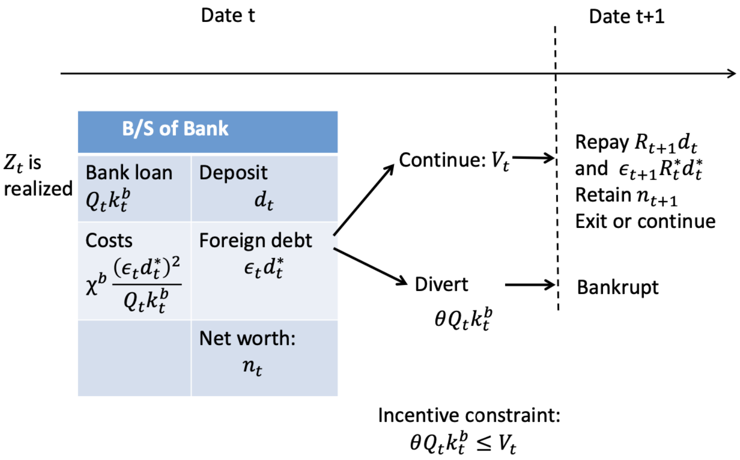


Figure 2: Timing of Banks' Choice

Bankers and Moral Hazard

- Absconding takes time.
- Banker can abscond with fraction $\Theta(x_t)$ of assets, where

$$\Theta(x_t) = \frac{\theta_0}{\exp(\theta x_t)},$$

and where x_t is the fraction of assets financed by foreign borrowing.

Rewriting the Bankers' Problem I

- Since the bankers' problem and constraints are all constant returns to scale, we can write
$$\psi_t \equiv \frac{V_t}{n_t} = \mathbb{E}_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\frac{n_{t+1}}{n_t}\right]$$
where ψ_t is akin to Tobin's Q ratio for the bank.

Rewriting the Bankers' Problem II

- Use the flow of funds constraint of the banker to write:

$$\frac{n_{t+1}}{n_t} = (Z_{t+1} + \lambda Q_{t+1}) k_t \frac{Q_t}{Q_t n_t} - \frac{R_t}{\Pi_{t+1}} \frac{d_t}{n_t} - \frac{\epsilon_{t+1}}{\epsilon_t} \frac{R_t^*}{\Pi_{t+1}^*} \frac{\epsilon_t d_t^*}{n_t}.$$

- Then use the balance sheet constraint to substitute in the value for $\frac{d_t}{n_t}$ to write:

$$\begin{aligned}\frac{n_{t+1}}{n_t} &= \left[\frac{Z_{t+1} + \lambda Q_{t+1}}{Q_t} - (1 + \tau_t^K) \frac{R_t}{\Pi_{t+1}}\right] \phi_t \\ &\quad + \left[(1 - \tau_t^{D^*}) \frac{R_t}{\Pi_{t+1}} - \frac{\epsilon_{t+1}}{\epsilon_t} \frac{R_t^*}{\Pi_{t+1}^*}\right] x_t \phi_t + \left(1 + \tau_t^N - \frac{\varkappa^b}{2} x_t^2 \phi_t\right) \frac{R_t}{\Pi_{t+1}}.\end{aligned}$$

Rewriting the Bankers' Problem III

- Thus, the bankers' problem is to maximise the Tobin's Q ratio,

$$\psi_t = \max_{\phi_t, x_t} \left[\mu_t \phi_t + \mu_t^* \phi_t x_t + \left(1 + \tau_t^N - \frac{\varkappa^b}{2} x_t^2 \phi_t \right) \upsilon_t \right],$$

subject to the incentive constraint,

$$\psi_t \geq \Theta(x_t)\phi_t = \frac{\theta_0}{\exp(\theta x_t)} \phi_t.$$

Rewriting the Bankers' Problem IV

- This gives a theory for why UIP fails.

$$\mu_t = \mathbb{E}_t \left[\Omega_{t,t+1} \left\{ \frac{z^k_{t+1} + \lambda Q_{t+1}}{Q_t} - (1+\tau^K_t) \frac{R_t}{\Pi_{t+1}} \right\} \right], \tag{1}$$

$$\mu^*_t = \mathbb{E}_t \left[\Omega_{t,t+1} \left\{ (1-\tau^{D^*}_t) \frac{R_t}{\Pi_{t+1}} - \frac{\epsilon_{t+1}}{\epsilon_t} \frac{R^*_t}{\Pi^*_{t+1}} \right\} \right] \tag{2}$$

$$\upsilon_t = \mathbb{E}_t \left[\Omega_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right] \tag{3}$$

$$\Omega_{t,t+1} = \Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1}). \tag{4}$$

Production I

- Standard with final goods and intermediate goods producers.
- From intermediate producer's problem (FOC wrt $P_t(i)$), under the symmetric equilibrium $P_t(i) = P_t$

$$(\Pi_t - 1)\,\Pi_t = \frac{1}{\kappa}\left(\eta mc_t + 1 - \eta\right) + \mathbb{E}_t\left[\Lambda_{t,t+1}\frac{Y_{t+1}}{Y_t}\Pi_{t+1}\left(\Pi_{t+1} - 1\right)\right],$$

  where $\Pi_t = 1 + \pi_t = \frac{P_t}{P_{t-1}}$.
- Also, under the symmetric equilibrium:

$$Y_t = A_t\left(\frac{K_t}{\alpha_K}\right)^{\alpha_K}\left(\frac{M_t}{\alpha_M}\right)^{\alpha_M}\left(\frac{L_t}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M}.$$

Production II

- Law of motion for capital is

$$K_t = \lambda K_{t-1} + I_t \xi_t^K,$$

  where $\lambda \in (0,1)$ is one minus a constant depreciation rate and ξ_t^K is akin to a marginal efficiency of investment shock.
- Total investment cost equals:

$$\left[1 + \Phi\left(\frac{I_t}{\bar{I}}\right)\right] I_t,$$

  where $\Phi\left(\frac{I_t}{\bar{I}}\right)$ is the additional production cost of supplying investment goods that is different from the non-stochastic steady state level $\bar{I}$, and $\Phi(1) = \Phi'(1) = 0$ and $\Phi''\left(\frac{I_t}{\bar{I}}\right) > 0$.

Market Equilibrium I

- Output is either consumed, invested, exported, or used to pay the cost of changing prices and managing households' capital as:

$$Y_t = C_t + \left[1 + \Phi\left(\frac{I_t}{\bar{I}}\right)\right] I_t + EX_t + \frac{\kappa}{2}(\pi_t - 1)^2 Y_t$$
$$+ \chi^h(K_t^h, K_t) + \chi^b(\epsilon_t D_t^*, Q_t K_t^b).$$

- Net output which corresponds to final expenditure is:

$$Y_t^{Net} = Y_t - \epsilon_t M_t - \frac{\kappa}{2}(\pi_t - 1)^2 Y_t - \chi^h(K_t^h, K_t) - \chi^b(\epsilon_t D_t^*, Q_t K_t^b).$$

Market Equilibrium II

- Net foreign debt, which is equal to the foreign debt of home banks, evolves through net imports and the repayment of foreign debt from the previous period as:

$$D_t^* = R_{t-1}^* D_{t-1}^* + M_t - \frac{1}{\epsilon_t} EX_t.$$

- The aggregate net worth of banks evolves according to:

$$N_t = \sigma \left[(Z_t + \lambda Q_t) K_{t-1}^b - \frac{R_{t-1}}{\Pi_t} D_{t-1} - \epsilon_t R_{t-1}^* D_{t-1}^* \right] + \gamma (Z_t + \lambda Q_t) K_{t-1}.$$

Market Equilibrium III

- The aggregate balance sheet of the bank is given by:

$$\begin{aligned} Q_t K_t^b \left(1 + \frac{\varkappa^b}{2} x_t^2\right) &= \left(1 + \frac{\varkappa^b}{2} x_t^2\right) \phi_t N_t, \\ &= N_t + D_t + \epsilon_t D_t^*, \\ x_t &= \frac{\epsilon_t D_t^*}{Q_t K_t^b}. \end{aligned}$$

- The market equilibrium for capital ownership (equity) implies:

$$K_t = K_t^b + K_t^h.$$

Foreign Exchange I

- Foreign output is
$$\ln Y_t^* = \ln y_t^* + \ln A_t.$$
- Assume the following structure for foreign variables:

$$\begin{bmatrix} \log\left(\frac{y_t^*}{\bar{y}^*}\right) \\ \Pi_t^* - \bar{\Pi}^* \\ R_t^* - \bar{R}^* \\ \log\left(\frac{A_t}{\bar{A}}\right) \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & 0 \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ 0 & 0 & 0 & \rho_A \end{bmatrix} \begin{bmatrix} \log\left(\frac{y_{t-1}^*}{\bar{y}^*}\right) \\ \Pi_{t-1}^* - \bar{\Pi}^* \\ R_{t-1}^* - \bar{R}^* \\ \log\left(\frac{A_{t-1}}{\bar{A}}\right) \end{bmatrix} + \begin{bmatrix} \sigma_{Y^*} & 0 & 0 & 0 \\ c_{21} & \sigma_{\Pi^*} & 0 & c_{24} \\ c_{31} & c_{32} & \sigma_{R^*} & c_{34} \\ 0 & 0 & 0 & \sigma_A \end{bmatrix} \begin{bmatrix} \varepsilon_t^{Y^*} \\ \varepsilon_t^{\Pi^*} \\ \varepsilon_t^{R^*} \\ \varepsilon_t^{A} \end{bmatrix},$$

  or in compact form:
$$\boldsymbol{X}_t^* = \boldsymbol{A}\boldsymbol{X}_{t-1}^* + \boldsymbol{C}\boldsymbol{\varepsilon}_t.$$

Foreign Exchange II

- Exports are determined by a simple demand curve:

$$
\begin{aligned}
EX_t &= \left(\frac{P_t}{e_t P_t^*}\right)^{-\varphi} Y_t^* \\
&= \epsilon_t^{\varphi} Y_t^* .
\end{aligned}
$$

- Pin down the nominal exchange rate:

$$
\Delta \ln \epsilon_t = \Delta \ln E_t + \hat{\pi}_t^* - \hat{\pi}_t .
$$

Government

- Taxes and subsidies are balanced in aggregate:

$$\tau_t^N N_t = \tau_t^K Q_t K_t^b + \tau_t^{D^*} \epsilon_t D_t^*.$$

- Central bank operates an inertial Taylor Rule:

$$\frac{R_t}{\bar{R}} = \left(\frac{R_{t-1}}{\bar{R}}\right)^{\rho_i} \left[\left(\frac{\Pi_t}{\bar{\Pi}}\right)^{\frac{1-\omega_E}{\omega_E}} \left(\frac{E_t}{\bar{E}}\right)^{\frac{\omega_E}{1-\omega_E}}\right]^{1-\rho_i} \exp(\varepsilon_t^R),$$

Numerical Experiments I

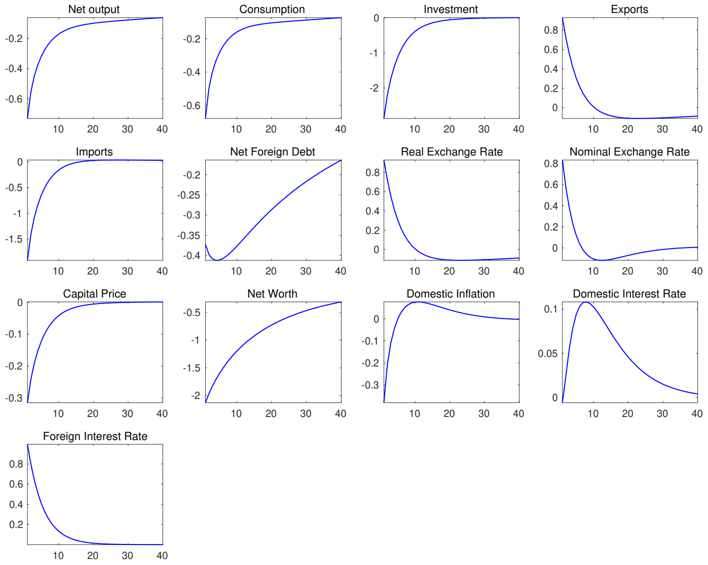
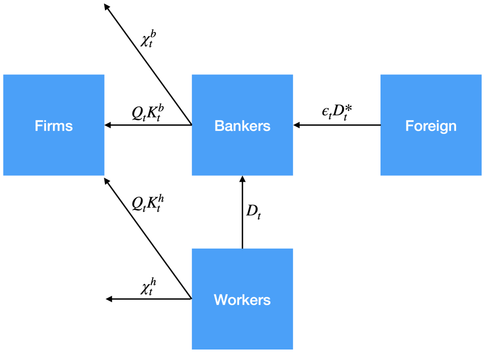


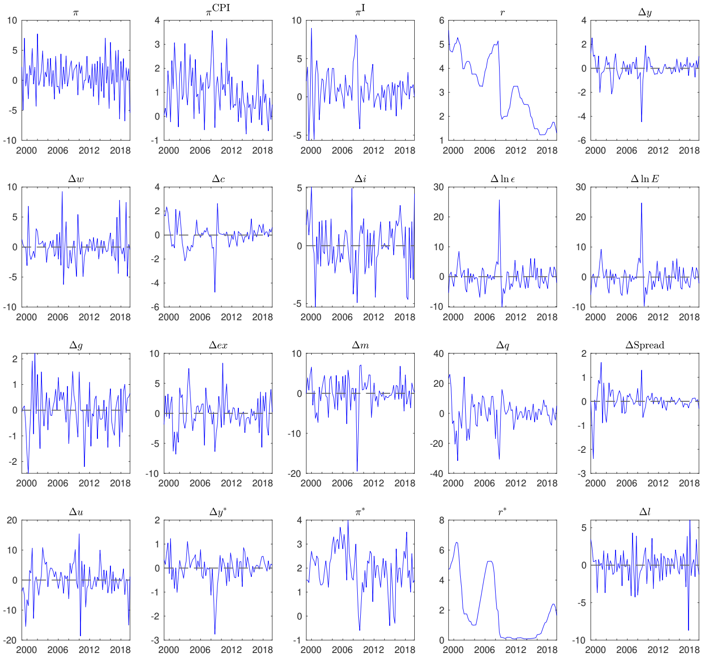
Figure 3: Response to 1% Annual Foreign Interest Rate Shock

Numerical Experiments II



Assets	Liabilities + Equity
Loans $Q_t k_t^b$	Deposits d_t
Management costs χ_t^b	Foreign debt $\epsilon_t d_t^*$
	Net worth n_t

Estimation



π
π^{CPI}
π^{I}
r
Δy
Δw
Δc
Δi
$\Delta \ln \epsilon$
$\Delta \ln E$
Δg
Δex
Δm
Δq
ΔSpread
Δu
Δy^*
π^*
r^*
Δl

Estimation II

Parameter	Prior dist.	Prior mean	Prior SD	Post. mean	Post. SD	5%	95%
ρ_A	β	0.850	0.0750	0.7954	0.0049	0.7910	0.8035
ρ_h	β	0.850	0.0750	0.9947	0.0203	0.9936	0.9958
ρ_C	β	0.850	0.0750	0.9997	0.0286	0.9995	0.9999
ρ_L	β	0.850	0.0750	0.8774	0.0055	0.8715	0.8833
ρ_K	β	0.850	0.0750	0.8200	0.0029	0.8118	0.8285
ζ	Γ	0.333	0.1000	0.4702	0.0319	0.4612	0.4795
ζ_0	Γ	7.883	2.0000	3.3836	0.4077	3.1420	3.5974
θ	Γ	0.100	0.0750	0.0925	0.0252	0.0861	0.0990
η	Γ	9.000	1.0000	8.4972	0.1736	8.3358	8.6552
ω	β	0.667	0.1000	0.9043	0.0176	0.8934	0.9157
κ_I	β	0.667	0.1000	0.2986	0.0733	0.2873	0.3082
φ	Γ	1.000	0.2500	1.0110	0.0012	1.0031	1.0158
ρ_R	β	0.800	0.1000	0.8866	0.0247	0.8690	0.9012
ω_E	β	0.250	0.0500	0.1313	0.0227	0.1260	0.1366

Estimation III

Parameter	Prior dist.	Prior mean	Prior SD	Post. mean	Post. SD	5%	95%
a_{11}	$\mathcal{N}$	0.800	0.1000	0.8220	0.0057	0.8140	0.8289
a_{22}	$\mathcal{N}$	0.000	0.5000	-0.2947	0.0886	-0.3664	-0.2262
a_{33}	$\mathcal{N}$	0.800	0.1000	0.8574	0.0142	0.8489	0.8642
a_{12}	$\mathcal{N}$	0.000	0.5000	0.0594	0.0659	0.0135	0.1213
a_{13}	$\mathcal{N}$	0.000	0.5000	0.1808	0.0545	0.1126	0.2427
a_{21}	$\mathcal{N}$	0.000	0.5000	0.1964	0.0312	0.1782	0.2167
a_{23}	$\mathcal{N}$	0.000	0.5000	-0.7289	0.1399	-0.7578	-0.6931
a_{24}	$\mathcal{N}$	0.000	0.5000	0.0568	0.0241	0.0419	0.0745
a_{31}	$\mathcal{N}$	0.000	0.5000	-0.0075	0.0077	-0.0137	-0.0011
a_{32}	$\mathcal{N}$	0.000	0.5000	-0.1160	0.0337	-0.1379	-0.0927
a_{34}	$\mathcal{N}$	0.000	0.5000	0.0374	0.0114	0.0320	0.0433
c_{21}	$\mathcal{N}$	0.000	0.5000	0.1612	0.0996	0.1391	0.1825
c_{31}	$\mathcal{N}$	0.000	0.5000	0.1131	0.1015	0.0947	0.1337
c_{32}	$\mathcal{N}$	0.000	0.5000	0.2781	0.0476	0.2473	0.3189
c_{24}	$\mathcal{N}$	0.000	0.5000	0.0532	0.0337	0.0203	0.0813
c_{34}	$\mathcal{N}$	0.000	0.5000	0.0647	0.0908	0.0411	0.0911

Estimation IV

Parameter	Prior dist.	Prior mean	Post. mean	Post. SD	5%	95%
$100\sigma_A$	Γ^{-1}	0.500	0.7221	0.3989	0.6585	0.7962
$100\sigma_h$	Γ^{-1}	0.150	3.2022	0.2846	2.9535	3.4583
$100\sigma_C$	Γ^{-1}	0.150	2.4582	0.2492	2.3128	2.6238
$100\sigma_L$	Γ^{-1}	0.150	0.9103	0.3841	0.8318	0.9883
$100\sigma_K$	Γ^{-1}	0.500	3.6687	0.4192	3.2214	3.9976
$100\sigma_R$	Γ^{-1}	0.250	0.0753	0.0090	0.0661	0.0862
$100\sigma_{y^*}$	Γ^{-1}	0.500	0.9331	0.3853	0.8231	1.0193
$100\sigma_{\Pi^*}$	Γ^{-1}	0.250	0.2305	0.0531	0.1953	0.2573
$100\sigma_{R^*}$	Γ^{-1}	0.250	0.0968	0.0325	0.0851	0.1076

Appendix I

- Baseline calibration
  Elasticity of leverage wrt foreign borrowing: $\theta = 0.1$;
  Home bias in funding: $\theta_0 = 0.401$;
  Survival probability: $\sigma = 0.94$;
  Fraction of total assets brought by new banks: $\xi = 0.0045$;
  Management cost for foreign borrowing: $\varkappa^b = 0.0197$;
  Discount rate: $\beta = 0.985$;
  Inverse of Frisch elasticity of labour supply: $\zeta = 0.333$;
  Inverse of labour supply capacity: $\zeta_0 = 7.883$;
  Cost parameter of direct finance: $\varkappa^h = 0.0197$;
  Cost share of capital: $\alpha_K = 0.3$;
  Cost share of imported intermediate goods: $\alpha_M = 0.18$;
  One minus depreciation rate: $\lambda = 0.98$;
  Elasticity of demand: $\eta = 9$;
  Fraction of non-adjusters (pins down κ): $\omega = 0.66$;
  Cost of adjusting investment goods production: $\kappa_I = 0.67$; and
  Price elasticity of export demand: $\varphi = 1$.

Appendix II

- ABK baseline steady state values:
  Price of capital: $\bar{Q} = 1$;
  Inflation rate: $\bar{\pi} = 0 \implies \bar{\Pi} = 1$;
  Foreign gross interest rate: $\bar{R}^* = 1.04$;
  Gross deposit interest rate: $\bar{R} = 1.06$;
  Gross rate of return on capital for banks: $\bar{R}_k = 1.08$;
  Bank leverage multiple: $\bar{\phi} = 4$;
  Foreign debt-to-bank asset ratio: $\bar{x} = 0.25$;
  Capital-output ratio: $\frac{\bar{K}}{\bar{Y} - \bar{\epsilon}\bar{M}} = 1.98$;
  Share of capital financed by banks: $\bar{K}^b / \bar{K} = 0.75$;
  Foreign debt-to-GDP ratio: $\frac{\bar{\epsilon}\bar{D}^*}{\bar{Y} - \bar{\epsilon}\bar{M}} = 0.372$;
  GDP: $\bar{Y} - \bar{\epsilon}\bar{M} = 10.8$;
  Consumption: $\bar{C} = 8.15$;
  Investment: $\bar{I} = 1.6$;
  Exports: $\bar{EX} = 2.07$;
  Imports: $\bar{\epsilon}\bar{M} = 1.92$;
  Cost of direct finance: $\chi(\bar{K}^h) = 0.0123$; and
  Cost of foreign borrowing: $\chi(\bar{K}^b) = 0.0103$.

Appendix III

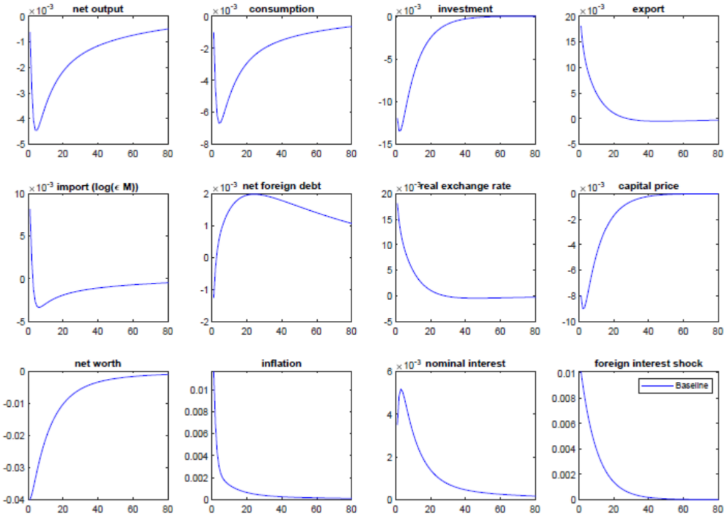


Figure 4: Response to 1% Annual Foreign Interest Rate Shock

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