# Financial Crises, Monetary and Macroprudential Policies

## Hotelling Lecture 3

Nobuhiro Kiyotaki

Recent financial crisis

Slow run on shadow banks from Summer 2007

Loss in subprime loans and related assets $\longrightarrow$ Financial intermediaries loose capital $\longrightarrow$ Spreads between liquid and illiquid assets expand

Fast run after Lehman failure in September 2008

Securitized assets market freezes

Wholesale and retail funding contracts. Asset prices fall further

"Great Recession"

We develop a simple macro model of banking crisis

- Financial accelerator / Credit cycles
- Roll-over risk, or "Bank run"
  - Slow bank run $\approx$ An increase of the likelihood of run

Macroeconomic conditions affect whether runs are feasible

- Bank leverage ratio
- Liquidation prices

# Model of Run on Shadow Banks

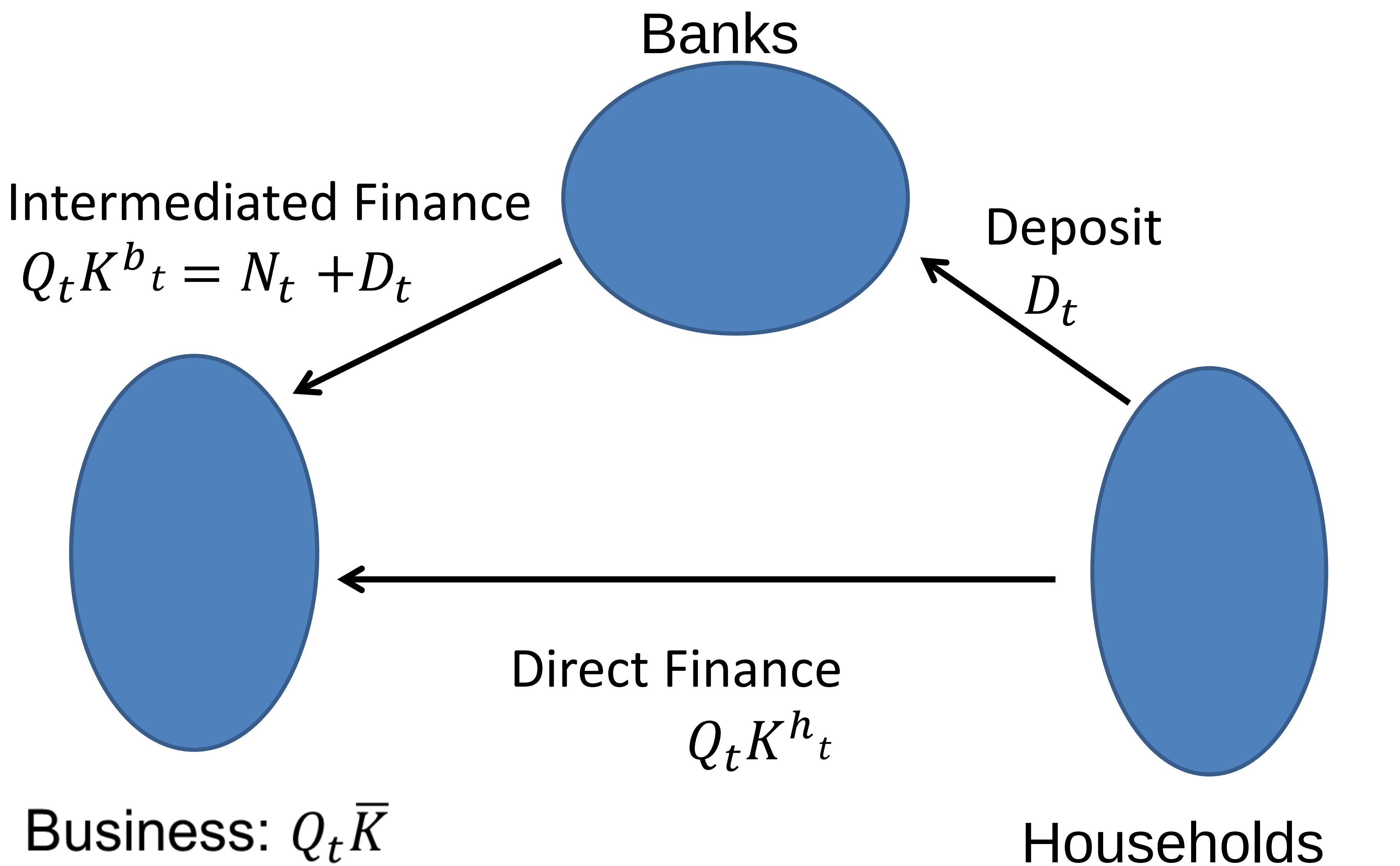
Capital is either intermediated by banks or directly held by households

$$K_t^b + K_t^h = \overline{K} = 1$$

$$\begin{array}{c} \textit{date t} \\ K_t^b \text{ capital}\} \end{array} \rightarrow \begin{array}{c} \textit{date t+1} \\ \left\{ \begin{array}{c} K_t^b \text{ capital} \\ Z_{t+1} K_t^b \text{ output} \end{array} \right. \end{array}$$

$$\begin{array}{c} \textit{date t} \\ \left. \begin{array}{c} K_t^h \text{ capital} \\ f(K_t^h) \text{ goods} \end{array} \right\} \end{array} \rightarrow \begin{array}{c} \textit{date t+1} \\ \left\{ \begin{array}{c} K_t^h \text{ capital} \\ Z_{t+1} K_t^h \text{ output} \end{array} \right. \end{array}$$

$$f(K_t^h) = \frac{\alpha}{2}(K_t^h)^2 \text{: management cost } \alpha > 0$$


Banks
Intermediated Finance
$Q_t K^b{}_t = N_t + D_t$
Deposit
$D_t$
Direct Finance
$Q_t K^h{}_t$
Business: $Q_t \bar{K}$
Households

Deposit contract

Short term

Promised rate of return $\overline{R}_t$ is non-contingent

$$\text{Realized returns } R_{t+1} = \begin{cases} \overline{R}_t, & \text{if no default w.p. } 1 - p_t \\ \rho_{t+1}\overline{R}_t, & \text{if default w.p. } p_t \end{cases}$$

Recovery rate $\rho_{t+1}$ equals total realized bank assets per deposit obligation - depends upon both individual bank and aggregate conditions

Bank defaults because of rollover crisis

Each household consists of many members, $1 - \iota$ workers and $\iota$ bankers

Workers supply labor and bring wages back to the household

Each banker manages a bank, retains some earning and bring back the rest to the household

Perfect consumption insurance within the household

Each period, each banker becomes a worker and brings back the net worth with probability $1 - \sigma$

$(1 - \sigma)\iota$ workers become bankers with the start-up funds $w^b$

Households maximize

$$U_t = E_t \left( \sum_{i=0}^{\infty} \beta^i \ln C_{t+i}^h \right)$$

subject to:

$$C_t^h + D_t + Q_t K_t^h + f(K_t^h) = W^h + \Pi_t + R_t D_{t-1} + (Z_t + Q_t) K_{t-1}^h$$

$\longrightarrow$

$$1 = E_t \left( \Lambda_{t,t+1} R_{t+1} \right)$$

$$1 = E_t \left[ \Lambda_{t,t+1} \frac{Z_{t+1} + Q_{t+1}}{Q_t + f'(K_t^h)} \right]$$

where

$$\Lambda_{t,t+1} = \beta \frac{C_t}{C_{t+1}}$$

Each banker pays dividend which equals net worth $n_t$ upon exit

$$V_t = E_t \left\{ \Lambda_{t,t+1} \left[ (1-\sigma) n_{t+i} + \sigma V_{t+1} \right] \right\}$$

Bank balance sheet

$$Q_t k_t^b = d_t + n_t$$

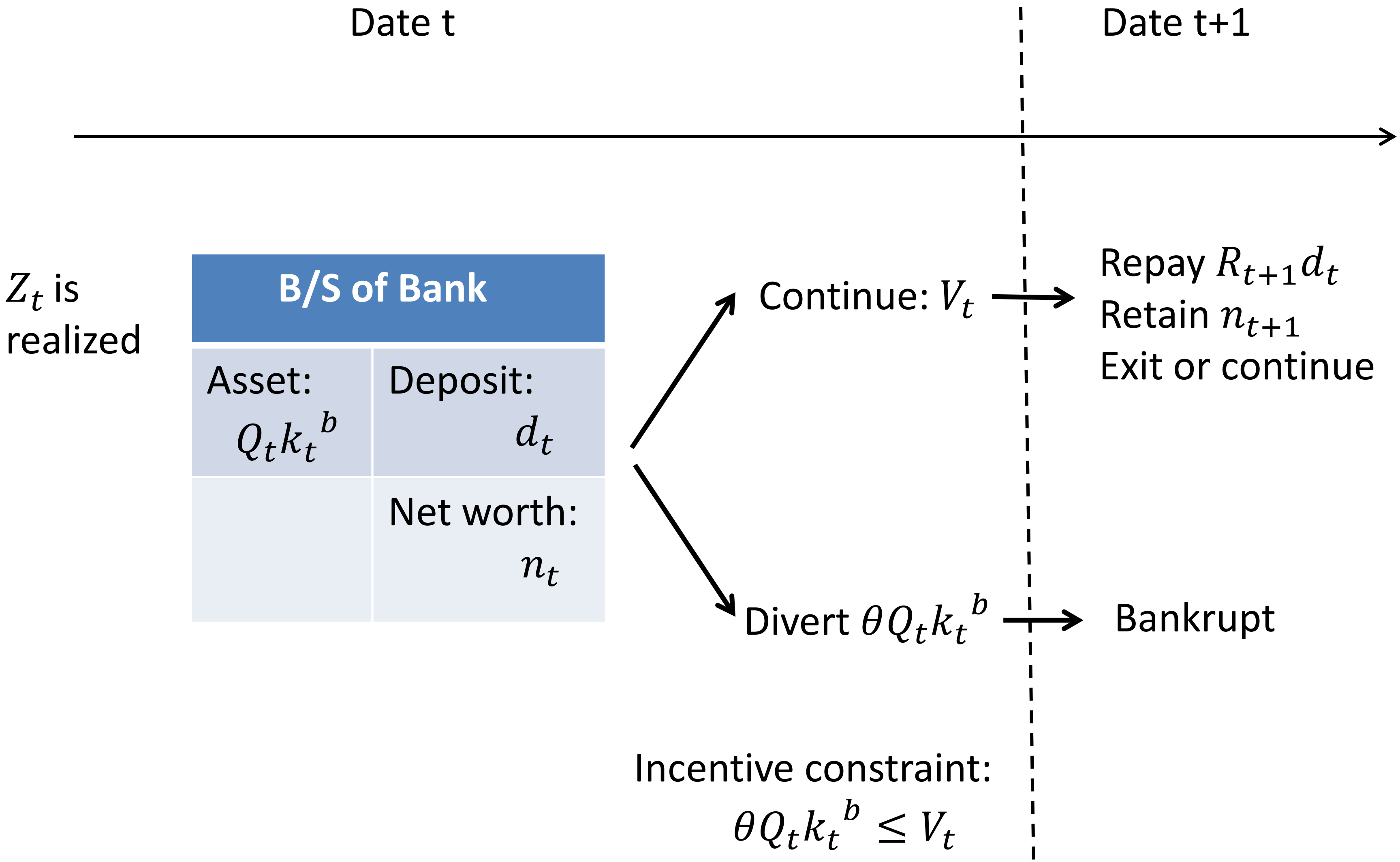
Net worth $n_t$ of surviving bankers

$$\begin{aligned} n_t &= (Z_t + Q_t) k_{t-1}^b - R_t d_{t-1} \\ &= R_t^b Q_{t-1} k_{t-1}^b - R_t d_{t-1} \end{aligned}$$

where

$$R_t^b = \frac{Z_t + Q_t}{Q_{t-1}} : \text{ bank asset return}$$

## Figure 1: Timing



Bank chooses "leverage multiple" $\phi_t = \frac{Q_t k_t^b}{n_t}$ to maximize

$$\frac{V_t}{n_t} = \psi_t = E_t \left[ \Lambda_{t,t+1} (1 - \sigma + \sigma \psi_{t+1}) \frac{n_{t+1}}{n_t} \right]$$

$$= E_t \left\{ \Lambda_{t,t+1} (1 - \sigma + \sigma \psi_{t+1}) \left[ \phi_t \left( R_{t+1}^b - R_{t+1} \right) + R_{t+1} \right] \right\}$$

subject to $\theta Q_t k_t^b \leq V_t$ and

$$\begin{aligned} 1 &= E_t \left\{ \Lambda_{t,t+1} \cdot Max \left[ \overline{R}_t, \frac{(Z_{t+1} + Q_{t+1}) k_t^b}{d_t} \right] \right\} \\ &= E_t \left\{ \Lambda_{t,t+1} \cdot Max \left[ \overline{R}_t, \; R_{t+1}^b \frac{\phi_t}{\phi_t - 1} \right] \right\} \end{aligned}$$

Endogenous leverage constraint

$$\phi_t \leq \frac{\psi_t}{\theta}$$

## Aggregate bank assets

$$Q_t K_t^b = \phi_t N_t$$

## Aggregate net worth

$$N_t = \sigma \left[ \left( Z_t + Q_t \right) K_{t-1}^b - R_t D_{t-1} \right] + (1 - \sigma) \iota w^b$$

## Goods market

$$C_t = Z_t \overline{K} + W^h - f(K_t^h) = Y_t$$

# Bank Runs: Self-fulfilling Rollover Crisis

At the beginning of period $t$, depositors decide whether to roll over their deposits or run

A bank run equilibrium exists if:

$$\left(Z_t + Q_t^*\right) K_{t-1}^b < \overline{R}_t D_{t-1}$$

Run occurs iff run equilibrium exists AND sunspot appears with probability $\varkappa$ to coordinate run

The time-t probability of run at t+1 is

$$p_t = \varkappa \cdot \mathsf{Pr}\left\{Z_{t+1} < Z_{t+1}^R\right\}$$

$Z_{t+1}^R$ is threshold value below which a run equilibrium exists

$$[Q_{t+1}^*(Z_{t+1}^R) + Z_{t+1}^R] K_t^b = \overline{R}_t D_t$$

## $Q_t^*$ : Liquidation Price

After a bank run at $t$, household holds all capital and will gradually decrease their holdings as new bankers enters and grow. Household condition for direct capital holding $\longrightarrow$

$$Q_t^* = E_t\left\{\sum_{i=1}^{\infty} \Lambda_{t,t+i}[Z_{t+i} - f'(K_{t+i}^h)]\right\} - f'(1)$$

where $f'(K_t^h)$ is the marginal management cost which as at a maximum at $K_t^h = 1$

FIGURE 3: A Recession in the Baseline Model; No Bank Run Case

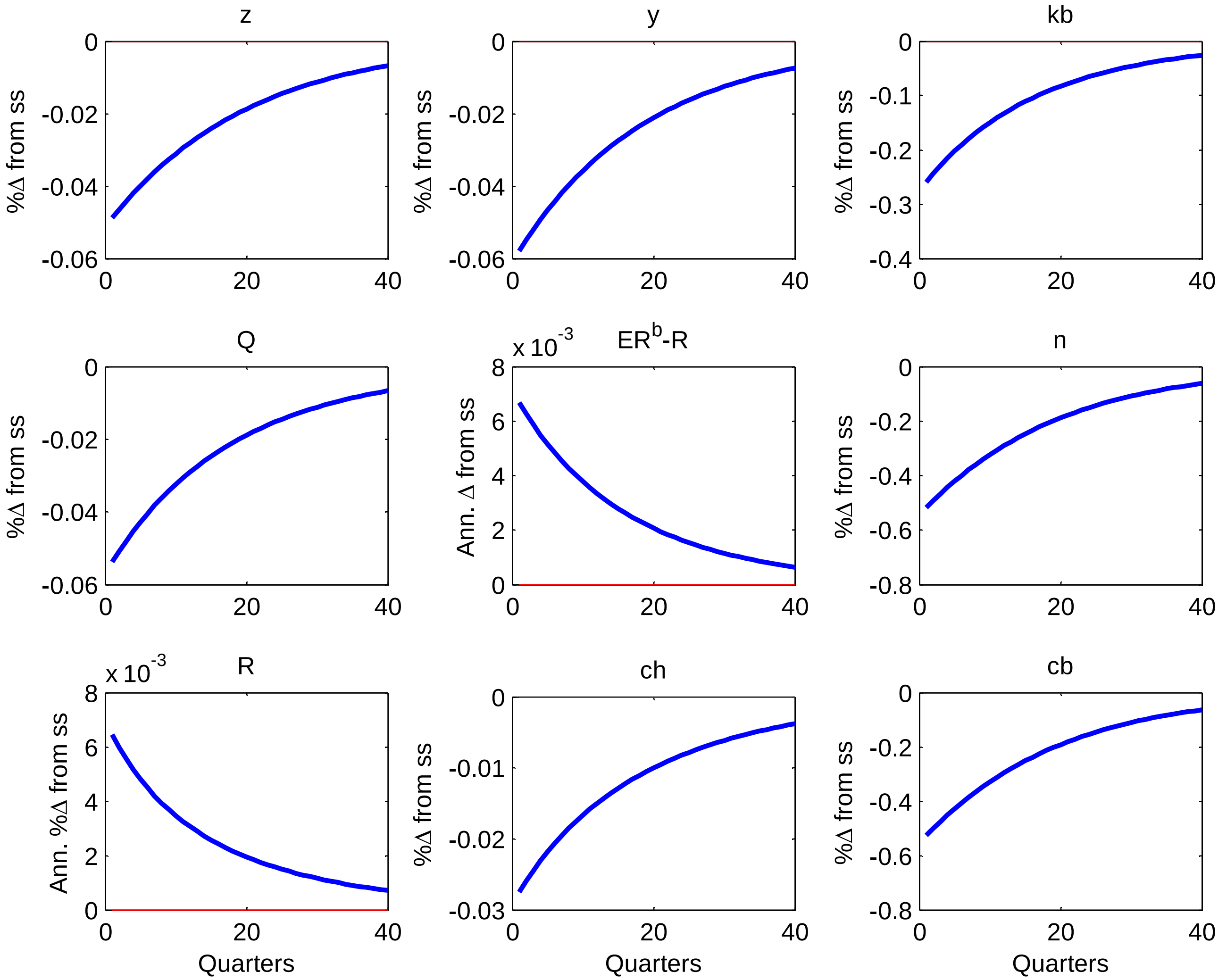
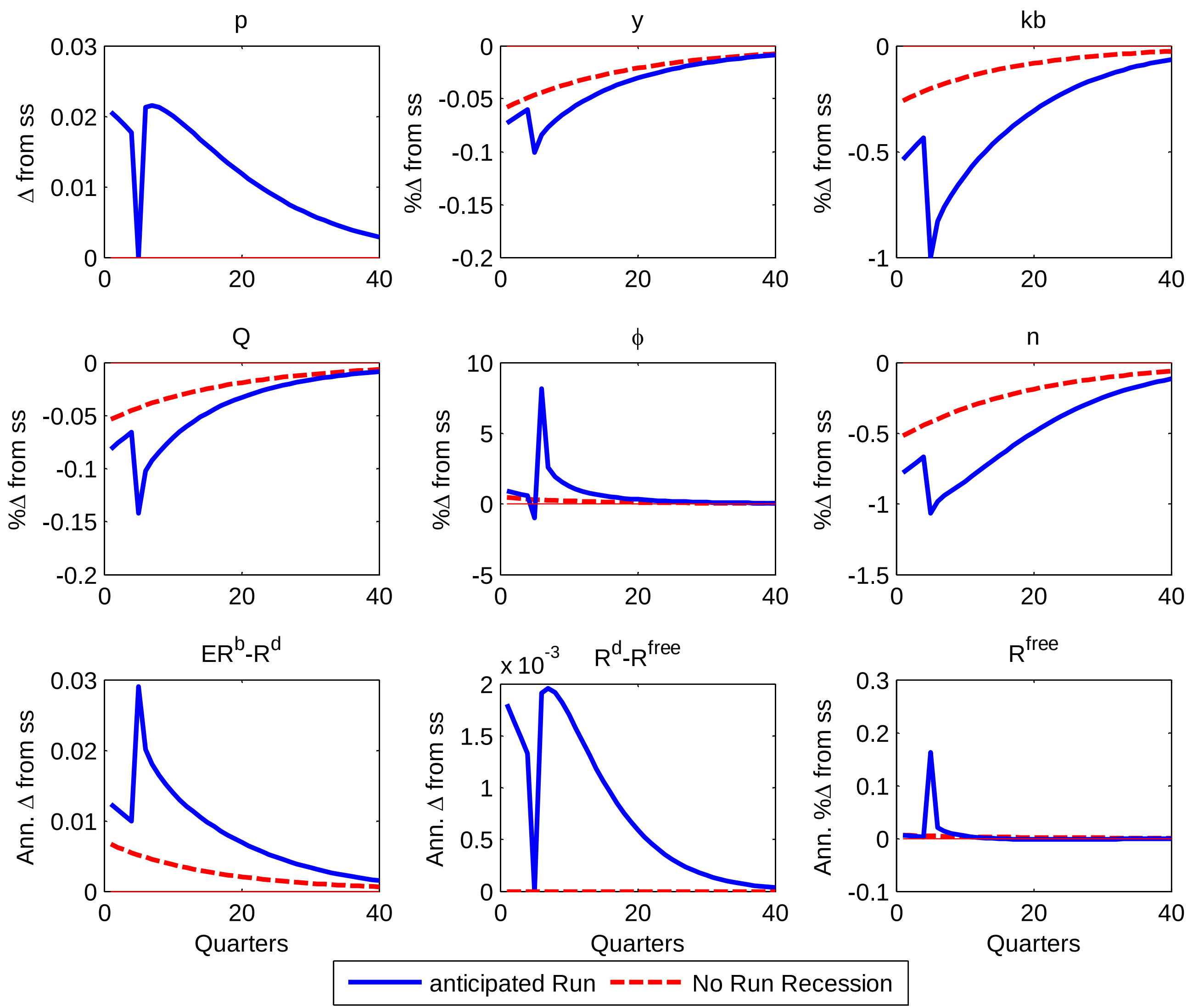
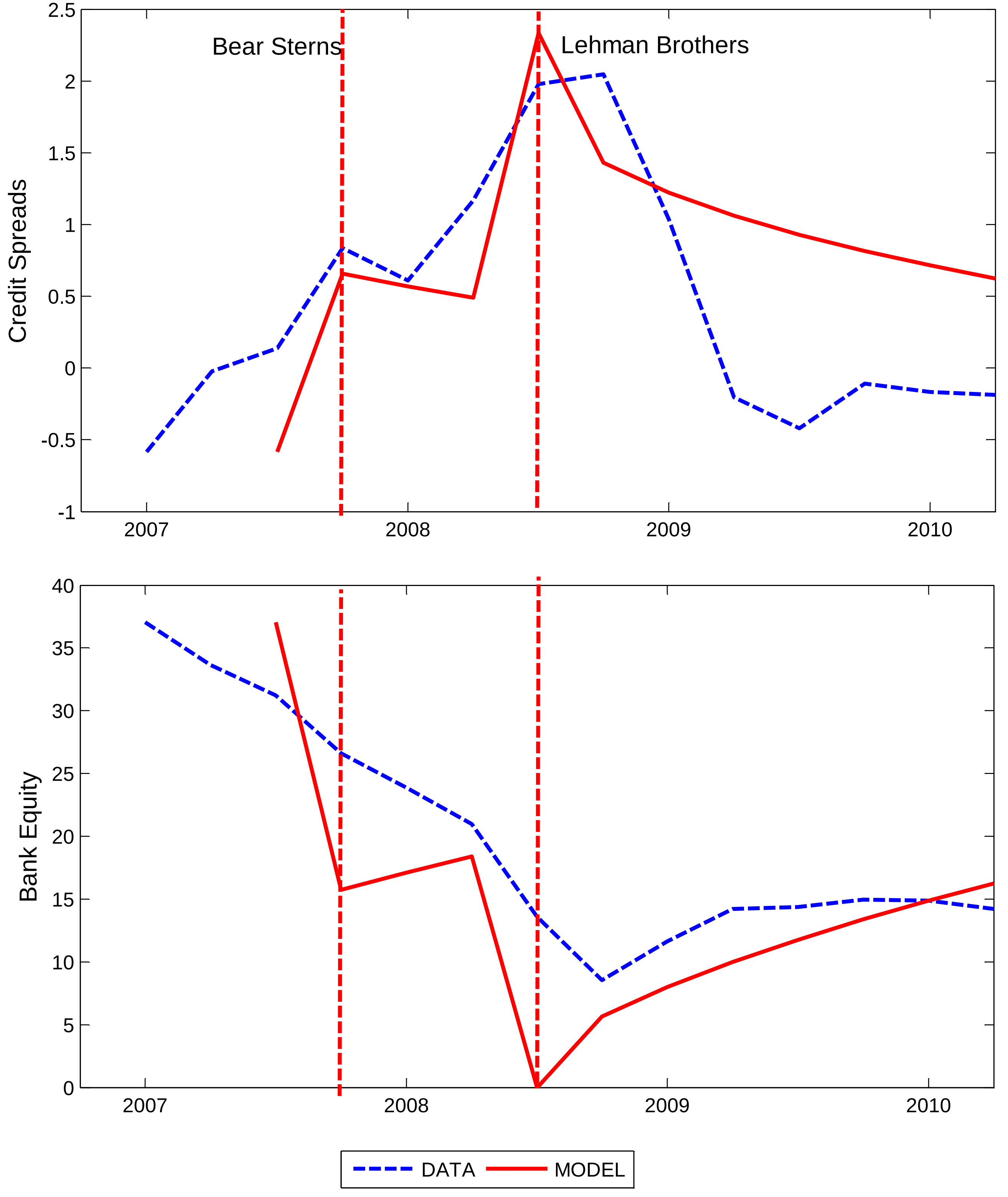


Figure 6: Recession with positive Run Probability and Ex-Post Run






Description: The data series for Credit spreads is the Excess Bond Premium as computed by Gilchrist and Zakrasjek (2012); Bank Equity is the S&P500 Financial Index. The model counterparts are the paths of $E(R^b-R^d)$ and V as depicted in Figure 6 normalized so that their steady-state values match the actual values in 2007 Q2.

## Some Remarks About Policy

Deposit insurance makes depositors careless $\longrightarrow$ Bank will divert the assets

Capital requirement reduces bank risk-taking and likelihood of bank run

Can increase intermediation cost if capital is costly to raise

Lender-of-last resort stabilizes liquidation price

May reduce the likelihood of run

But increases the leverage multiple ex ante and the financial accelerator

## Emerging Market and Global Financial Cycles

Emerging market economies tend to be vulnerable to global financial cycle

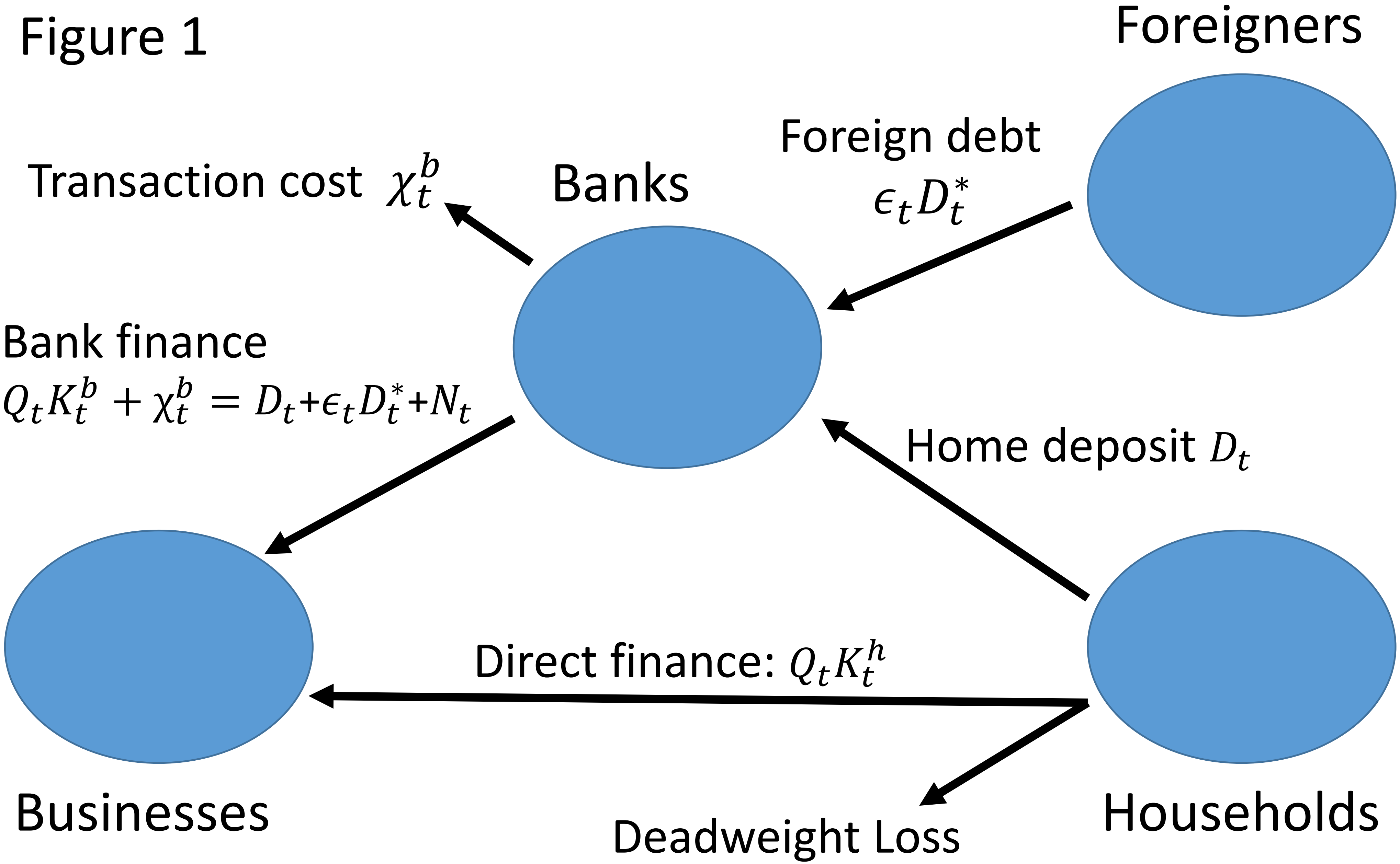
Why?

How to conduct monetary policy?

How to coordinate with macro-prudential policy?

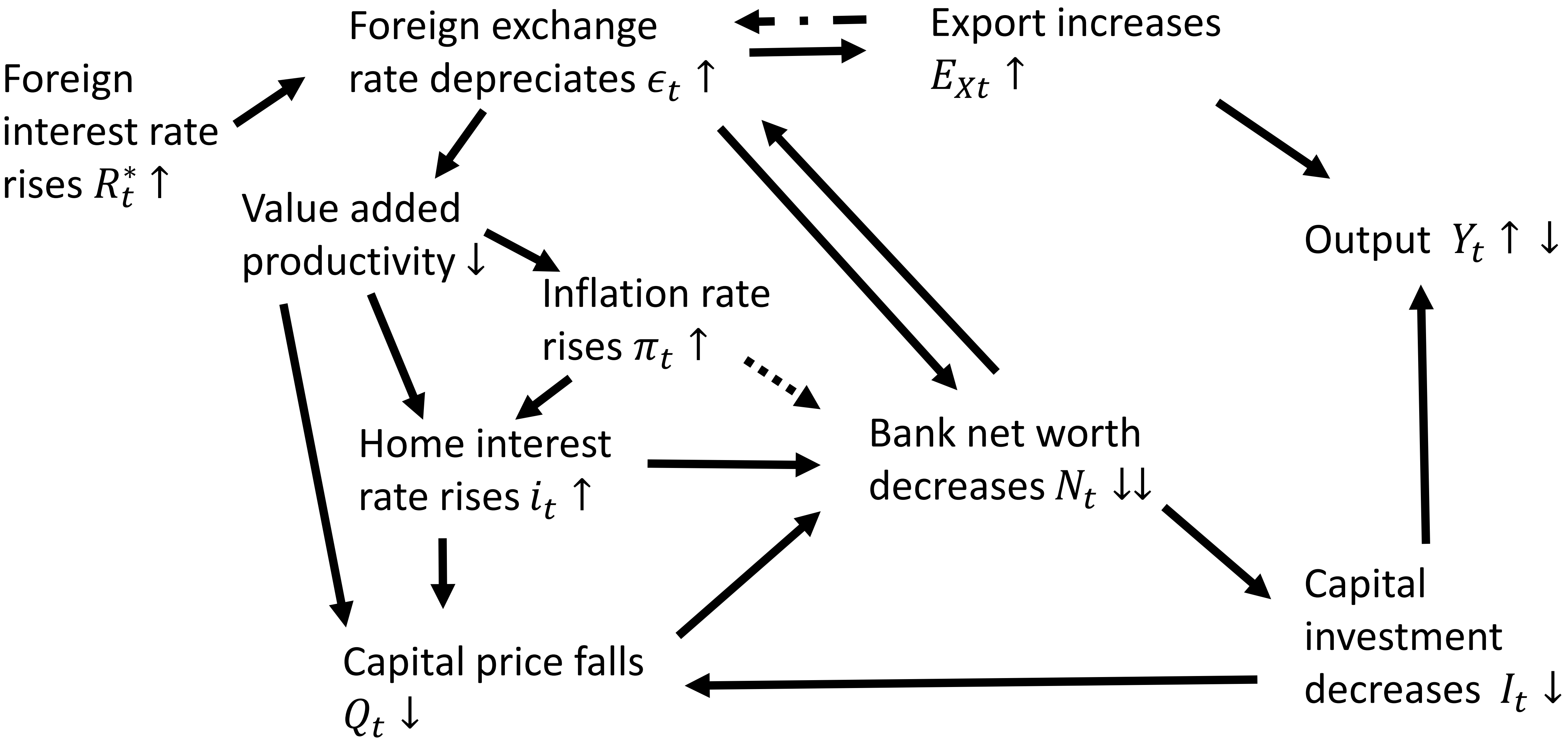
Approach: Open Economy New Keynesian + Banks

Figure 1



Foreigners
Foreign debt
$\epsilon_t D_t^*$
Transaction cost $\chi_t^b$
Banks
Bank finance
$Q_t K_t^b + \chi_t^b = D_t + \epsilon_t D_t^* + N_t$
Home deposit $D_t$
Direct finance: $Q_t K_t^h$
Businesses
Households
Deadweight Loss

# Transmission of external financial shocks



# Model

$$Y_t = \left(\int_0^1 y_{it}^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}} \text{ : Final goods}$$

$$y_{it} = A_t^y \left(\frac{k'_{it}}{\alpha_K}\right)^{\alpha_K} \left(\frac{l_{it}}{\alpha_L}\right)^{\alpha_L} \left(\frac{m_{it}}{\alpha_M}\right)^{\alpha_M} \left(\frac{x_{it}}{\alpha_X}\right)^{\alpha_X}$$

$$m_t^C = \frac{1}{A_t^y}(Z_t^y)^{\alpha_K} w_t^{\alpha_L} \epsilon_t^{\alpha_M} (p_t^x)^{\alpha_X}$$

$$\underset{p_{it},\, y_{it}}{Max}\ E_0 \left\{ \sum_{t=0}^{\infty} \Lambda_{0,t} \left[ \left(\frac{p_{it}}{P_t} - m_t^C\right) y_{it} - \frac{\kappa}{2} \left(\frac{p_{it}}{p_{it-1}} - 1\right)^2 Y_t \right] \right\}$$

$\longrightarrow$

$$\pi_t (\pi_t - 1) \ = \ \frac{\eta}{\kappa} \left(m_t^C - \frac{\eta\text{-}1}{\eta}\right) + E_t \left[\Lambda_{t,t+1} \frac{Y_{t+1}}{Y_t} \pi_{t+1} (\pi_{t+1}\text{-}1)\right]$$

where $\pi_t \ = \ \dfrac{P_t}{P_{t-1}}$

# Primary Commodity Sector

Perfect competition with fixed capital

$$y_t^x = A_t^x \left(\frac{k^x}{\alpha_K}\right)^{\alpha_K} \left(\frac{l_t}{\alpha_L}\right)^{\alpha_L} \left(\frac{m_t}{\alpha_M}\right)^{\alpha_M} \left(\frac{x_t}{\alpha_X}\right)^{\alpha_X}$$

$$p_t^x = P_t^{x*}\epsilon_t : \text{ real primary commodity price}$$

$\longrightarrow$

$$Y_t^x = A_t^x \left(\frac{K^x}{\alpha_K}\right)^{\alpha_K} \left(\frac{L_t^x}{\alpha_L}\right)^{\alpha_L} \left(\frac{M_t^x}{\alpha_M}\right)^{\alpha_M} \left(\frac{X_t^x}{\alpha_X}\right)^{\alpha_X}$$

$$p_t^x = \frac{1}{A_t}(Z_t^x)^{\alpha_K} {w_t}^{\alpha_L} {\epsilon_t}^{\alpha_M} (p_t^x)^{\alpha_X}$$

## Capital Accumulation in Final Goods Sector

$$K_t = \lambda K_{t-1} + \left[1 - \Phi\left(\frac{I_t}{I_{t-1}}\right)\right] I_t$$

$$\text{where } \Phi\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I} - 1\right)^2$$

## Export

$$E_{Xt} = \left(\frac{P_t}{e_t P_t^*}\right)^{-\varphi} Y_t^* = {\epsilon_t}^{\varphi} Y_t^*, \text{ where } \epsilon_t = \frac{e_t P_t^*}{P_t}$$

$$P_t^* = P^* = 1$$

# Household

Each household consists of a continuum of workers and bankers

Each banker manages a bank until retires with probability $1-\sigma$, and then brings back the net worth as dividend

Equal number of workers become new bankers with start-up funds given by the household

Household saves in home currency deposit and capital ownership. To own capital, household needs management cost $\frac{\varkappa^h}{2K_t}(K_t^h)^2$

Household members consume together

## Household's choice

$$E_t\left[\sum_{t=0}^{\infty}\beta^t \ln\left(C_t - \frac{\zeta_0}{1+\zeta}{L_t}^{1+\zeta}\right)\right],$$

$$C_t + Q_t K_t^h + \frac{\varkappa^h}{2}\frac{\left(K_t^h\right)^2}{K_t} + D_t$$

$$= w_t L_t + \Pi_t + (Z_t + \lambda Q_t)K_{t-1}^h + R_t D_{t-1}$$

$\longrightarrow$

$$w_t = \zeta_0 {L_t}^{\zeta}$$

$$1 = E_t\left(\Lambda_{t,t+1}R_{t+1}\right),\ \text{where } R_{t+1} = \frac{1+i_t}{\pi_{t+1}}$$

$$1 = E_t\left(\Lambda_{t,t+1}\frac{Z_{t+1}+\lambda Q_{t+1}}{Q_t + \varkappa^h \frac{K_t^h}{K_t}}\right)$$

Bank's Flow-of-funds

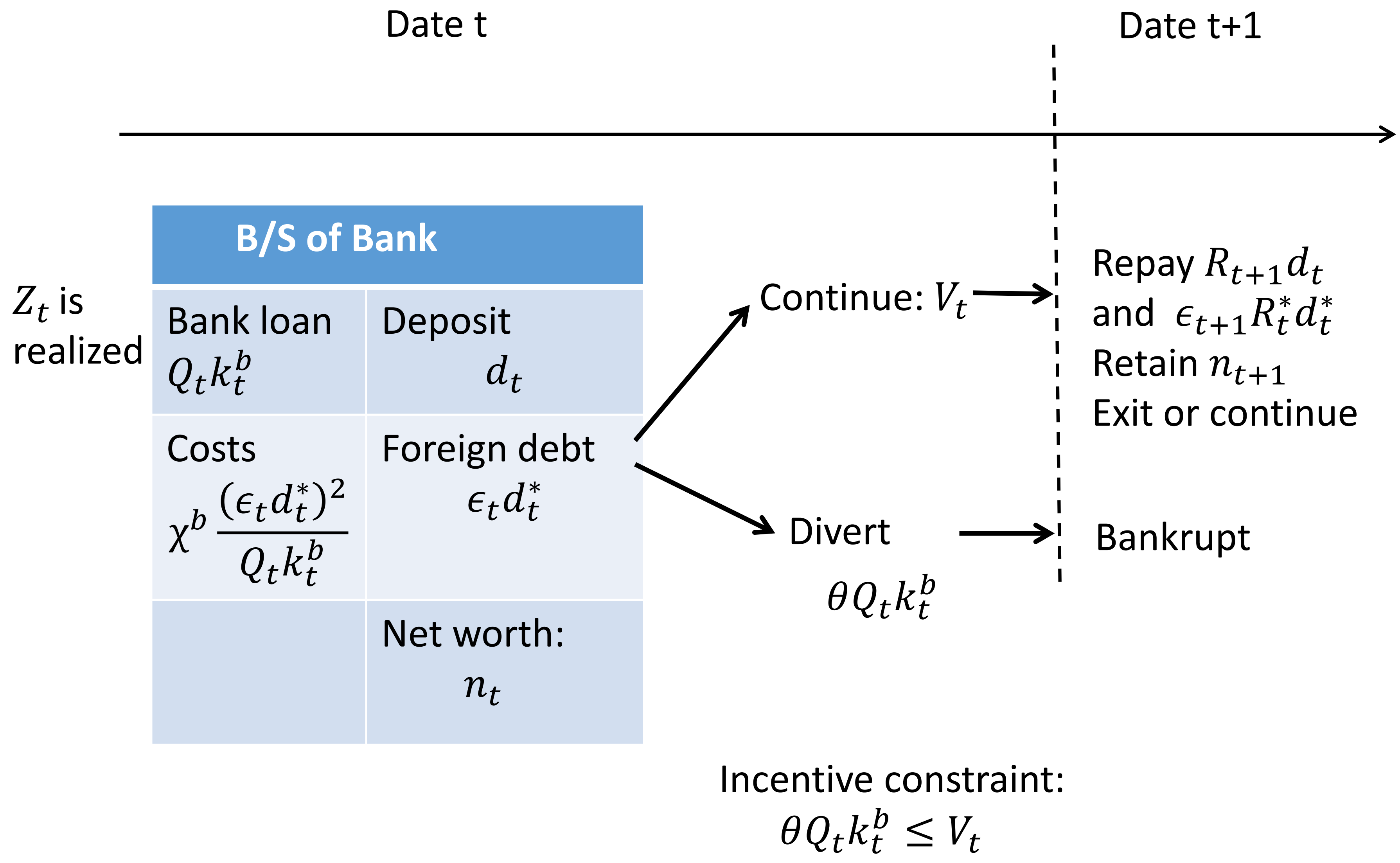
$$Q_t k_t^b + \frac{\varkappa^b}{2}\frac{(\epsilon_t d_t^*)^2}{Q_t k_t^b} = n_t + d_t + \epsilon_t d_t^*$$

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

Bank franchise value

$$V_t = E_t\{\Lambda_{t,t+1}[(1-\sigma) n_{t+j} + \sigma V_{t+1}]\}$$

# Figure 2: Timing



The bank chooses the leverage multiple $\phi_t = \frac{Q_t k_t^b}{n_t}$ and the share of foreign borrowing $\gamma_t = \frac{\epsilon_t d_t^*}{Q_t k_t^b}$ to maximize Tobin's Q

$$\frac{V_t}{n_t} = \psi_t = E_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\frac{n_{t+1}}{n_t}\right], \; st. \; \psi_t \geq \theta\phi_t$$

$\longrightarrow$

$$\phi_t = \phi\left(\underset{+}{\frac{\mu_t}{\nu_t}}, \underset{+}{\frac{\mu_t^*}{\nu_t}}\right), \; \gamma_t = \Gamma\left(\underset{+}{\frac{\mu_t^*}{\nu_t}}\right)$$

$$\begin{aligned}
\mu_t &= E_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\left(\frac{Z_{t+1}+\lambda Q_{t+1}}{Q_t} - R_{t+1}\right)\right] \\
\mu_t^* &= E_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\left(R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t}R_t^*\right)\right] \\
\nu_t &= E_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})R_{t+1}\right]
\end{aligned}$$

Bank balance sheet

$$Q_t K_t^b \left(1 + \frac{\varkappa^b}{2}\gamma_t^2\right) = \phi_t N_t \left(1 + \frac{\varkappa^b}{2}\gamma_t^2\right) = N_t + D_t + \epsilon_t D_t^*$$

$$N_t = (\sigma + \xi)(Z_t + \lambda Q_t) K_{t-1}^b - \sigma R_t D_{t-1} - \sigma \epsilon_t R_{t-1}^* D_{t-1}^*$$

Capital market

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

Bank intermediated foreign debt

$$\epsilon_t D_t^* = \gamma_t \phi_t N_t$$

$B_t^*$: Net foreign debt, $F_t$: Foreign reserve

$$D_t^* = B_t^* + F_t$$

Current account

$$\frac{1}{\epsilon_t} E_{Xt} + P_t^{x*}(Y_t^x - X_t^x - X_t^y) + B_t^* = M_t^x + M_t^y + R_{t-1}^* B_{t-1}^*$$

Final goods market equilibrium

$$Y_t = C_t + I_t + G + E_{Xt}$$

$$+\frac{\kappa}{2}(\pi_t - 1)^2 Y_t + \frac{\varkappa^h}{2}\frac{\left(K_t^h\right)^2}{K_t} + \frac{\varkappa^b}{2}\gamma_t^2 Q_t K_t^b$$

Net output

$$\begin{aligned} Y_t^n \;=\; & Y_t - \epsilon_t(M_t^x + M_t^y) + p_t^x\left(Y_t^x - X_t^x - X_t^y\right) \\ & -\frac{\kappa}{2}(\pi_t - 1)^2 Y_t - \frac{\varkappa^h}{2}\frac{\left(K_t^h\right)^2}{K_t} - \frac{\varkappa^b}{2}\gamma_t^2 Q_t K_t^b \end{aligned}$$

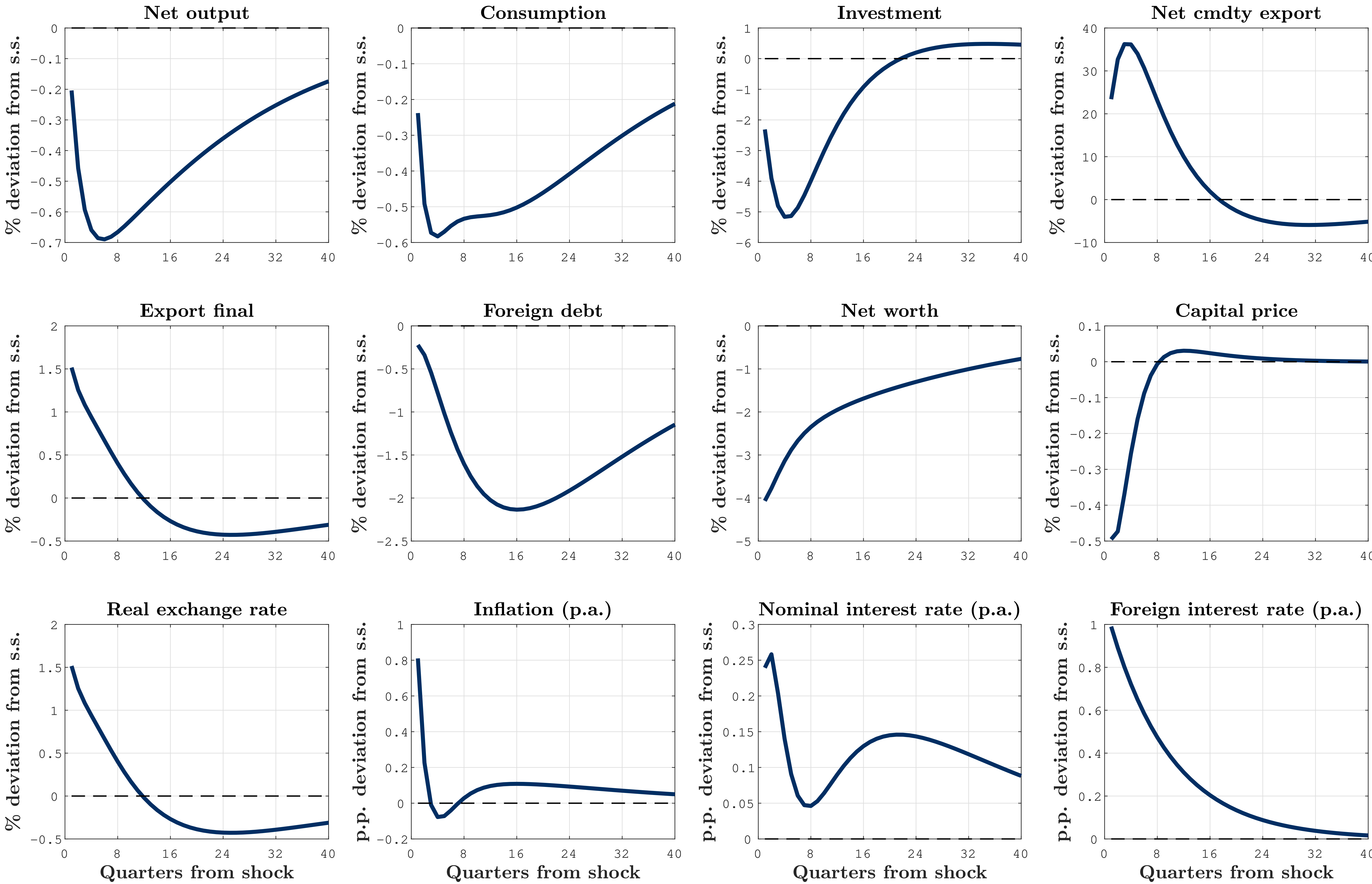
Monetary policy rule

$$i_t - i = (1 - \rho_i)\omega_\pi(\pi_t - 1) + \rho_i(i_{t-1} - i) + \xi_t^i$$

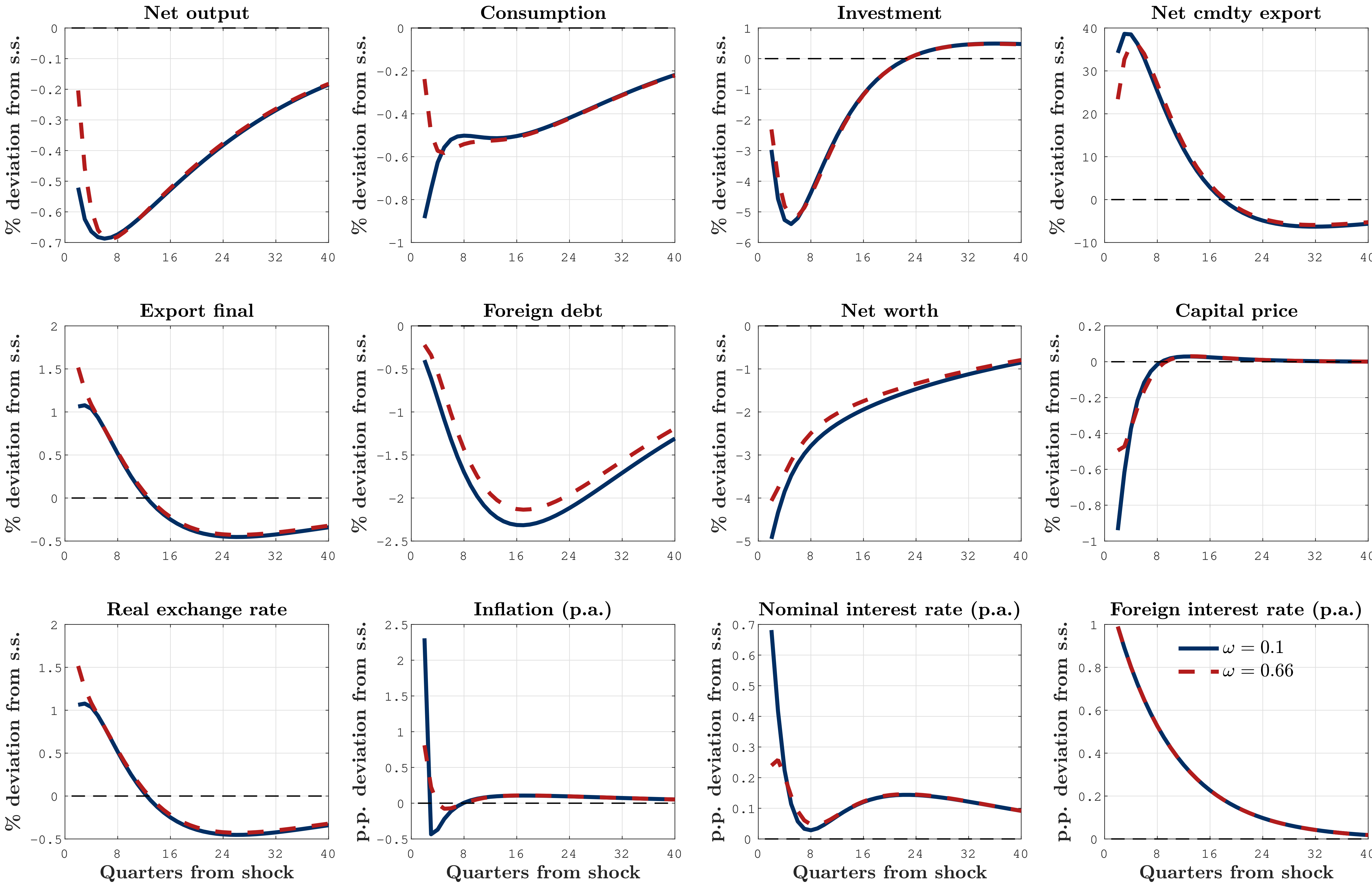
| Baseline Parameters | | |
|---|---|---|
| $\theta$ | divertable proportion of asset | 0.359 |
| $\sigma$ | survival probability | 0.94 |
| $\xi$ | fraction of assets brought by new banks | 0.00174 |
| $\varkappa^b$ | managem't cost parameter of foreign borrowing | 0.0197 |
| $\beta$ | discount rate | 0.985 |
| $\zeta$ | inverse of Frisch elasticity of labor supply | 0.333 |
| $\varkappa^h$ | management cost parameter of direct finance | 0.0197 |
| $\alpha_K$ | cost share of capital | 0.395 |
| $\alpha_L$ | cost share of labor | 0.245 |
| $\alpha_M$ | cost share of imported intermediate goods | 0.182 |
| $\kappa_I$ | adjustment cost of investment | 0.67 |
| $\omega$ | fraction of non-adjusters $\kappa = \frac{(\eta-1)\omega}{(1-\omega)(1-\beta\omega)}$ | 0.66 |
| $\varphi$ | price elasticity of export demand | 1 |

| Table 2: Baseline Steady State (Annual) | | |
|---|---|---|
| $R^*$ | foreign interest rate | 1.04 |
| $R$ | deposit interest rate | 1.06 |
| $R^b$ | rate of return on capital for bank | 1.08 |
| $\phi$ | bank leverage multiple | 6 |
| $\gamma$ | foreign debt-to-bank asset ratio | 0.25 |
| $K^b/K$ | share of capital financed by banks | 0.75 |
| $K^x/K$ | share of commodity sector capital | 0.16 |

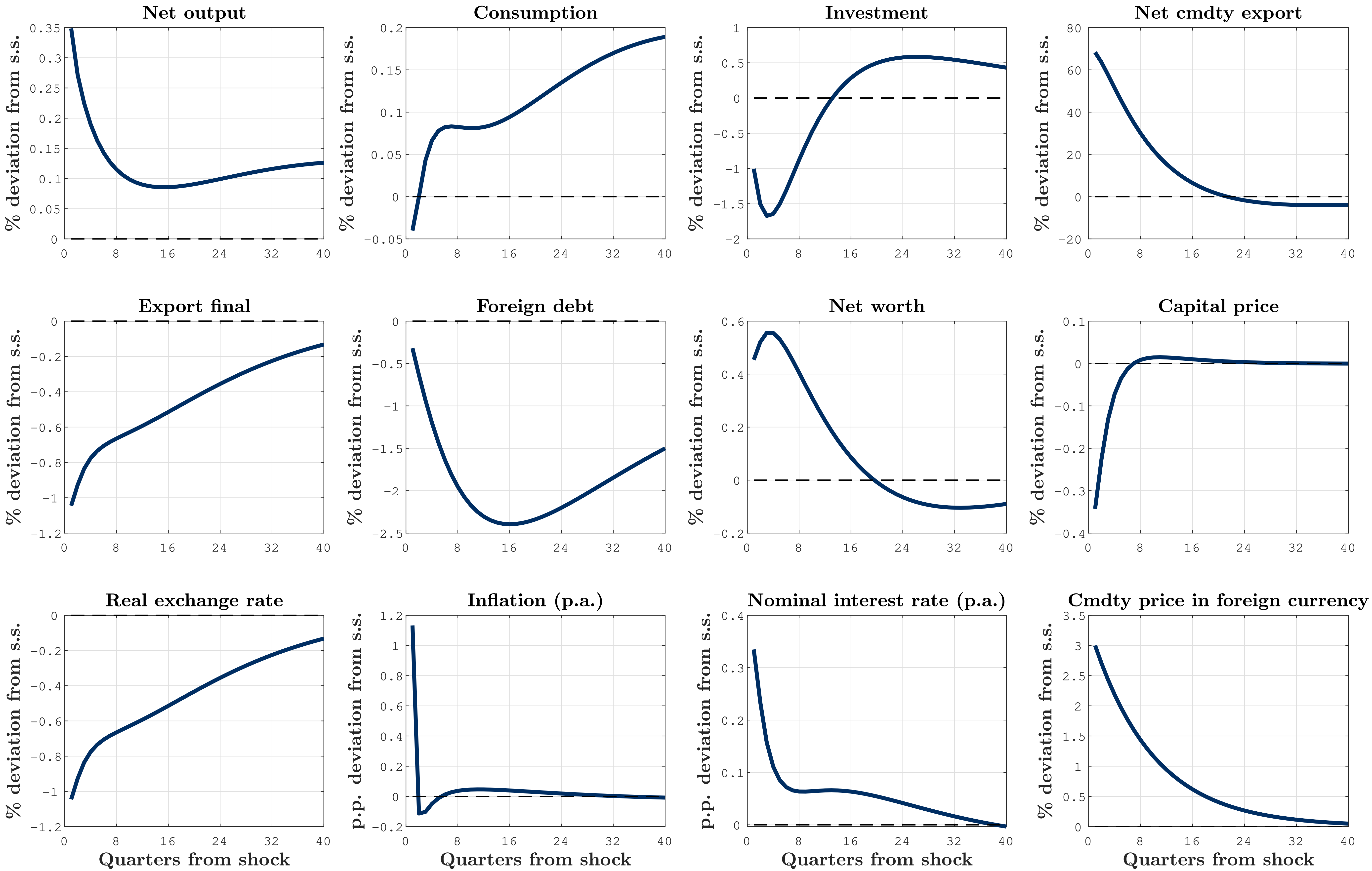
| Shock process (Quarterly) | | |
|---|---|---|
| $\rho_{R^*}, \rho_{P^{x*}}$ | serial correlation of shocks | 0.9 |
| $\sigma_{R^*}$ | stand div of foreign interest shock | 0.0025 |
| $\sigma_{P^{x*}}$ | stand div of commodity price shock | 0.03 |



Net output
Consumption
Investment
Net cmdty export
Export final
Foreign debt
Net worth
Capital price
Real exchange rate
Inflation (p.a.)
Nominal interest rate (p.a.)
Foreign interest rate (p.a.)
% deviation from s.s.
p.p. deviation from s.s.
Quarters from shock



Net output
Consumption
Investment
Net cmdty export
Export final
Foreign debt
Net worth
Capital price
Real exchange rate
Inflation (p.a.)
Nominal interest rate (p.a.)
Foreign interest rate (p.a.)
% deviation from s.s.
p.p. deviation from s.s.
Quarters from shock
$\omega = 0.1$
$\omega = 0.66$

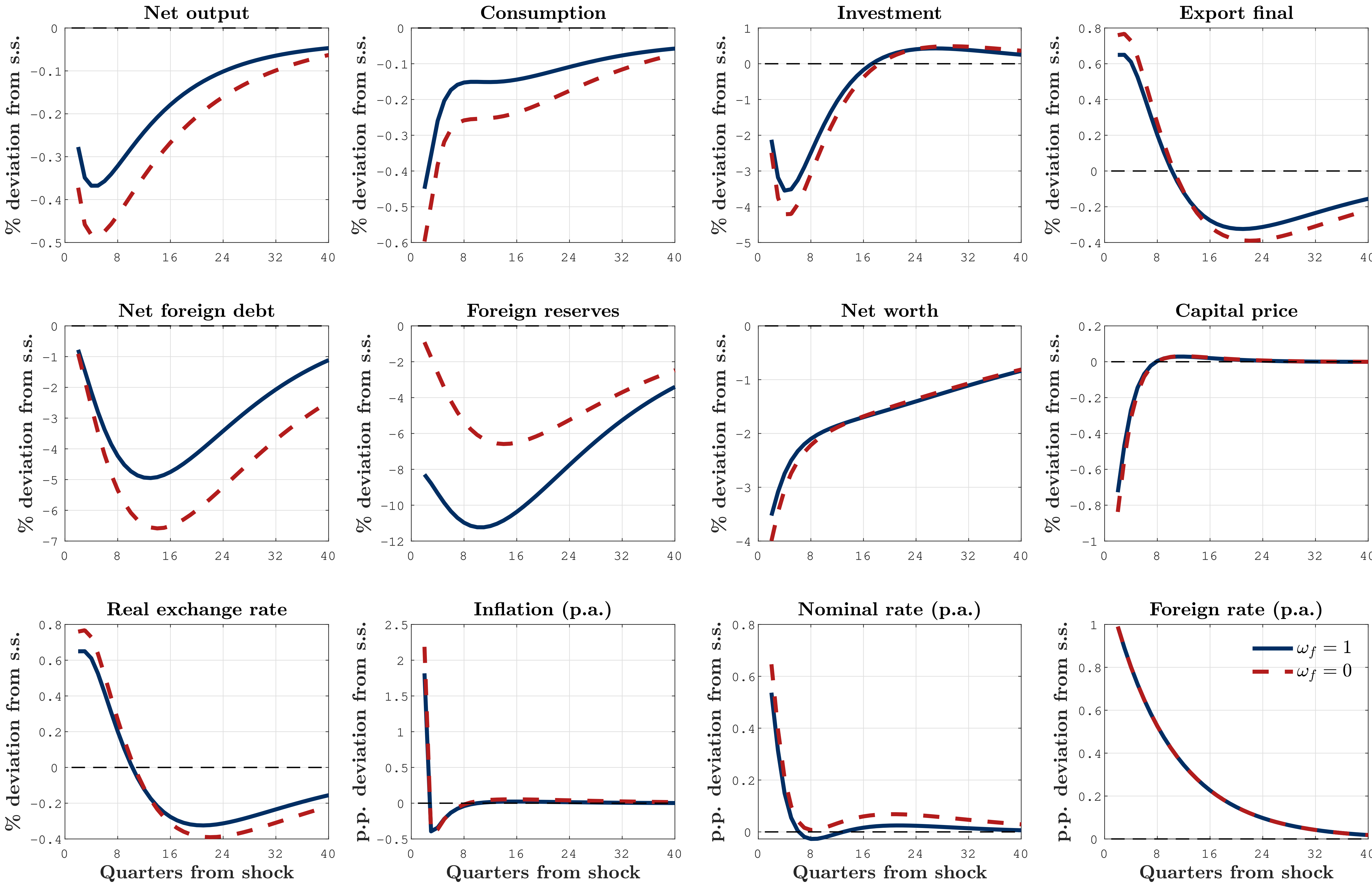

Net output
Consumption
Investment
Net cmdty export
Export final
Foreign debt
Net worth
Capital price
Real exchange rate
Inflation (p.a.)
Nominal interest rate (p.a.)
Cmdty price in foreign currency
% deviation from s.s.
p.p. deviation from s.s.
Quarters from shock

# Foreign exchange intervention

$$\frac{F_t}{D_t^*} = \omega_0 + \omega_f \left( \ln K_t^b - \ln K^b \right)$$

$$T_t = G + \epsilon_t \left( F_t - R_{t-1}^* F_{t-1} \right)$$

| Welfare Effects: consumption equivalent % | | | |
|---|---|---|---|
| $\omega_\pi \diagdown \omega_f$ | 0 | 0.5 | 1 |
| 1.25 | 0.006 | 0.045 | 0.139 |
| 1.5 | 0.000 | 0.041 | 0.139 |
| 2.0 | −0.010 | 0.032 | 0.138 |


Net output
Consumption
Investment
Export final
Net foreign debt
Foreign reserves
Net worth
Capital price
Real exchange rate
Inflation (p.a.)
Nominal rate (p.a.)
Foreign rate (p.a.)
% deviation from s.s.
p.p. deviation from s.s.
Quarters from shock
$\omega_f = 1$
$\omega_f = 0$

Macro-prudential policy:

Tax on foreign currency borrowing $\tau_t^{D*}$

Subsidy on net worth $\tau_t^N$ to balance the budget

$$\tau_t^N N_t = \tau_t^{D*} \epsilon_t D_t^*$$

Cyclical macro-prudential policy

$$\tau_t^{D*} = \omega_{\tau^{D*}} \left( \ln K_{t-1}^b - \ln K^b \right)$$

| Welfare Effects: consumption equivalent % | | | |
|---|---|---|---|
| $\omega_\pi \setminus \omega_{\tau^{D*}}$ | 0 | 0.01 | 0.02 |
| 1.25 | $-0.019$ | $-0.011$ | $-0.027$ |
| 1.5 | 0.000 | 0.013 | 0.000 |
| 2.0 | 0.008 | 0.025 | 0.015 |

## Remark on Policy

Foreign exchange intervention significantly improves welfare

Procyclical tax on bank foreign borrowing marginally improves welfare with inflation targeting

They allow monetary authority to pursue macroeconomic stability

Topics for future research: home-currency denominated debt, currency hedging, gross financial flows, and foreign direct investment