INSTITUTE FOR CAPACITY DEVELOPMENT

L-5: The New Keynesian Model in the Open Economy

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Daniel Baksa

Course on Monetary and Fiscal Policy Analysis with DSGE Models (OT26.08)

Outline

1. Introduction (to be adjusted)
2. New Keynesian Model for a Small Open Economy
   - Main ingredients
   - Log-linear version
   - A short detour: More on the UIP condition and exchange rate determination
   - Another short detour: Incomplete vs Complete Markets for foreign debt/bonds
3. Analyzing Transmission mechanisms
4. Discussion of Alternative Monetary Policies
5. Pricing assumption: PCP vs LCP
6. Conclusions

1. Introduction

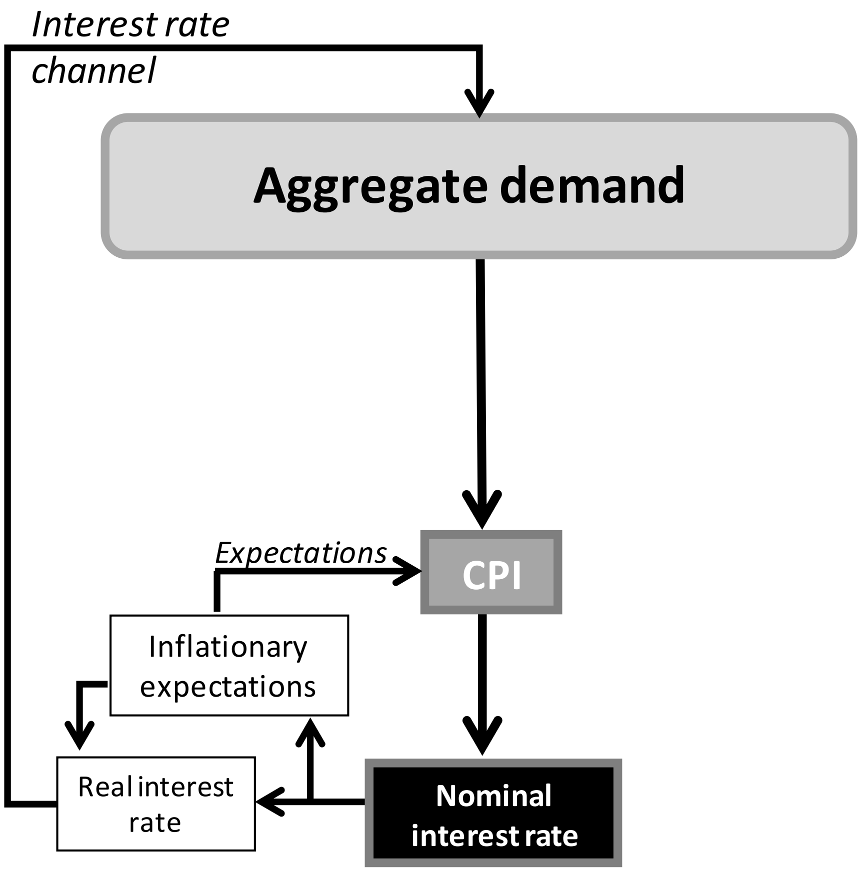
Opening the economy: general considerations

- Open = trade, capital flows vis-à-vis rest of the world
- Why care? Encompassing large part of the economy
  - Most economies trade extensively (average trade openness in 2016 in the world - 56% of GDP)
  - Current account is rarely zero – backed by financial flows
- Why care? Many additional policy-relevant questions
  - How do external shocks propagate within the economy?
  - Any change with regard to domestic shocks compared to autarky?
  - Optimal monetary policy in open economies? Role for exchange rate?

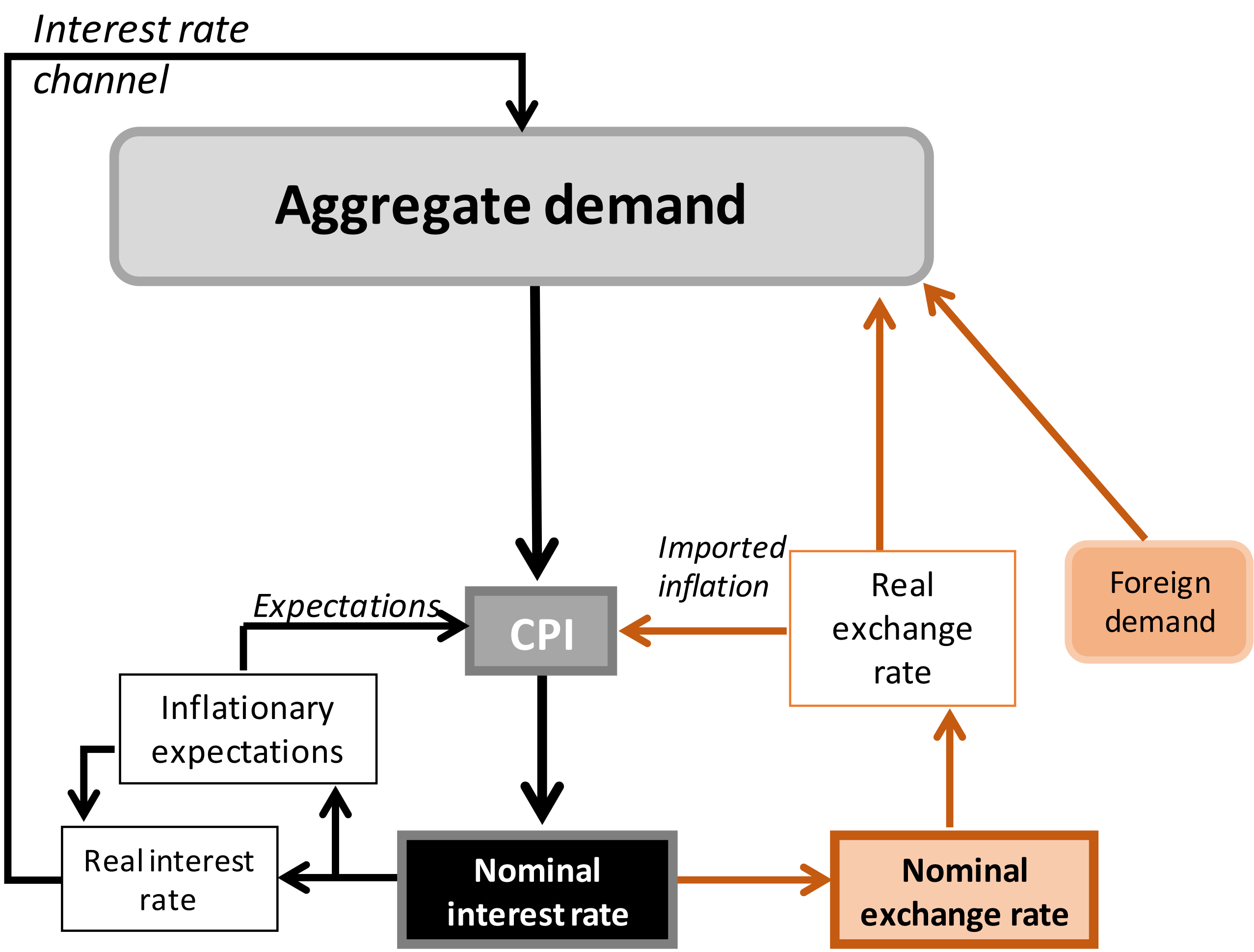
Opening the economy: general considerations

- Modeling considerations:
  - "Small" vs. "large"?
  - Law of one price or pricing to the market?
  - Complete vs. incomplete markets?
  - Non-traded goods allowed? Trade costs?

Closed economy models

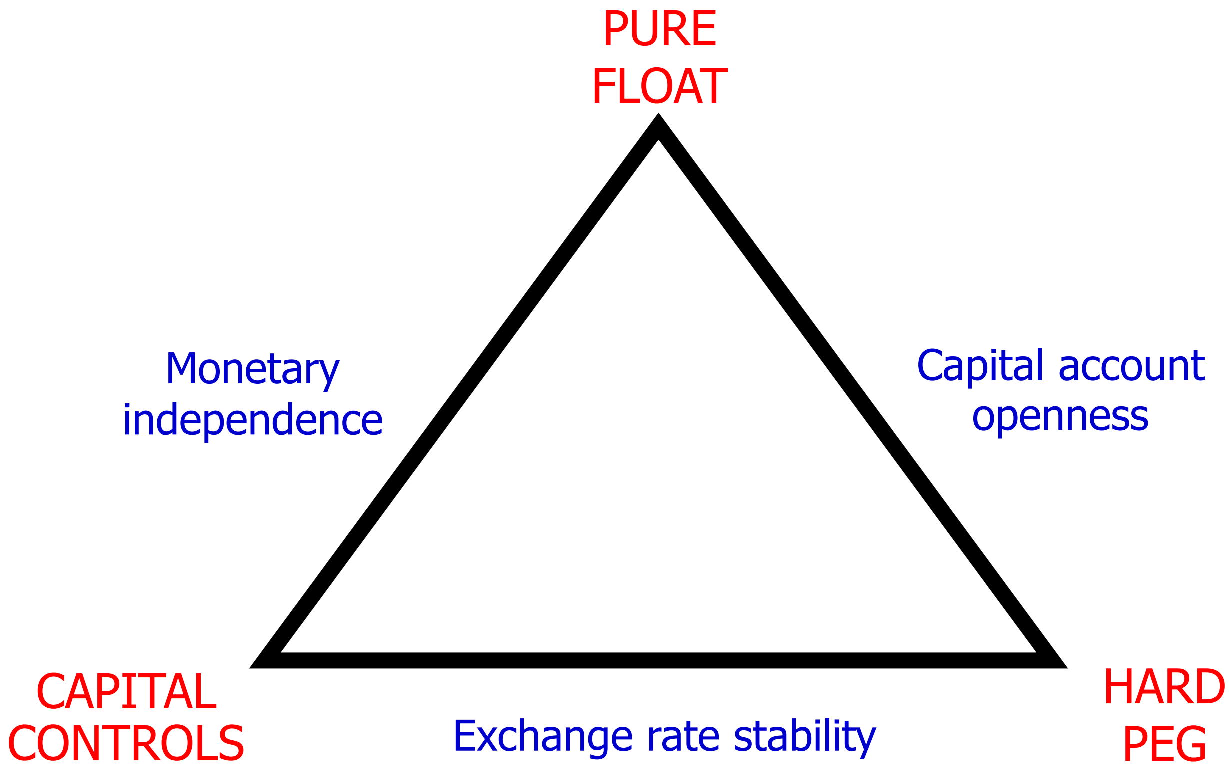


Open economy models



Question: Under what circumstances can a small open economy conduct independent monetary policy?

Policy trilemma or "impossible trinity":



A: If capital flows freely and the exchange rate is flexible.

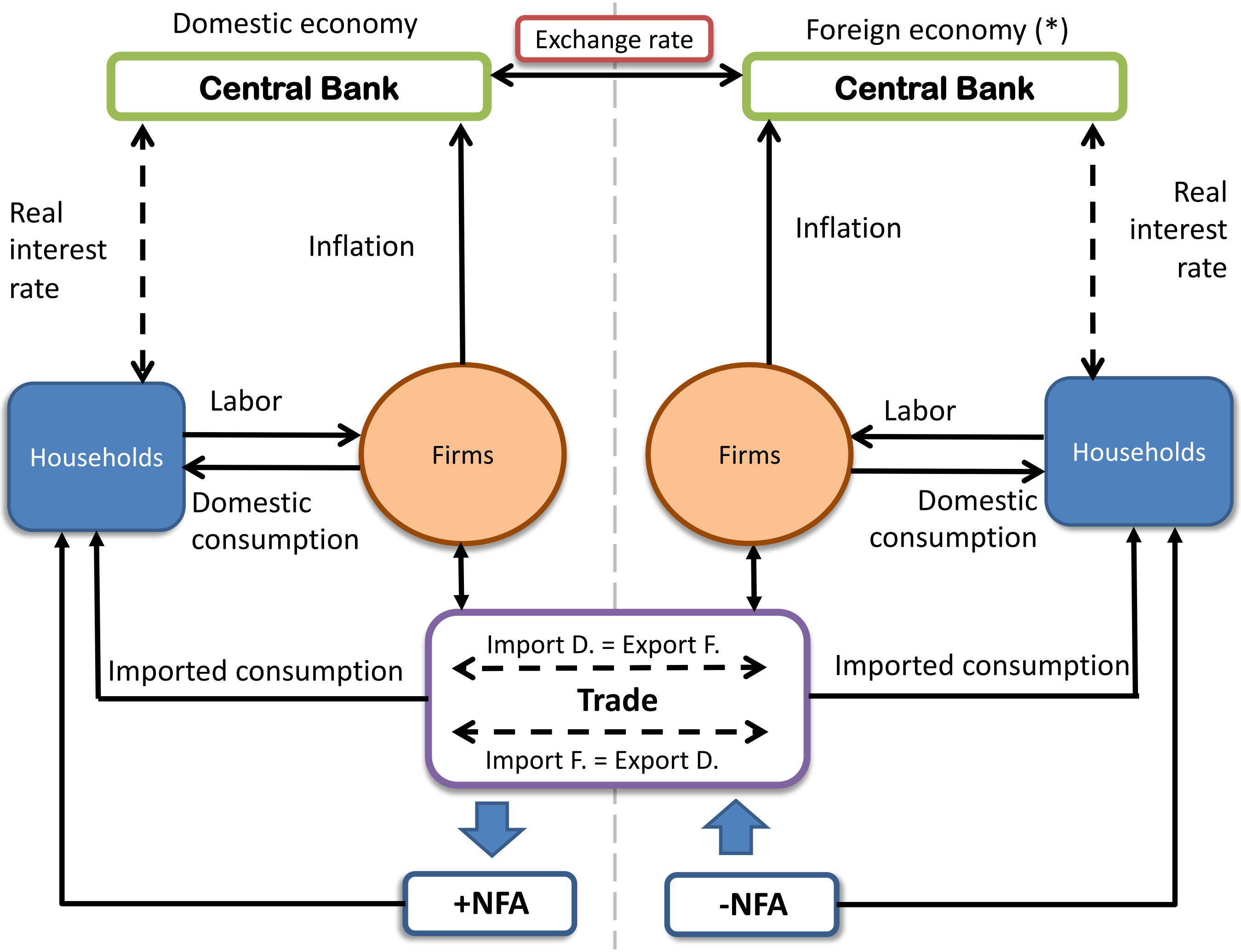
2. New Keynesian Model for a Small Open Economy

NK small open economy model

The main reference is Galí and Monacelli (2005). Key elements:

- Small open economy (does not affect international prices and interest rates).
- Two bundles of goods: domestic and imported.
- Nominal rigidities: price setting of domestic goods as in Calvo (1983).
- Households: decisions on labor supply and consumption.
- Production: two sectors, retailers and intermediate goods producers. Labor is the only input in production.
- Monetary policy: defined through an interest rate rule.
- Perfect pass-through from exchange rate fluctuations to local import prices: law of one price holds.
- Key difference: We will deviate from Gali and Monacelli (2005) assuming an incomplete market for international financial integration.

Theoretical structure



Households (similar to basic NK model)

Households

- Utility function of representative household:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \exp(g_t) \left[\frac{(C_t)^{1-1/\sigma} - 1}{1-1/\sigma} - \zeta_L \frac{(L_t)^{1+\sigma_L}}{1+\sigma_L} \right] \right\} \quad (1)$$

where C_t: aggregate consumption (bundle); L_t: employment; σ: intertemporal elasticity of substitution of consumption; σ_L: inverse of the Frisch elasticity of labor supply; g_t: domestic demand shock; $\zeta_{L\ \mathrm{L}}$: weight of labor supply in utility

- Aggregate consumption (C_t) combines domestic ($C_{H,t}$ with price $P_{H,t}$) and foreign/imported ($C_{F,t}$ with price $P_{F,t}$) goods:

$$C_t = \left[(1-\alpha_c)^{1/\eta_c} \left(C_{H,t}\right)^{1-1/\eta_c} + (\alpha_c)^{1/\eta_c} \left(C_{F,t}\right)^{1-1/\eta_c} \right]^{\frac{\eta_c}{\eta_c - 1}} \quad (2)$$

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Households (similar to basic NK model)

In the last expression, α_c determines the share of imports in total consumption, whereas η_c is the substitution elasticity between domestic and foreign goods in the aggregate consumption basket.

Households budget constraint in period t:

$$P_t C_t + B_t - e_t B_t^* = W_t L_t + R_{t-1} B_{t-1} - \psi_{t-1} R_{t-1}^* e_t B_{t-1}^* \qquad (3)$$

where P_t is the price level of the aggregate consumption, W_t is the wage rate B_t are the non-contingent domestic bonds, B_t^* is the foreign non-contingent foreign debt, e_t is the nominal exchange rate (domestic currency per unit of foreign currency), R_{t-1} is the nominal interest rate of domestic bonds, R_{t-1}^* is the nominal interest of the foreign debt; and ψ_{t-1} is a country risk premium, that in equilibrium depends on foreign debt. This last friction has the role of introducing a wedge in the arbitrage condition between domestic and foreign bonds as discussed previously.

Households

- Taking prices as given (P_t, W_t, $P_{H,t}$, $P_{F,t}$, R_t, e_t,R_t^*), households maximize (1) choosing C_t, L_t, $C_{H,t}$, $C_{F,t}$, B_t, B_t^* subject to (2) and (3)

Households' problem is twofold:

i. (dynamic: inter-temporal) decide on optimal time-path for consumption/bond holdings;

ii. (static: intra-temporal) decide on optimal allocation of consumption goods (domestic and foreign varieties); decide on optimal allocation of consumption & labor.

Households

Households (static problem): allocation of consumption goods

- Optimal consumption is thus a mix of home and foreign goods (from cost min.):

$$C_{H,t} = (1-\alpha_c)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta_c} C_t \,;\, C_{F,t} = (\alpha_c)\left(\frac{P_{F,t}}{P_t}\right)^{-\eta_c} C_t \qquad (4)$$

Where the aggregate price level is given by

$$P_t = \left[(1-\alpha_c)\left(P_{H,t}\right)^{1-\eta_c} + (\alpha_c)\left(P_{F,t}\right)^{1-\eta_c}\right]^{\frac{1}{1-\eta_c}} \qquad (5)$$

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Households (labor supply)

Households (static problem): allocation between consumption and labor supply

- From FOC (labor supply):

$$\zeta_L L_t^{\sigma_L} C_t^{1/\sigma} = \frac{W_t}{P_t} \qquad (6)$$

implying that the *marginal rate of substitution* between labor and consumption is equal to the real wage.

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Households (domestic bonds)

Households (dynamic problem): allocation of consumption/bond holdings – consumption/saving decision

- From FOC of households' maximization problem (Euler equation):

$$1 = \beta E_t \left[\frac{\exp(g_{t+1})}{\exp(g_t)} \left(\frac{C_{t+1}}{C_t} \right)^{-1/\sigma} \left(\frac{P_t}{P_{t+1}} \right) R_t \right] \qquad (7)$$

- This equation determines the optimal consumption path: the *marginal rate of substitution* between future and current consumption is equal to the price of future relative to current consumption (i.e., $1/(R_t P_t / P_{t+1})$).

Households (foreign debt)

Households (dynamic problem): another Euler equation for foreign debt:

$$1 = \beta E_t \left[\frac{\exp(g_{t+1})}{\exp(g_t)} \left(\frac{C_{t+1}}{C_t} \right)^{-1/\sigma} \left(\frac{P_t}{P_{t+1}} \right) \left(\frac{e_{t+1}}{e_t} \right) R_t^* \psi_t \right] \tag{8}$$

- Combine this equation with the previous one: Uncovered Interest Parity (UIP) condition,

$$R_t = R_t^* \psi_t E_t \left[\frac{e_{t+1}}{e_t} \right] + \vartheta_t, \tag{9}$$

where

$$\vartheta_t = \frac{cov\left(\frac{\exp(g_{t+1})}{\exp(g_t)} \left(\frac{C_{t+1}}{C_t} \right)^{-1/\sigma}, \left(\frac{e_{t+1}}{e_t} \right) R_t^* \psi_t \right) - cov\left(\frac{\exp(g_{t+1})}{\exp(g_t)} \left(\frac{C_{t+1}}{C_t} \right)^{-1/\sigma} \left(\frac{P_t}{P_{t+1}} \right), R_t \right)}{E_t \left[\frac{\exp(g_{t+1})}{\exp(g_t)} \left(\frac{C_{t+1}}{C_t} \right)^{-1/\sigma} \left(\frac{P_t}{P_{t+1}} \right) \right]}$$

Households (foreign debt, cont.)

Country risk premium is modelled as

$$\psi_t = (1 + \psi_{B*} B_t^*)\exp(\varphi_t)$$

Where

- ψ_{B*} is a parameter that controls the sensitivity of the country risk premium to the foreign debt of the country. In small open economy models, Schmitt-Grohe and Uribe (2003) stress the relevance of this element to obtain a stationary dynamics in small open economy models.
- φ_t is exogenous risk premium shock that is interpreted as non-fundamental perturbation, which could be thought as coming, for instance, from noisy international investors.

A short detour: More on the UIP condition and exchange rate determination

Microfounded approaches for UIP is an arbitrage condition

- Equation (9) provides an arbitrage condition between domestic and foreign bonds:

$$R_t = R_t^* \psi_t E_t \left[\frac{e_{t+1}}{e_t} \right] + \vartheta_t,$$

- Hence, ψ_t is a wedge that limits arbitrage opportunities between domestic and foreign bonds.

- Following Schmitt-Grohé and Uribe (2003), the baseline model assumes that ψ_t increases with the level of foreign debt. However, recent studies have proposed different micro-founded approaches to modeling ψ_t.

Recent microfounded approaches for ψ_t

- Gabaix and Maggiori (2015) propose a model with financial market frictions, where the balance sheets of financial institutions (financiers) influence exchange rate determination.

- Fanelli and Straub (2021) introduce partial segmentation between domestic and foreign bond markets.

- Itskhoki and Mukhin (2021) model a segmented international financial market with noise traders and risk-averse intermediaries, leading to equilibrium deviations from Uncovered Interest Parity (UIP) due to limits to arbitrage.

For instance, Gabaix and Maggiori (2015)

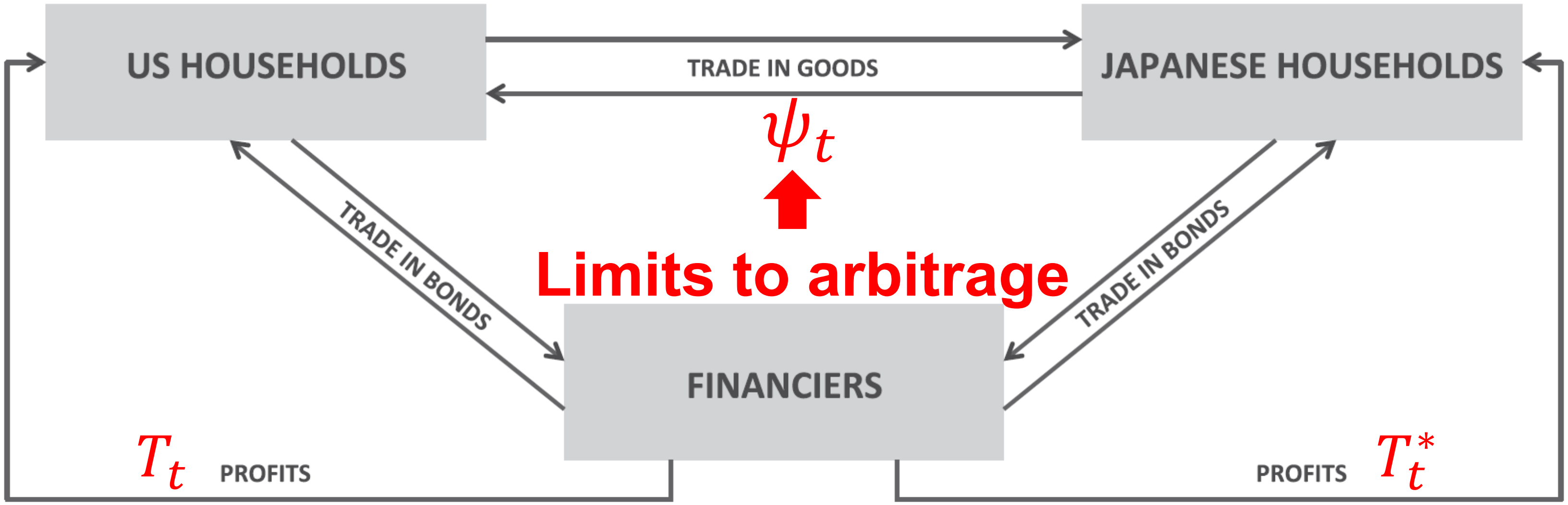

FIGURE I

Basic Structure of the Model

Source: Gabaix and Maggiori (2015)

Some equivalence across approaches for ψ_t

- All these approaches share a microfounded structure in which the financial sector faces limits to arbitrage in the intermediation of foreign bonds.

- More importantly, Yakhin (2022) shows that, up to a first-order approximation, all these approaches are equivalent to the one developed in the baseline model. The first-order approximation of equation (9) is:

$$i_t = i_t^* + E_t[\Delta e_{t+1}] + \psi_{B*} B_t^* + \varphi_t$$

  – $\psi_{B*} B_t^*$ captures the role of balance sheets in limiting arbitrage opportunities.

  – φ_t represents noisy or non-fundamental risk-premium shocks in exchange rate determination.

Continue with the baseline model

Prices and Real Exchange Rate

- Recall: aggregate consumer price index:

$$P_t = \left[(1-\alpha_c)\left(P_{H,t}\right)^{1-\eta_c} + (\alpha_c)\left(P_{F,t}\right)^{1-\eta_c}\right]^{\frac{1}{1-\eta_c}}$$

- Assume perfect pass-through from foreign prices: $P_{F,t} = e_t P_t^*$, where P_t^* is the price of the foreign good measured in foreign currency.

- The law of one price defines the Real Exchange Rate (RER):

$$RER_t = \frac{e_t P_t^*}{P_t} \qquad (10)$$

- Using the definition of P_t and re-arranging gives:

$$1 = (1-\alpha_c)\left(\frac{P_{H,t}}{P_t}\right)^{1-\eta_c} + (\alpha_c)(RER_t)^{1-\eta_c} \qquad (11)$$

Firms

Production of local goods: (i) intermediate goods producers; and (ii) retailer.

(i) Intermediate goods producers are continuum (z in [0,1]).
Production function:

$$Y_t(z) = A_t L_t(z)$$

- They solve a two-stage problem:

Stage 1. Given demand, choose demand for labor:

$L_t(z) = Y_t(z)/A_t$; observe that: $mc_t^{nom} = W_t/A_t$ (common to all firms)

Stage 2 . Set optimal price to *maximize profits* (monopolistic competition)

Firms (cont.)

Continuation stage 2 . Set optimal price to *maximize profits* (monopolistic competition)

- Calvo(1983)-pricing: with $(1-\theta)$ as the share of firms getting to reset the price each period
- As a result, the pricing rule (log-linearized around symmetric steady-state) is the following (Eq. 6 from Lecture 2):

$$p_t^* = \mu + (1-\beta\theta)\sum_{k=0}^{\infty}(\beta\theta)^k\, E_t\{\widehat{mc}_{t+k|t} + p_{t+k} + \mu_{H,t}\}$$

- We have added an exogenous changes in the marginal costs ($\mu_{H,t}$), which could be interpreted as a cost-push shock to intermediate goods producers.

Firms (cont.)

(ii) Retailers sell the final good, 'produced' with intermediate goods (perfect competion at this level), solving a *cost minimization problem*, subject to demand for variety *j*:

$$Y_t = \left(\int_0^1 Y_t^{1-1/\varepsilon}(j) dj \right)^{\frac{\varepsilon}{\varepsilon - 1}}$$

$$\Rightarrow Y_t(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}} \right)^{-\varepsilon} Y_t$$

$$\text{with } P_{H,t} = \left(\int_0^1 P_{H,t}^{1-\varepsilon}(j) dj \right)^{\frac{1}{1-\varepsilon}}$$

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Goods market clearing

Demand for final goods: $Y_t = C_{H,t} + C^*_{H,t}$

Where $C^*_{H,t}$ is the foreign demand for the local good:

$$C^*_{H,t} = (1-\alpha^*)\left(\frac{P_{H,t}}{e_t P^*_t}\right)^{-\eta^*} C^*_t$$

- Trade balance (in real terms):

$$TB_t = \frac{1}{P_t}\left(P_{H,t}Y_t - P_t C_t\right) \quad \text{or} \Longrightarrow \quad TB_t = \frac{1}{P_t}\left(P_{H,t}C^*_{H,t} - P_{F,t}C_{F,t}\right)$$

- Using the definition of *RER* this can be written as:

$$TB_t = \frac{P_{H,t}}{P_t}C^*_{H,t} - RER_t C_{F,t}$$

Trade balance is zero in the steady state

- Recall that the trade balance:

$$TB_t = \frac{P_{H,t}}{P_t} C^*_{H,t} - RER_t C_{F,t}$$

- From the assumption of zero initial net foreign assets, symmetric preferences and equal initial consumption ratios, the trade balance must be zero initially and once the steady state is achieved.

- Assuming relative prices equal to 1 in the steady state:

$$C = Y$$

$$C_F = \alpha_c C = C^*_H = (1-\alpha^*)C^*$$

The log-linear NK small open economy model

$$c_{H,t} = c_t - \eta_c(p_{H,t} - p_t) \quad \text{(SOE.1)}$$

$$c_{F,t} = c_t - \eta_c rer_t \quad \text{(SOE.2)}$$

$$0 = (1 - \alpha_c)(p_{H,t} - p_t) + \alpha_c rer_t \quad \text{(SOE.3)}$$

- (SOE.1) is the demand for domestic goods (H). $(p_{H,t} - p_t)$ is the price of good H relative to that of the total consumption basket.
- Similarly, (SOE.2) is the local demand for the imported good.
- (SOE.3) is the consumption basket price index, or a weighted average of the price of home (H) and imported goods (F). In steady state (SS) the trade balance or net exports are zero, and thus α_c is the ratio of imports (exports) to GDP (RER is one in the SS).

The log-linear NK small open economy model

$$c_t = -\sigma(i_t - E_t\pi_{t+1}) + E_t c_{t+1} + \sigma(1-\rho_g)g_t \quad \text{(SOE.4)}$$

$$i_t = i_t^* + E_t[\Delta e_{t+1}] + \psi_{B*}B_t^* + \varphi_t \quad \text{(SOE.5)}$$

- (SOE.4) is the aggregate demand for consumption (Euler eq for domestic bonds), where c_t is consumption, i_t is the nominal interest rate, π_t is inflation and g_t the domestic demand shock. σ is the elasticity of intertemporal substitution. $E_t(\quad)$ represents expectations taken at period t.

- (SOE.5) is the uncovered interest parity condition, where Δe_{t+1} is the depreciation rate in log form relative and is the nominal foreign interest rate, which includes a country risk premium shock (φ_t). Also, using the definition of the real exchange rate: $rer_t - rer_{t-1} = \Delta e_t + \pi_t^* - \pi_t$, implying

$$i_t - E_t\pi_{t+1} = i_t^* - E_t\pi_{t+1}^* + E_t[rer_{t+1} - rer_t] + \psi_{B*}B_t^* + \varphi_t \quad \text{(SOE.5')}$$

where π_t^* is the foreign inflation rate.

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The log-linear NK small open economy model (cont.)

$$rw_t = \sigma_L l_t + \frac{1}{\sigma} c_t \qquad \text{(SOE.6)}$$

$$y_t = a_t + l_t \qquad \text{(SOE.7)}$$

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \kappa\left(mc_t - \left(p_{H,t} - p_t\right)\right) + \gamma_{H,t} \qquad \text{(SOE.8)}$$

- (SOE.6) is the labor supply equation, where σ_L is the inverse of the labor supply elasticity and rw_t is the real wage .
- (SOE.7) is the supply function of local production, y_t, where a_t is total factor productivity and l_t is total labor used in production.
- (SOE.8) is the NK Phillips curve (pricing rule) for the locally-produced goods ($p_{H,t}$); and κ ($\kappa = (1-\theta)(1-\theta\beta)/\theta$) is its slope, given by marginal costs relative to the price of locally-produced goods. $\gamma_{H,t} = \kappa\mu_{H,t}$ is the cost-push shock described earlier.

The log-linear NK small open economy model (cont.)

$$mc_t = rw_t - a_t \qquad \text{(SOE.9)}$$

$$i_t = \phi_i i_{t-1} + (1 - \phi_i)\left(\phi_\pi \pi_t + \phi_y y_t\right) + z_t \qquad \text{(SOE.10)}$$

$$y_t = (1 - \alpha_c)c_{H,t} + \alpha_c \left(c_t^* - \eta^* \left(p_{H,t} - p_t - rer_t\right)\right) \qquad \text{(SOE.11)}$$

$$\pi_t = \pi_{H,t} + \frac{\alpha_c}{1-\alpha_c}(rer_t - rer_{t-1}) \qquad \text{(SOE.12)}$$

- (SOE.9) defines the real marginal costs of local production (relative to the price level of the consumption basket.
- (SOE.10) is the Taylor rule. Monetary policy can react to total (CPI) inflation with interest rate smoothing. z_t represents a discretionary monetary policy shock.
- (SOE.11) represents the goods market clearing (resource constraint), where c_t^* is the demand from the rest of the world.
- (SOE.12) defines inflation of the consumption basket, under the assumption of perfect pass through from the exchange rate to imported good prices sold locally. [It comes from re-writing (SOE.3)]

The log-linear NK small open economy model (cont.)

$$B_t^* = \frac{1}{\beta}B_{t-1}^* + \alpha_c\left(rer_t + c_{F,t}\right) - \alpha_c\left(p_{H,t} - p_t + c_{H,t}^*\right) \qquad \text{(SOE.13)}$$

$$\Delta e_t = rer_t - rer_{t-1} + \pi_t - \pi_t^* \qquad \text{(SOE.14)}$$

$$c_{H,t}^* = c_t^* - \eta^*\left(p_{H,t} - p_t - rer_t\right) \qquad \text{(SOE.15)}$$

$$tb_t = \alpha_c(\underbrace{p_{H,t} - p_t + c_{H,t}^*}_{exports} - \underbrace{\left(rer_t + c_{F,t}\right)}_{imports}) \qquad \text{(SOE.16)}$$

- (SOE.13) is the balance of payment identity that relates current account with the change in the net international investment position.
- (SOE.14) is the evolution of the nominal exchange rate (it comes from its definition), and is given by the variation of the real exchange rate and the inflation differential with respect to the foreign economy.
- (SOE.15) define the demand for the *H* good by foreigners.
- (SOE.16) is the trade balance condition as percentage of the SS GDP.

NK small open economy model (cont.)

- Exogenous processes:

$$a_t = \rho_a a_{t-1} + \varepsilon_{a,t} \qquad \text{(SOE.17)}$$

$$g_t = \rho_g g_{t-1} + \varepsilon_{g,t} \qquad \text{(SOE.18)}$$

$$z_t = \rho_z z_{t-1} + \varepsilon_{z,t} \qquad \text{(SOE.19)}$$

$$c_t^* = \rho_{c*} c_{t-1}^* + \varepsilon_{c*,t} \qquad \text{(SOE.20)}$$

$$i_t^* = \rho_{i*} i_{t-1}^* + \varepsilon_{i*,t} \qquad \text{(SOE.21)}$$

$$\pi_t^* = \rho_{\pi*} \pi_{t-1}^* + \varepsilon_{\pi*,t} \qquad \text{(SOE.22)}$$

$$\varphi_t = \rho_\varphi \varphi_{t-1} + \varepsilon_{\varphi,t} \qquad \text{(SOE.23)}$$

$$\gamma_{H,t} = \rho_{\gamma H} \gamma_{H,t-1} + \varepsilon_{\gamma H,t} \qquad \text{(SOE.24)}$$

- (SOE-17)-(SOE-24) are the AR(1) processes for shocks to productivity (a_t), demand or preferences (g_t), monetary policy (z_t), foreign demand (c_t^*), foreign interest rate (i_t^*), foreign inflation (π_t^*), exogenous country risk premium (φ_t), and cost-push in domestic produced prices ($\gamma_{H,t}$).

Another short detour: Incomplete vs Complete Markets for foreign debt/bonds

Modeling links with international financial markets: General considerations

Financial autarky

in between (capital controls)

Open capital account

Exchange rate is pinned down by trade balance

Complete markets? (e.g. perfect international risk sharing)

Exchange rate is pinned down by uncovered interest parity

Incomplete markets? (e.g. trade in only some assets – implies role of risk premia)

Complete financial markets

- A well-known study by Galí and Monacelli (2005) assumes complete financial markets to develop a model for a small open economy (e.g., Canada).

- Although this assumption is less appealing for emerging economies, it provides interesting theoretical results:

  - A more direct comparison of the transmission mechanisms between open and closed New Keynesian (NK) models.
  - Under certain conditions, the open economy model can be expressed using the same three equations as the closed economy model (see next slides).

Under complete market: the small open economy looks similar to the closed economy model (I)

- Recall that the basic closed-economy NK model can be reduced to 3 equations:

$$y_t = E_t y_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1} - r_t^n) + \sigma(1-\rho_g)g_t$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t, \qquad \kappa = \lambda\left(\sigma + \frac{\varphi+\alpha}{1-\alpha}\right)$$

$$i_t = \phi_\pi \pi_t + \phi_y y_t + z_t$$

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Under complete market: the small open economy looks similar to the closed economy model (II)

- Under some conditions, Gali and Monacelli (2005) show that the open economy model can also be represented by 3 equations (assuming that MP responds to π_H and that $c^*_t = y^*_t$):

$$y_t = E_t y_{t+1} - \sigma_1 (i_t - E_t \pi_{H,t+1}) + (1-\alpha_c)\sigma(1-\rho_g) g_t + \alpha_c (1-\rho_{y*}) y_t^*$$

$$\pi_{H,t} = \beta E_t \pi_{H,t+1} + \tilde{\kappa}(y_t - \lambda_a a_t + \lambda_g g_t + \lambda_{y*} y_t^*), \quad \tilde{\kappa} = (\sigma_L + 1/\sigma_1)\kappa$$

$$i_t = \phi_\pi \pi_{H,t} + \phi_y y_t + z_t$$

- Similar specifications, but with external factors, different elasticities and effects of shocks:

$$\sigma_1 = \sigma(1-\alpha_c)\left(1-\alpha_c+\gamma_c\right), \quad \gamma_c = \frac{1}{\sigma}\left(\eta_c \alpha_c + \eta^* \frac{\alpha_c}{1-\alpha_c}\right),$$

$$\lambda_a = \frac{\sigma_L + 1}{\sigma_L + 1/\sigma_1}, \quad \lambda_{y*} = \frac{\gamma_c - \alpha_c - \alpha_c(1-\alpha_c+\gamma_c)}{\sigma_L \sigma_1 + 1},$$

$$\lambda_{g*} = \frac{\gamma_c - \alpha_c(1-\alpha_c+\gamma_c)}{(1-\alpha_c)(1-\alpha_c+\gamma_c)(\sigma_L + 1/\sigma_1)}$$

3. Analyzing transmission mechanisms

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Quantitative implementation

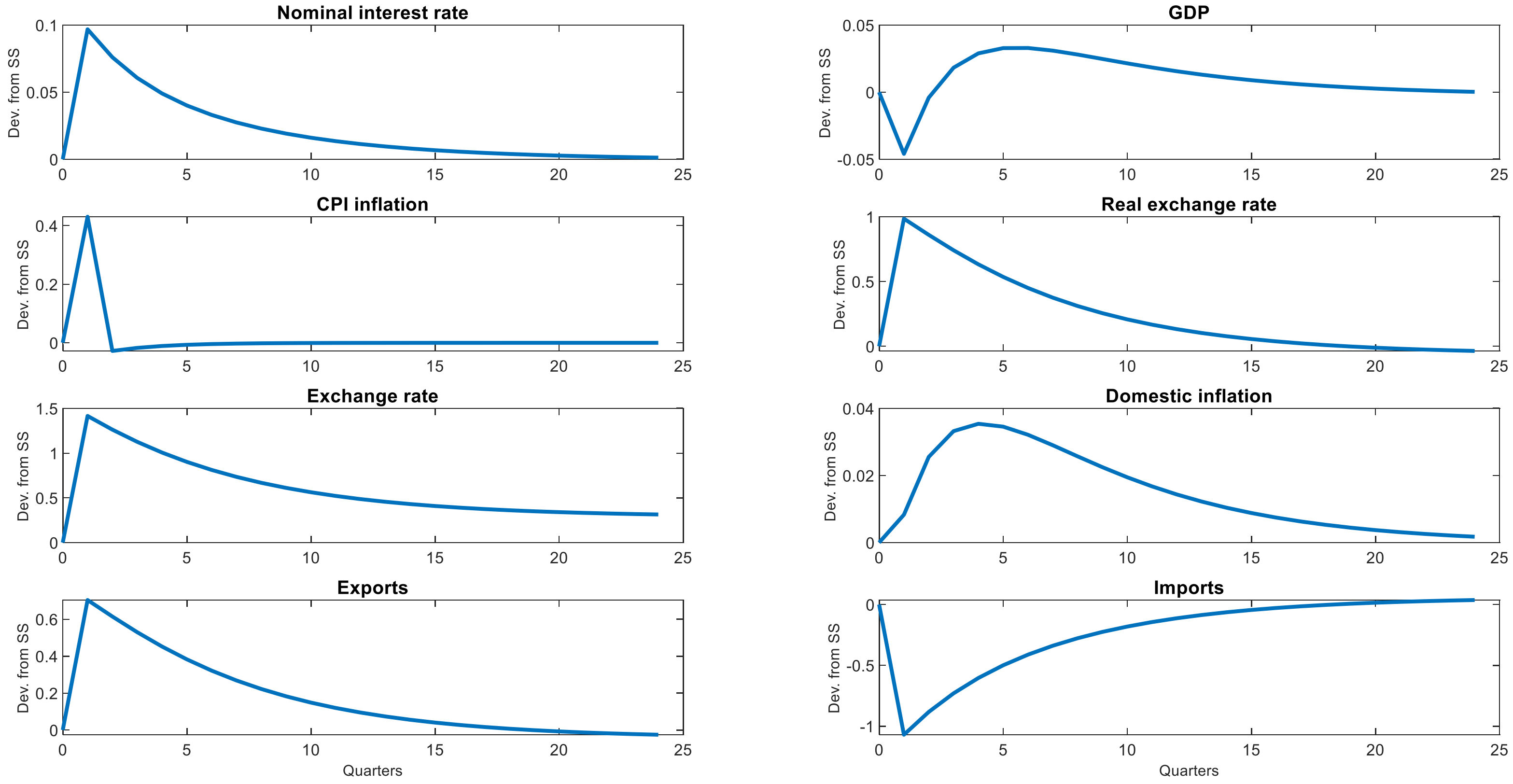
- Baseline model: equations (SOE.1)—(SOE.24)
- Calibration:
  - Quarterly: notice that interest rates will be set on a quarterly basis.
  - From the basic NK model: $\beta = 0.995; \theta = 0.75 \rightarrow \kappa = 0.0845; \phi_\pi = 1.5;$

  $\phi_i = 0.85; \phi_y = 0.0; \sigma = \sigma_L = 1.$
  - New parameters: $\alpha_c = 0.30;\ \eta_c = \eta^* = 0.5; \psi_{B*} = 0.001$
  - Persistence and size of shocks: $\rho_a = 0.90; \rho_g = 0.80\text{:}\ \rho_z = 0.70;\ \rho_{c*} = 0.85;$

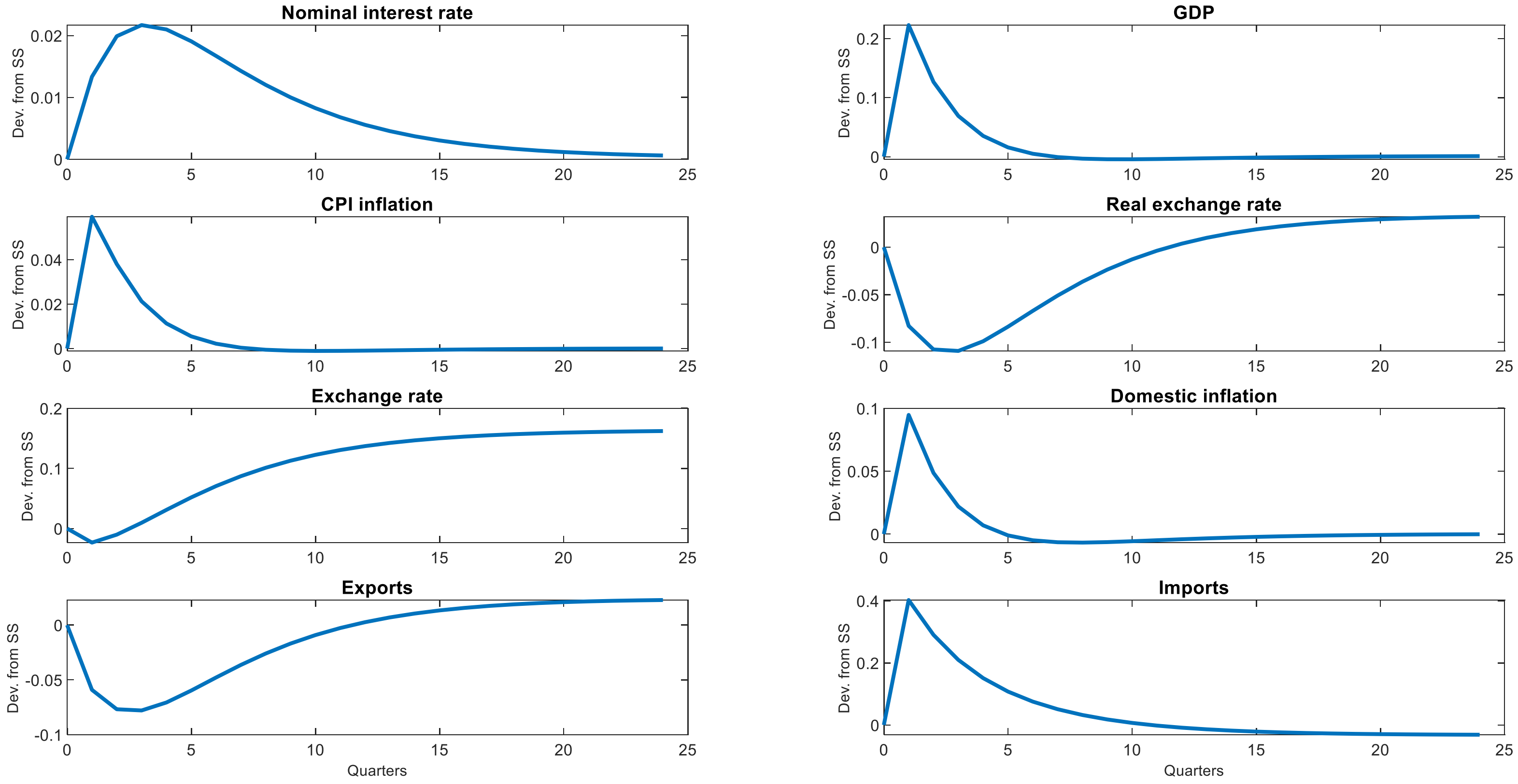
  $\rho_{i*} = 0.95\ ;\ \rho_{\pi*} = 0.90; \rho_\varphi = 0.85;\ ; \rho_{\gamma H} = 0; \sigma_a = 0.70\%; \sigma_g = 0.50\%\text{:}$

  $\sigma_z = 0.25\%;\ \sigma_{c*} = 1.00\%; \sigma_{i*} = 0.25\%\ ;\ \sigma_{\pi*} = 0.25\%; \sigma_\varphi = 0.25\%; \sigma_{\gamma H} = 0.5\%$
- Dynare Code **nk_1soe.mod** implements the model. Matlab Code **irf_nk_1soe.m** calls upon this code and plots the responses to different shocks. Monetary policy reacts to **CPI inflation (case CPI Inflation Targeting Rule: CITR)**.

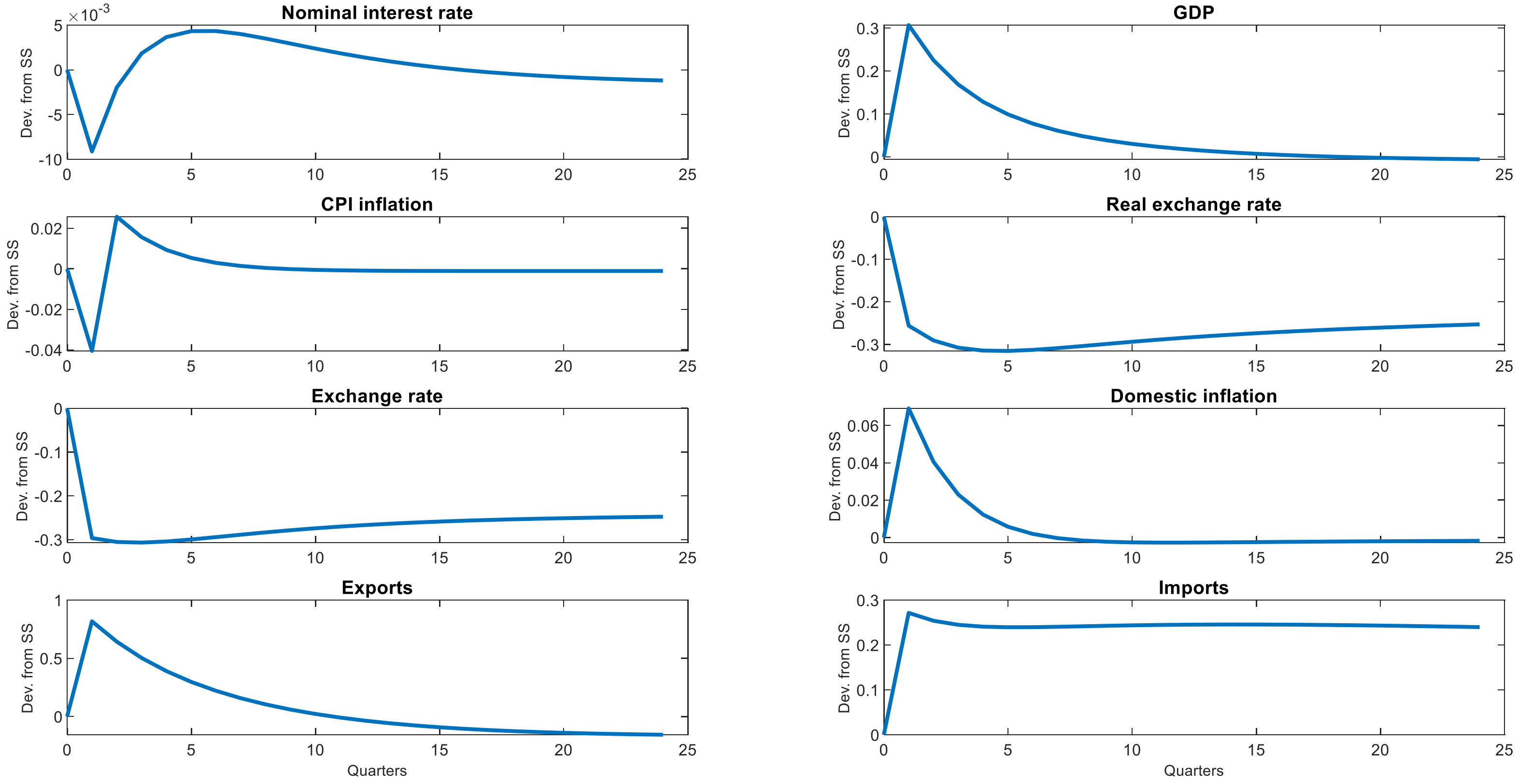
Responses to a risk-premium shock



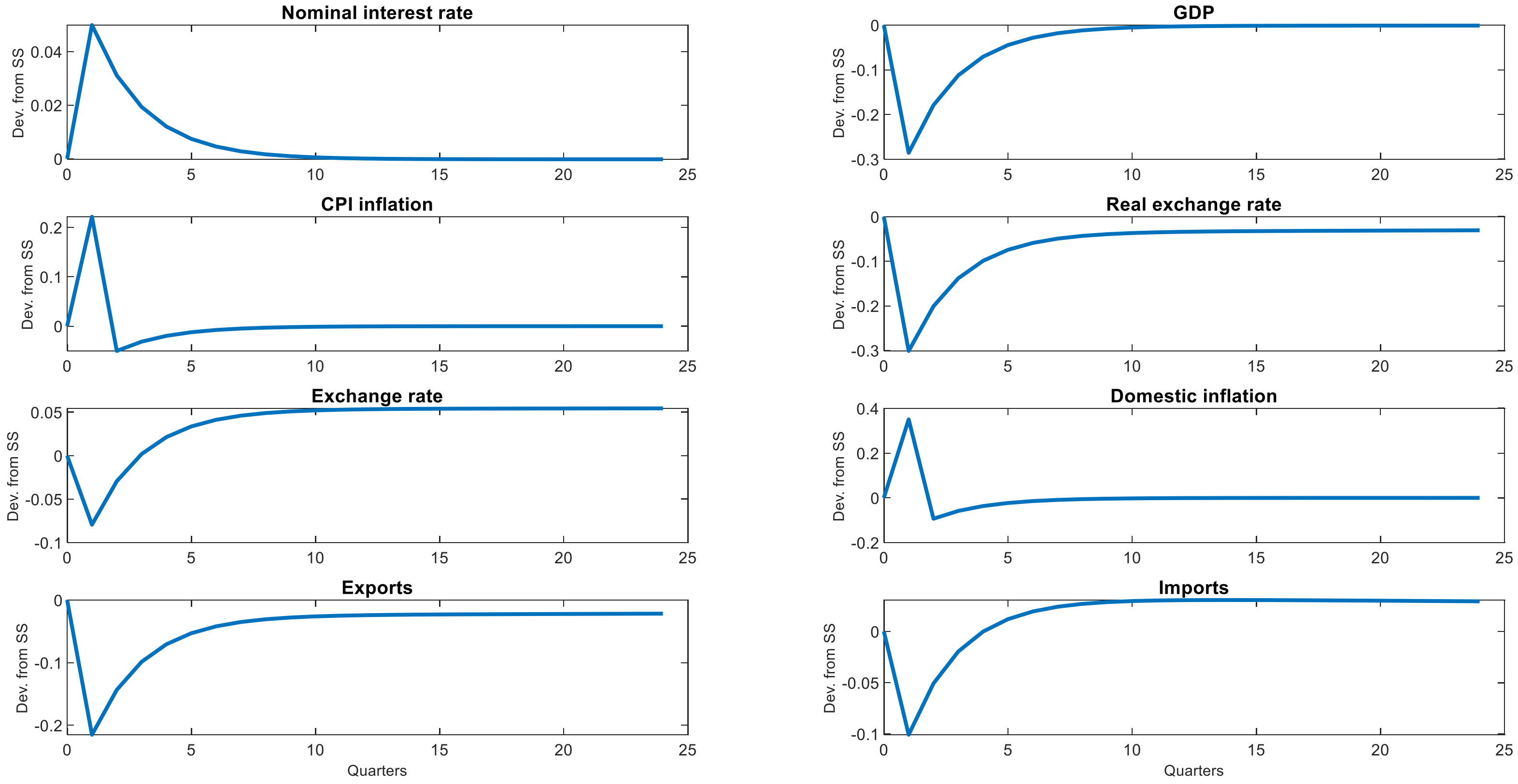
Responses to a domestic demand shock



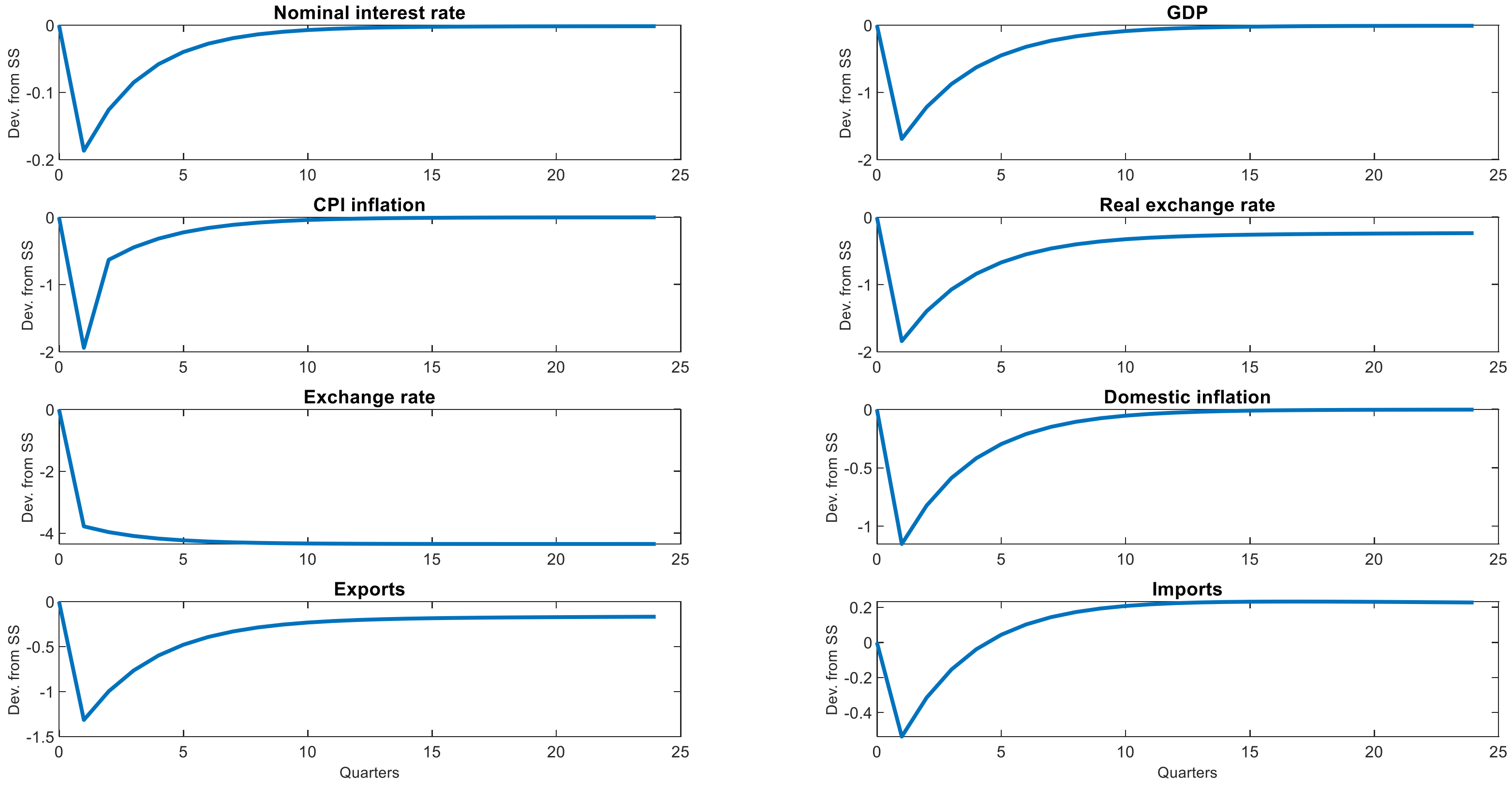
Responses to a foreign demand shock



Responses to a domestic cost-push shock



Responses to a domestic MP shock



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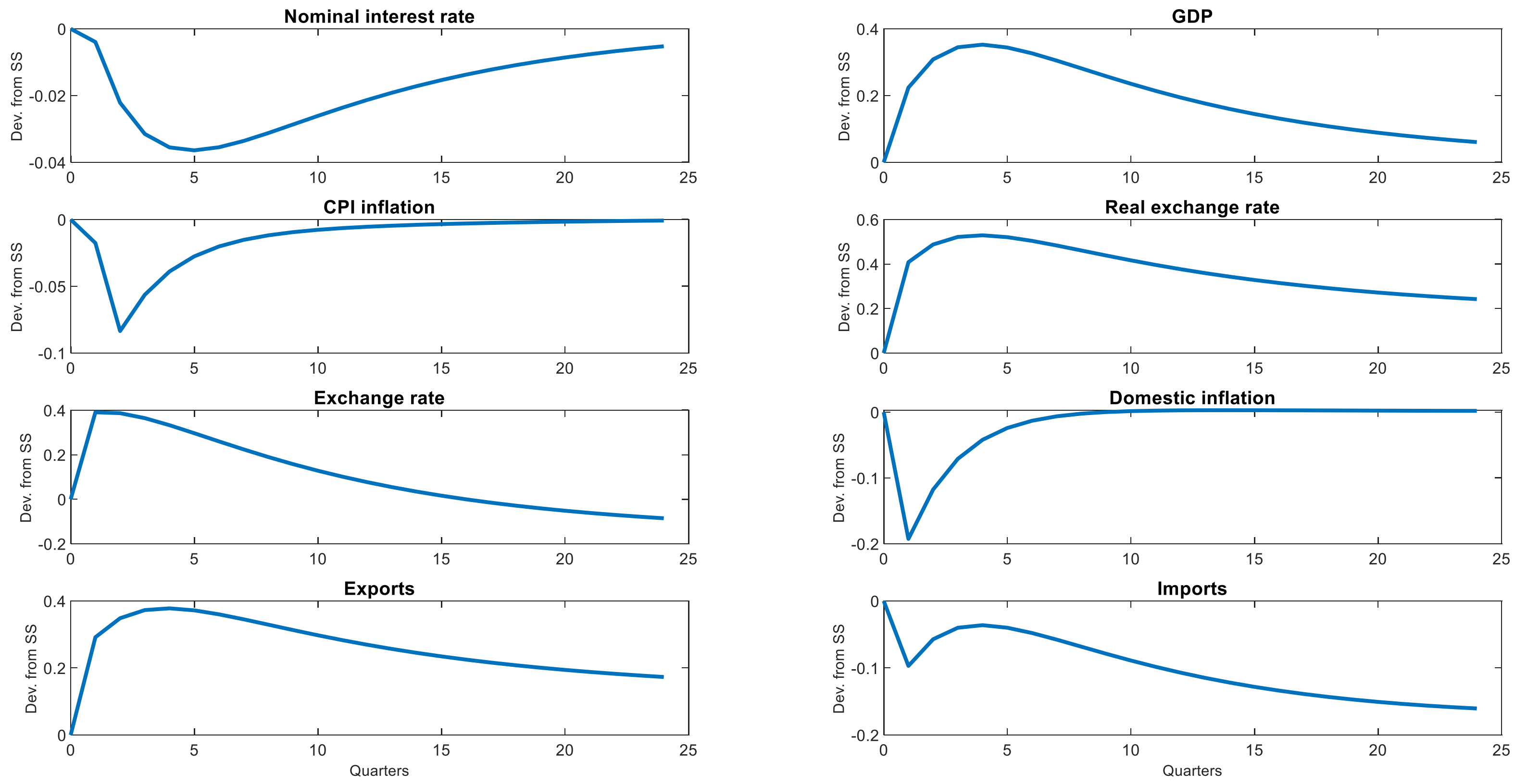
Responses to a domestic productivity shock



4. Discussion of Alternative Monetary Policies

Monetary Policy Discussion

Considering the Galí and Monacelli (2005) model to illustrate in simple manner the discussion

- From the Phillips Curve: a MP implying $\pi_H=0$ also implies zero output gap. E.g. GDP will be equal to its potential (or natural) level.

- Equivalent to a MP rule that stabilizes π_H with a very big coefficient!

- In other words, there is no tradeoff between stabilizing domestic inflation and the output gap. This situation has been denominated "**divine coincidence**". In this model, this is a consequence of the existence of only one friction: **price rigidities**. Adding more rigidities (e.g., wage rigidities) will break this result.

Alternative Monetary Policies

- Optimal monetary policy (DIT) (x_t – output gap): $\pi_{H,t} = 0 \Leftrightarrow x_t = 0$
  - ➢ Strict inflation targeting, the "divine coincidence" holds
- Taylor type rule – Domestic inflation (DITR): $i_t = \phi_\pi \pi_{H,t}$
- Taylor type rule – CPI inflation (CITR): $i_t = \phi_\pi \pi_t$
- Fixed E. Rate (assumes zero foreign inflation; PEG): $\Delta e_t = rer_t - rer_{t-1} + \pi_t = 0$
  - ➢ Domestic interest rate is always equal to foreign interest rate

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Alternative monetary/exchange regimes in our baseline model

- We follow Gali and Monacelli (2005) considering alternative policy regimes in the baseline model
- The previous responses were obtained under CPI inflation targeting rule (calibration: $\phi_\pi = 1.5$; $\phi_y = 0$; $\phi_i = 0.85$)

$$i_t = \phi_i i_{t-1} + (1 - \phi_i)\left(\phi_\pi \pi_t + \phi_y y_t\right) + z_t \text{ [CITR]}$$

- Alternatively, we can consider
  - An exchange rate peg: $\Delta e_t = 0$ [PEG]
  - Domestic inflation targeting rule:

$$i_t = \phi_i i_{t-1} + (1 - \phi_i)\left(\phi_\pi \pi_{H,t} + \phi_y y_t\right) + z_t \text{[DITR]}$$

- Key question: How does the same shocks transmit differently under the alternative regimes? We will see this in the workshop

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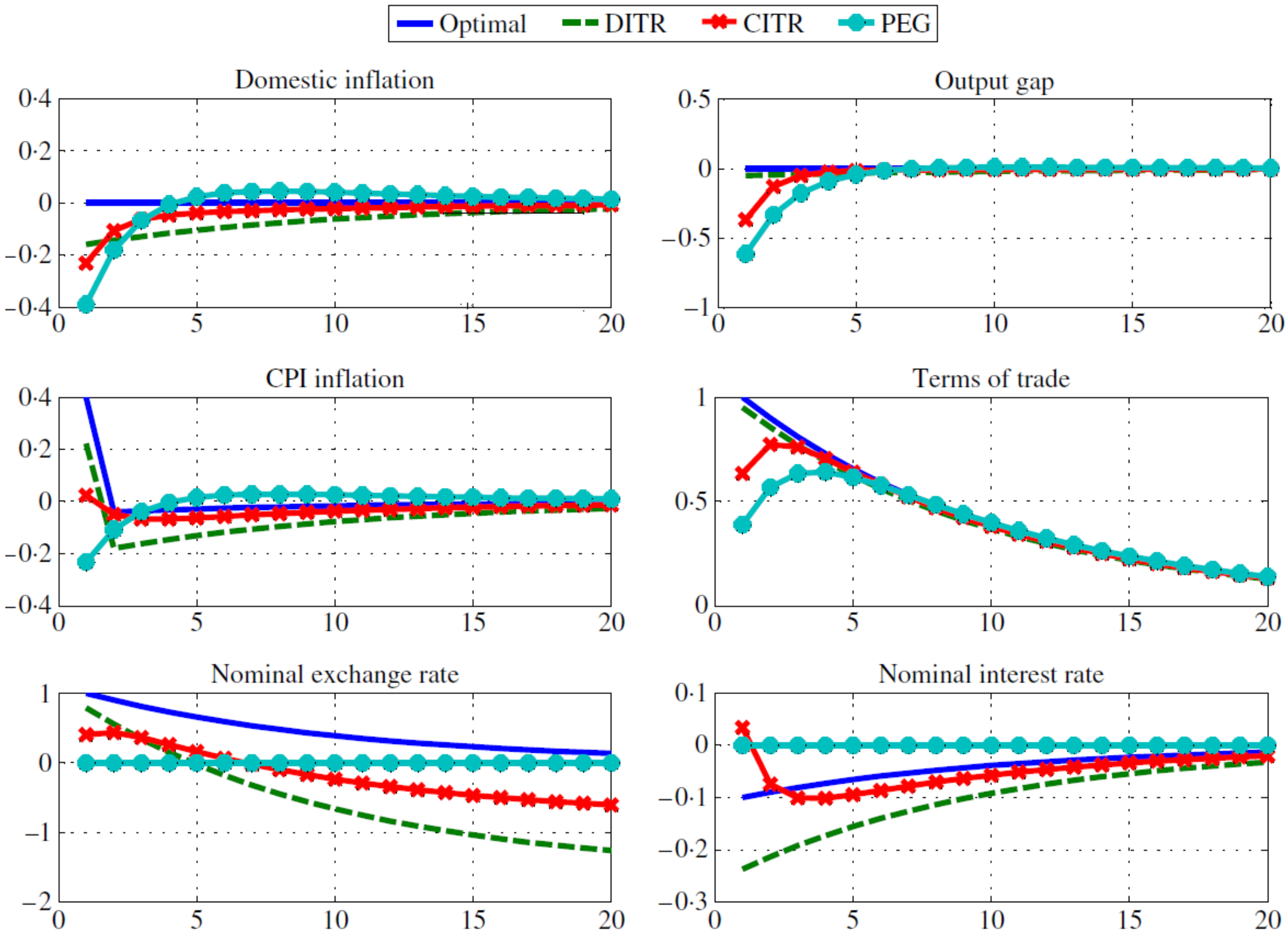
Full stabilization of Domestic Inflation

- Gali and Monacelli (2005) shows that, under complete market in the financial integration with the rest of world, optimal monetary policy fully stabilizes domestic inflation ($\pi_{H,t} = 0$)
- This equilibrium also stabilizes the GDP around its natural equilibrium
  - Natural equilibrium: allocation will prevail under flexible prices for the domestic goods
- Thus, we obtain a four regime: Full stabilization of domestic inflation [DITR_F]
- In contrast to Gali and Monacelli (2005), who consider only productivity and foreign demand shocks, in the workshop we will analyze this having also shocks to domestic demand, foreign interest rate and inflation.

Responses to productivity shocks under alternative monetary policies in Gali and Monacelli (2005)



Source: Galí and Monacelli (2005, p. 724)

Volatilities in Gali and Monacelli (2005)

TABLE 1

Cyclical properties of alternative policy regimes

	Optimal sd%	DI Taylor sd%	CPI Taylor sd%	Peg sd%
Domestic inflation	0.00	0.27	0.27	0.36
CPI inflation	0.38	0.41	0.27	0.21
Nominal int. rate	0.32	0.41	0.41	0.21
Terms of trade	1.60	1.53	1.43	1.17
Nominal depr. rate	0.95	0.86	0.53	0.00

Note : Sd denotes standard deviation in %.

Source: Galí and Monacelli (2005, p. 726)

Note: The processes for productivity shocks (a) and foreign demand (y*) are estimated with Canadian data.

Welfare Analysis in Gali and Monacelli (2005)

TABLE 2

Contribution to welfare losses

	DI Taylor	CPI Taylor	Peg
		Benchmark ε=6 ; σ_L=3	
Var(Domestic infl.)	0.0157	0.0151	0.0268
Var(Output gap.)	0.0009	0.0019	0.0053
Total	0.0166	0.0170	0.0321

Note : Entries are percentage units of steady state consumption.

Exchange rate as is a shock absorber to attenuate macroeconomic volatility!

Source: Galí and Monacelli (2005, p. 726)

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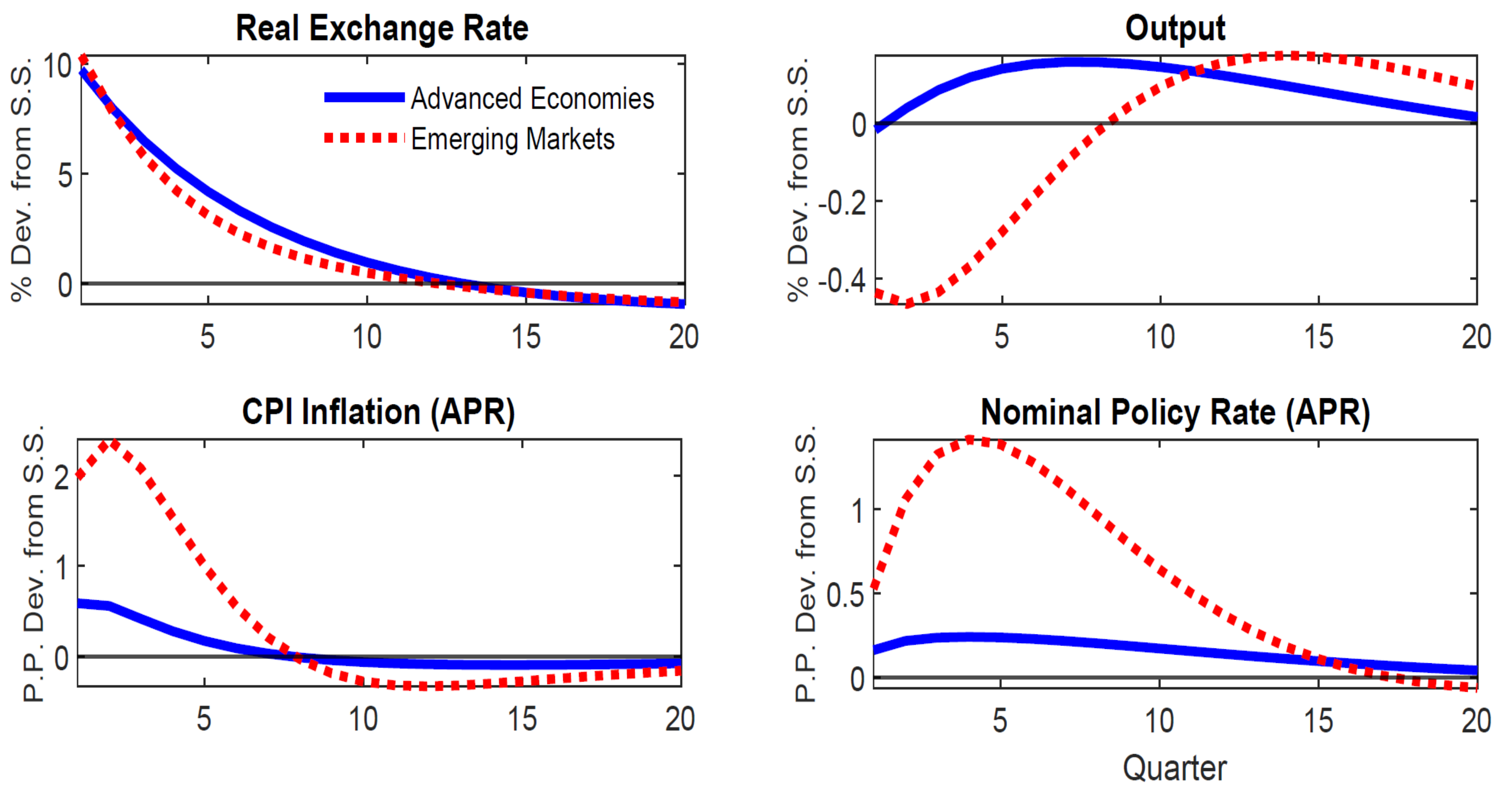
However, considering incomplete markets and the particularities of EME the previous results might change

Responses to a foreign risk appetite shock



Source: Adrian et al (2021)

Moreover, there are welfare benefits of using FXI in response to this type of shocks in EME

No debt limit	Occasionally binding debt limit				
Standard MP Rule	Standard MP Rule	FXI UIP Prem. Rule	CFM Rule	FXI UIP & CFM Rules	FXI Spread Rule
	Welfare Gain Relative to Standard MP Rule				
0.03	0.00	0.27	0.16	0.34	-0.01

Source: Adrian et al (2021)

Other studies also finds benefits of using FXI in responses to shocks that affect the UIP condition

- Fanelli and Straub (2021): FXI should lean against the wind of global capital flows, moderating exchange rate fluctuations without excessively smoothing them.
- Lama and Medina (2020): FXI and macroprudential policies are complementary tools to the monetary policy rate that can greatly reduce inflation and output volatility in a scenario of capital outflows.
- Adler et al (2019): under MP credibility, FXI can improve unambiguously macroeconomic stability in response to foreign disturbances to the UIP. However, when central bank lacks credibility, FXI policies entail a trade-off by reducing output volatility at the expense of inducing higher inflation volatility.

Adding FXI as additional policy instrument in the baseline model

- FX reserve management could modify the supply of foreign currency, potentially affecting the exchange rate. However, this effect is almost inexistent under deep FX markets since FX reserves movements are offset by changes in foreign debt.
- Nonetheless, under shallow FX markets, FXI could influence the exchange rate since foreign debt no offset fully the change in FX reserves.
- Two key equations in the baseline model have two be modified to consider an effective role for FXI: (i) the UIP condition and (ii) the balance of payment identity.

Adding FXI as additional policy instrument

- The UIP condition

$$i_t = i_t^* + E_t[\Delta e_{t+1}] + \psi_{B*} B_t^* + \varphi_t$$

- The balance of payment identity

$$B_t^* - FX_t = \frac{1}{\beta}(B_{t-1}^* - FX_{t-1}) + \alpha_c(rer_t + c_{F,t}) - \alpha_c(p_{H,t} - p_t + c_{H,t}^*)$$

- The baseline ($\psi_{B*} = 0.001$) corresponds to case of deep FX market
- An alternative calibration ($\psi_{B*} = 0.2$) will imply a shallow FX market.
- Assume a simple AR(1) process for the FX reserves.
- Note: we consider no interest rate smoothing in the CITR

For the workshop

- We will analyze how the effectiveness of the FXI depends on how deep is the FX market.

- We will also study how FXI can complement monetary policy under certain circumstances.

5. Pricing assumption: PCP vs LCP

Producer Currency Pricing (PCP) vs Local Currency Pricing (LCP)

- The baseline small open economy model assumes the Law of One Price for domestic and foreign goods. This implies that [**in logs**]:
  - The price of domestic goods abroad, in foreign currency, is $p_{H,t} - e_t$
  - The price of foreign goods in the local economy is $e_t + p_t^*$
- In open macroeconomics, this case is referred to as Producer Currency Pricing (PCP).
  - Exporter prices are sticky in the home economy's currency.
  - A depreciation of the home currency makes domestic goods relatively cheaper than foreign goods, generating an expenditure switching effect.

Producer Currency Pricing (PCP) vs Local Currency Pricing (LCP) (cont.)

- However, in practice, exporters in a small open economy set their prices in the foreign economy's currency. These prices are also sticky.

- Moreover, retailers of imported goods may face nominal rigidities, resulting in an imperfect exchange rate pass-through of exchange rate depreciation to local prices of imported goods.

  => Local Currency Pricing (LCP)

- These features reduce the strength of the expenditure switching effect.

- To model LCP, we need to add two additional Phillips curves: one for export prices and another for import prices.

LCP: New Phillips curves

- Two additional Phillips curves

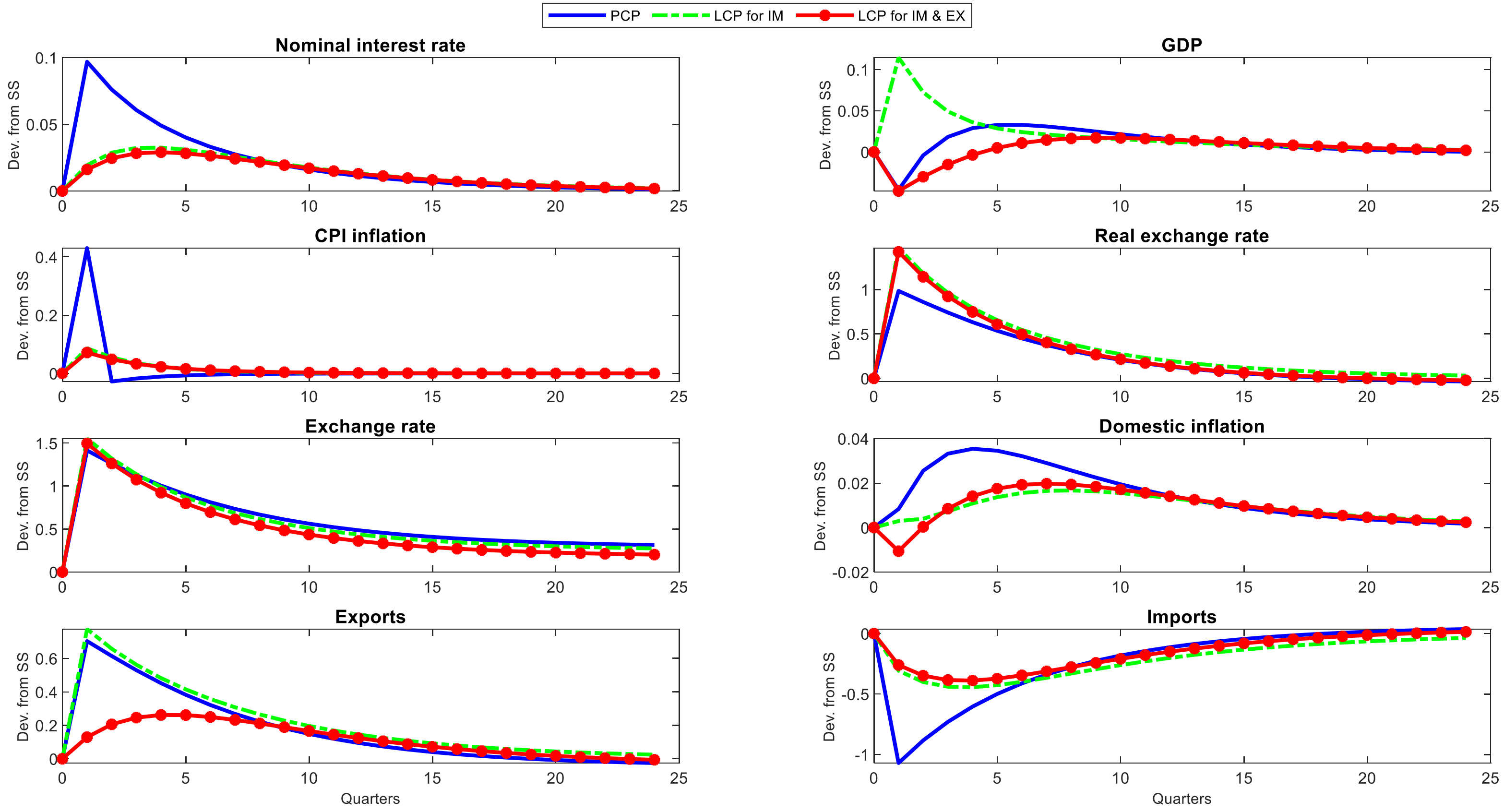
$$\pi^*_{H,t} = \beta E_t \pi^*_{H,t+1} + \kappa_X\left(p_{H,t} - e_t - p^*_{H,t}\right)$$
$$\pi_{F,t} = \beta E_t \pi_{F,t+1} + \kappa_F\left(e_t + p^*_{,t} - p_{F,t}\right)$$

where $\pi^*_{H,t}$ and $\pi_{F,t}$ are, respectively, the inflation of export prices in foreign currency and the inflation of imported goods domestically.

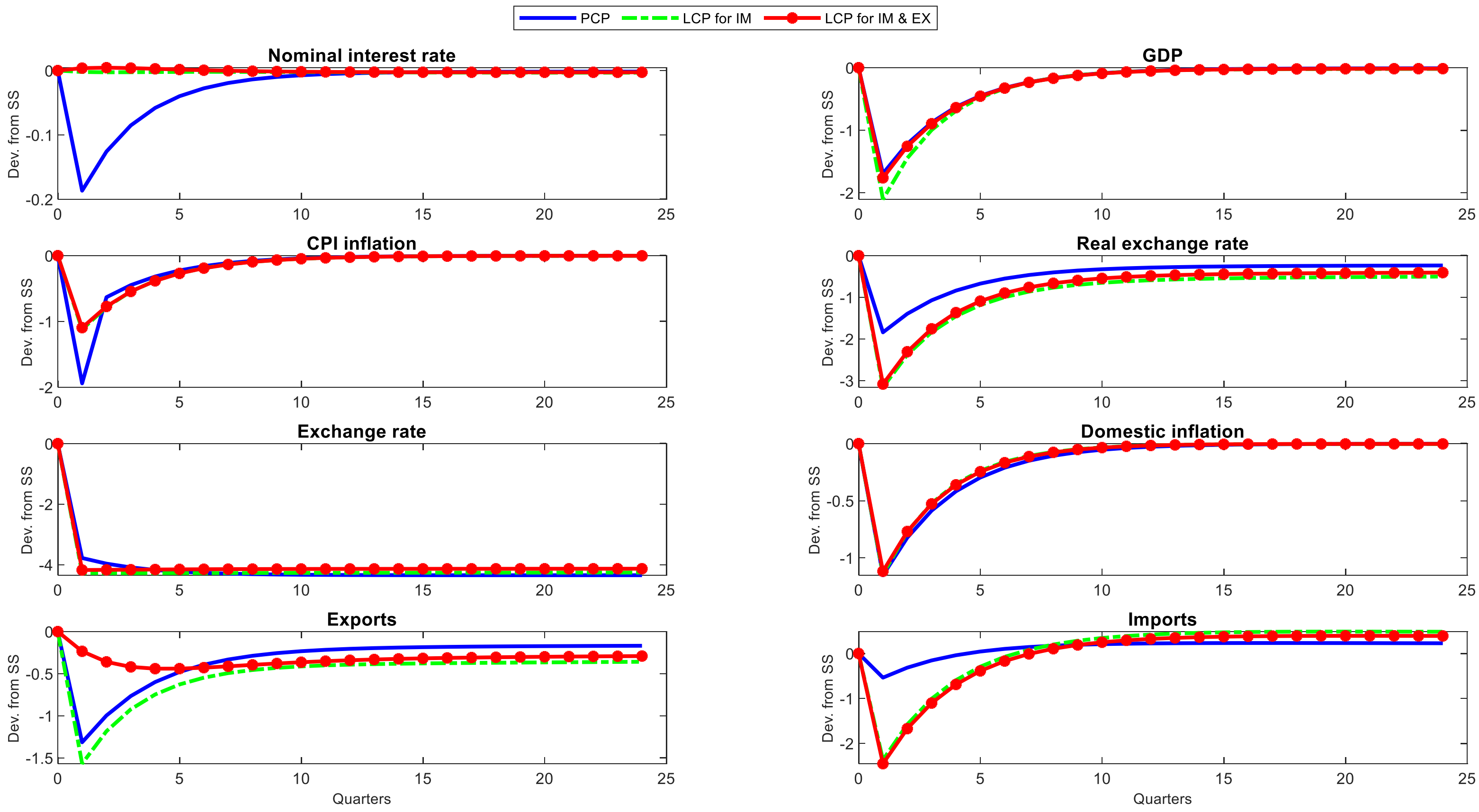
$$\pi^*_{H,t} = p^*_{H,t} - p^*_{H,t-1}$$
$$\pi_{F,t} = p_{F,t} - p_{F,t-1}$$

- During the workshop, we will explore how nominal rigidities for $p^*_{H,t}$ and $p_{F,t}$, equivalent to those in $p_{H,t}$, affect the transmission of shocks.

PCP (base) vs LCP. Responses to a risk premium shock



NEW: PCP (base) vs LCP. Responses to a MP shock



6. Conclusions

Concluding Remarks (I)

- The behavior of the exchange rate is central to an open economy, and accurately characterizing it empirically requires accounting for frictions in international financial markets, which are typically more pronounced in emerging economies.
- The Uncovered Interest rate Parity (UIP) is key feature of NK SOE models
  - **with incomplete markets** we need to include a risk premium that is linked to net foreign debt to maintain the external balance (hybrid UIP). This feature also helps justify the effectiveness of FXI as an additional policy instrument.
  - **with complete financial markets,** the NK SOE model shares similarities with the NK closed economy model.

Concluding Remarks (II)

- The exchange rate and the net foreign debt position determine the transmission of various shocks to inflation and output in the NK small open economy model.

- In standard NK model with flexible wages and complete markets **strict inflation targeting of domestic inflation** is optimal → "Divine coincidence".

- Exchange rate flexibility is optimal in standard NK SOE models with complete markets, as it helps cushion external shocks.

Concluding Remarks (III)

- However, when additional frictions are present and in response to certain external shocks (e.g., non-fundamental risk-premium shocks), other short-term stabilization policies, such as FXI, may be desirable for managing the exchange rate as a complement to conventional monetary policy.

- Local Currency Pricing (LCP) mitigates expenditure switching effects and exchange rate pass-through, aligning model predictions better than under Producer Currency Pricing (PCP).

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