Notes on International Prices and Monetary Policy in the Open Economy

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Outline

- Backus - Smith condition.
- Small Open Economy New Keynesian Model
- Local Currency Pricing (LCP) and monetary policy.

More on Complete Markets:

Backus - Smith (1993)

Backus - Smith (1993)

- Complete markets
- Ex-ante symmetric countries
- Preference of Home:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

$$P_t C_t + \sum Q(s_{t+1}) A(s_{t+1}) = W_t L_t + \Pi_t + A_t$$

- Preference of Foreign:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t^*, N_t^*)$$

$$P_t^* C_t^* + \mathcal{E}_t^{-1} \sum Q(\omega_{t+1}) A^*(\omega_{t+1}) = W_t^* L_t^* + \Pi_t^* + \mathcal{E}_t^{-1} A_t^*$$

- 1 dollar of $F = \mathcal{E}$ dollars of H.

Backus-Smith Puzzle

- Same logic as last section, but Arrow securities are now nominal.
- Optimal holding

$$p_t(\omega_{t+1}) = \beta \frac{u'(C_{t+1}(\omega_{t+1}))}{u'(C_t)} \frac{P_t}{P_{t+1}(\omega_{s+1})}$$

  P_t: price of consumption good relative to numeraire.

- Foreign country with nominal exchange rate $\mathcal{E}_t$

$$p_t(\omega_{t+1}) = \beta \frac{u'(C^*_{t+1}(\omega_{t+1}))}{u'(C^*_t)} \frac{P^*_t}{P^*_{t+1}(\omega_{t+1})} \frac{\mathcal{E}_t}{\mathcal{E}_{t+1}(\omega_{t+1})}$$

Efficient risk-sharing

$$\frac{u'(C_{t+1})}{P_{t+1}} = \text{const} \cdot \frac{u'(C^*_{t+1})}{P^*_{t+1}\mathcal{E}_{t+1}}$$

Countries ex-ante symmetric, so const $= 1$. If $u'(C) = C^{-\sigma}$:

$$\left(\frac{C_{t+1}}{C^*_{t+1}}\right)^{-\sigma} = \frac{P_{t+1}}{P^*_{t+1}\mathcal{E}_{t+1}} \equiv \frac{1}{Q_{t+1}}$$

Take logs (and go back 1 day):

$$c_t - c^*_t = \frac{1}{\sigma} q_t$$

- In logs:

$$\Delta c_{t+1} - \Delta c^*_{t+1} = \frac{1}{\sigma} \Delta rer^{cpi}_{t+1}$$

  Countries with high consumption growth are associated with depreciating RER $\Delta rer > 0$.

- In the data: regressing relative consumption growth on RER growth often finds low or negative coefficients.
- *Consumption - RER anomaly* a.k.a. the *Backus-Smith puzzle*.

Small Open Economy New Keynesian Model

Model

- Math gets complicated quickly. Useful to keep track of the main blocks.
- Blocks:
  - Demand: CES with H and F traded goods. No non-traded goods.
  - Assets: Complete markets (+ redundant bonds).
    - Full risk-sharing: $c_t = c_t^* + \frac{1}{\sigma} q_t$ (Backus-Smith condition)
  - Production: labor only, CRS.
  - Price setting: Calvo, PCP vs. LCP

Demand: Preferences

- Preference:

$$U_t = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \left(\frac{C_{t+s}^{1-\sigma}}{1-\sigma} - \frac{N_{t+s}^{1+\varphi}}{1+\varphi} \right)$$

- Intra-period:

$$C_t = \left[(1-\alpha) C_{H,t}^{1-\frac{1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}^{1-\frac{1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

where

$$C_{H,t} = \left[\int C_{H,t}(j)^{1-\frac{1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad C_{F,t} = \left[\int C_{F,t}(j)^{1-\frac{1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}}$$

η: elasticity of substitution between H vs F goods, ε: EoS of goods from same country.

Terms of Trade

- 1 Foreign dollar $= \mathcal{E}_t$ Home dollars ($\mathcal{E}_t \uparrow \Leftrightarrow$ Home depreciation)
- Terms of Trade:

$$s_t \equiv p_{F,t} - (p^*_{H,t} + e_t)$$

- Law of One Price:

$$p_{H,t} = p^*_{H,t} + e_t, \quad s_t = p_{F,t} - p_{H,t}$$

- RER:

$$q_t = p^*_t + e_t - p_t$$

Assets structure: Complete Markets

- Agents can trade a full set of Arrow securities.
- Full risk-sharing:

$$c_t = c_t^* + \frac{1}{\sigma} q_t$$

  This is the Backus - Smith condition.
- Intuition:
  - Suppose in state ω, a positive shock raises Home consumption $c_t(\omega)$ relative to foreign $c_t^*(\omega)$.
  - Home would sell Arrow securities in that good state, while Foreign buys. If that state is realized, there is a transfer from Home to Foreign.
  - With CRRA utility, that transfer is realized by a real depreciation of Home purchasing power ($q_t \uparrow$).
- Alternative interpretation: Consumption should be (relatively) higher when it is (relatively) cheaper.

Useful identities

- PPI to CPI:

$$p_t - p_{H,t} = \alpha s_t$$

  TOT improvement $s_t \downarrow$ means CPI lower relative to PPI $p_t - p_{H,t} \downarrow$.

- RER and TOT:

$$\begin{aligned} q_t &\equiv p_t^* + e_t - p_t \\ &= (1-\alpha)s_t \end{aligned}$$

  - A deterioration of Home TOT $= s_t \uparrow =$ F goods more expensive.
  - Since F consumes F goods in higher proportion (here: 100%) compared to H (here: $1-\alpha$), this leads to higher Foreign CPI than Home, i.e. Home RER depreciation.

Expenditure switching

- In closed economy: $y_t = c_t$. Open economy: $y_t \neq c_t$.
- Market clearing for H goods:

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

Log-linearizing and use Backus-Smith

$$y_t = c_t + \frac{\alpha\overline{\omega}}{\sigma} s_t$$

Expenditure switching

- Increase in the TOT: $s \uparrow \longrightarrow$ H goods cheaper relative to F $\longrightarrow$ both H and F agents substitute towards H goods $\longrightarrow y_t - c_t \uparrow$.
- Note this is not NX due to existence of foreign goods. (Indeed: $nx_t = y_t - c_t - \alpha s_t$)

Demand: Dynamic IS equation in closed economy

- Euler equation:

$$c_t = \mathbb{E}_t c_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{t+1} - \rho)$$

- In closed economy, $c_t = y_t$:

$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{t+1} - \rho)$$

- In open economy, generally $c_t \neq y_t$:

$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{t+1} - \rho) - \frac{\alpha\overline{\omega}}{\sigma}\mathbb{E}_t \Delta s_{t+1}$$

Demand: Intuition

- Expenditure switching effect.
  - If foreign goods are expected to get relatively more expensive ($\Delta s_{t+1} \uparrow$), demand will be substituted into Home goods ($\Delta y_{t+1} \uparrow$), ceteris paribus.
- Traditional NK channel still there:
  - Higher real interest rate ($i - \mathbb{E}\pi_{+1} \uparrow$) substitute demand today for tomorrow ($y_t - \mathbb{E}_t y_{t+1}$) $\downarrow$.
  - Important channel for MP shock: if nominal rate $i \uparrow$, but prices are slow to adjust $\mathbb{E}\pi_{+1} \approx 0$, then can influence the real rate $i - \mathbb{E}\pi_{+1} \uparrow$ and thus demand.
- How do these two channels interact?
  - High real interest rate ($i_t - \mathbb{E}_t \pi_{t+1} \uparrow$) contracts consumption, which leads to Home RER appreciation (risk sharing).
  - Since RER appreciation ($q_t \downarrow$) is associated with a TOT appreciation ($s_t \downarrow$), lowering output further.

Supply and Price-Setting

- Calvo pricing, θ: degree of price stickiness.
- Production:

$$Y_t(j) = A_t N_t(j)$$

- Optimal Price Setting for PCP:

$$\overline{p}_{H,t} = \mu + (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k \mathbb{E}_t \left[mc_{t+k} \right]$$

  - As in the closed economy, optimal reset price is a weighted average of today and future (nominal) marginal cost.
  - The exact total demand does not matter for optimal price.

New Keynesian Phillips Curve

- Rewrite equation for $\overline{p}_{H,t}$ in recursive form:

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \lambda \widehat{rmc}_t$$

where

$$\begin{aligned} \widehat{rmc}_t &= (\sigma - \sigma_\alpha) y_t^* + (\sigma_\alpha + \varphi) y_t - (1 + \varphi) a_t \\ &\equiv (\sigma_\alpha + \varphi)(y_t - y_t^n) \end{aligned}$$

- Higher y_t implies higher real wage due to increased demand for labor.
- Higher y_t^*:
  - increases demand for labor via higher c_t^* and c_t (risk sharing) $\rightarrow rmc \uparrow$.
  - But higher y_t^* leads to TOT appreciation $\rightarrow$ p_H goes up relative to p $\rightarrow$ product wage $w - p_H$ declines relative to $w - p$. $rmc \uparrow$.
  - If elasticities are high, TOT movement is small $\rightarrow$ first effect dominates.

New Keynesian Phillips Curve

- RMC proportional to output gap:

$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa_\alpha (y_t - y_t^n)$$

where:

$$\kappa \equiv \lambda \left(\sigma_\alpha + \varphi \right)$$

$$\sigma_\alpha \equiv \frac{\sigma}{1 + \alpha(\varpi - 1)}$$

- In general: $\sigma_\alpha < \sigma$. Higher openness $\alpha \uparrow \rightarrow$ lower σ_α.
- Higher level of openness reduces sensitivity of inflation to domestic output gap.

Synthesis: Theory

- Important channels:
  - RER and TOT: $q_t = (1-\alpha)s_t$.
  - Risk sharing: $c_t = c_t^* + \frac{1}{\sigma} q_t$.
  - TOT and expenditure switching: $y_t = c_t + \frac{\alpha\overline{\omega}}{\sigma} s_t = y_t^* + \frac{1}{\sigma_\alpha} s_t$
- IS curve:

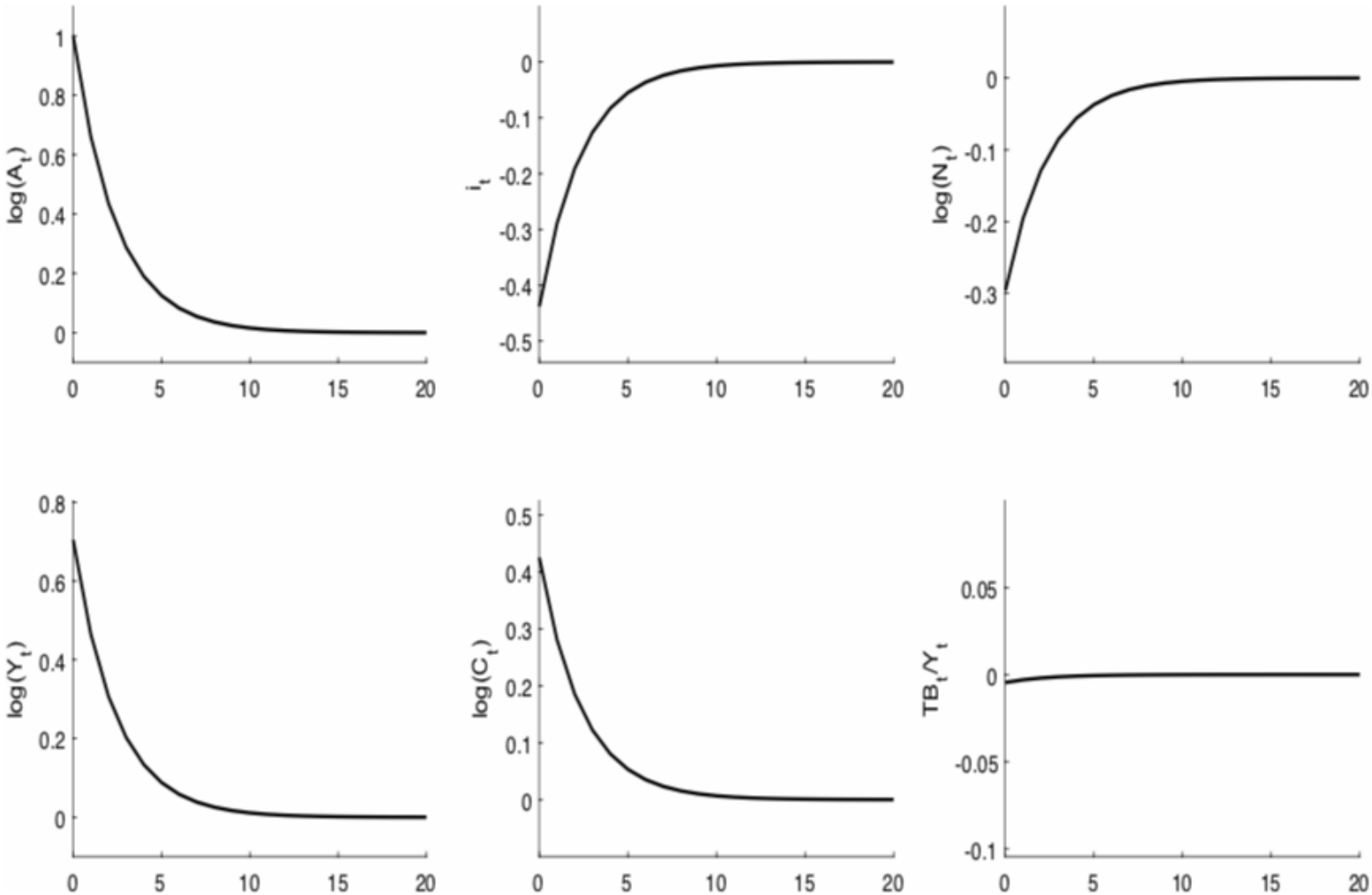
$$y_t = \mathbb{E}_t y_{t+1} - \frac{1}{\sigma}(i_t - \mathbb{E}_t \pi_{t+1} - \rho) - \frac{\alpha\overline{\omega}}{\sigma} \mathbb{E}_t \Delta s_{t+1}$$

  - Direct negative effect of real interest rate amplified by TOT appreciation (expenditure switching channel).
- NKPC curve:

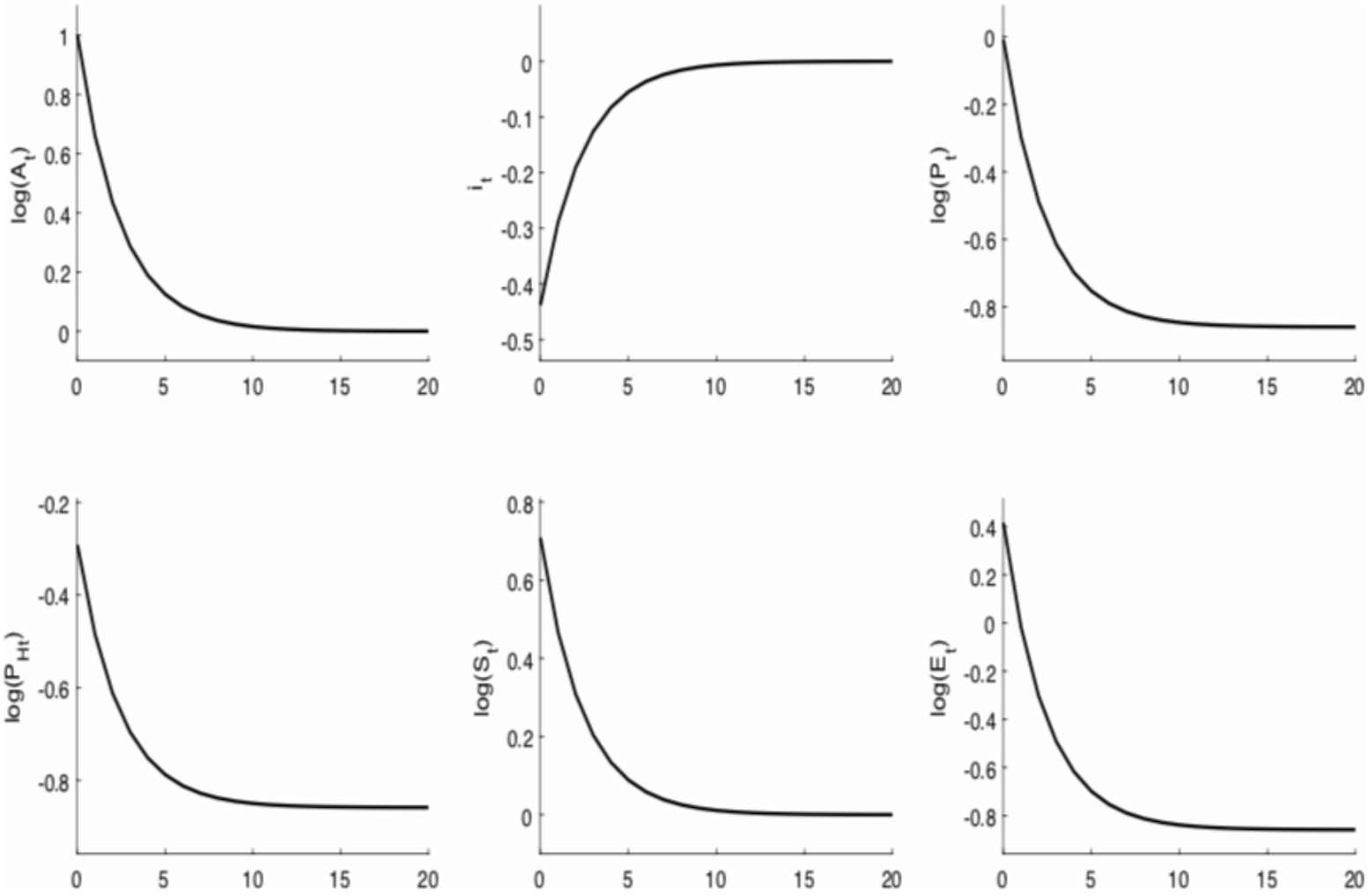
$$\pi_{H,t} = \beta \mathbb{E}_t \pi_{H,t+1} + \kappa_\alpha (y_t - y_t^n)$$

  - Higher level of openness reduces sensitivity of inflation on domestic output.

IRFs: productivity shock



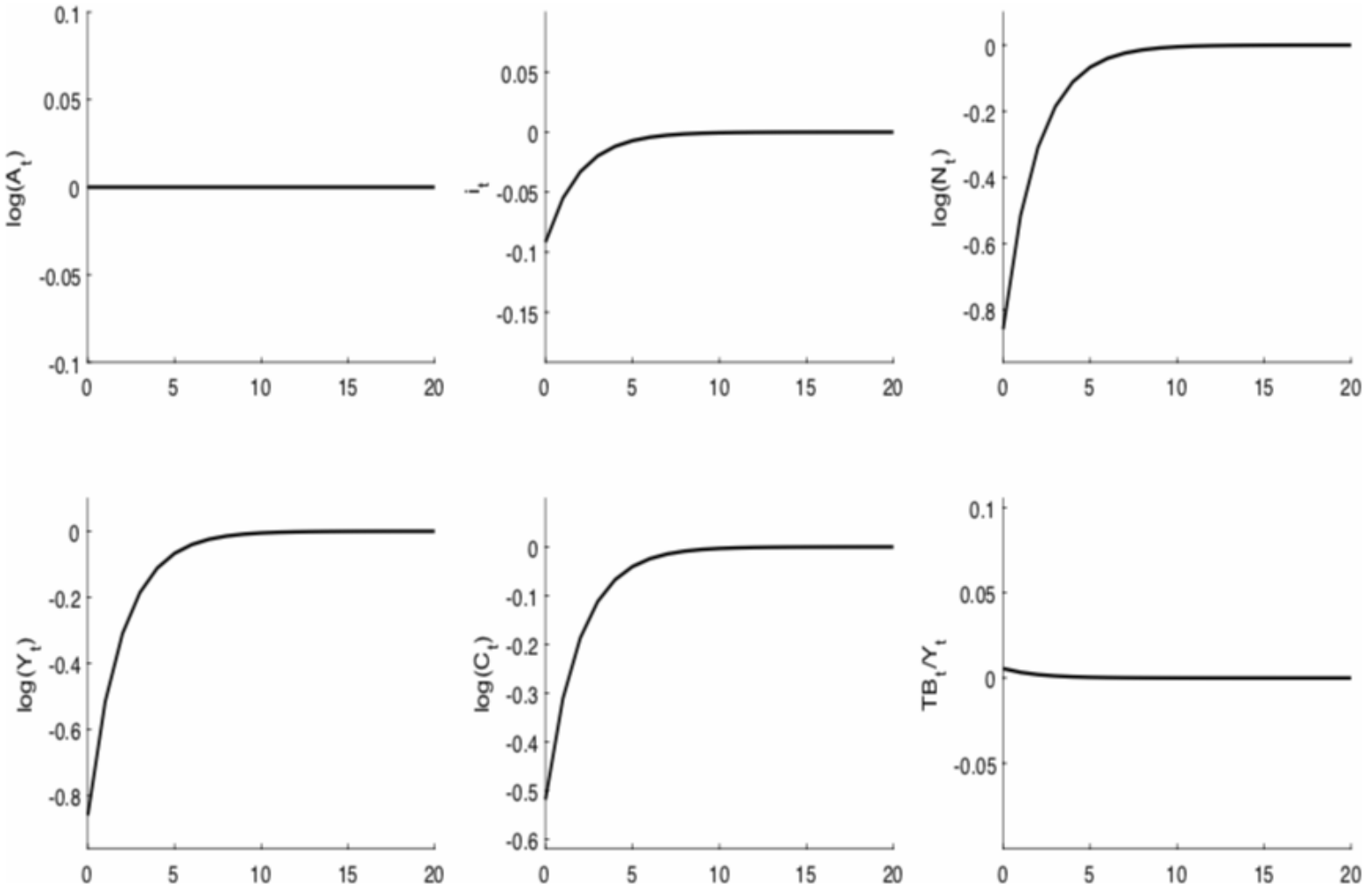
IRFs: productivity shock



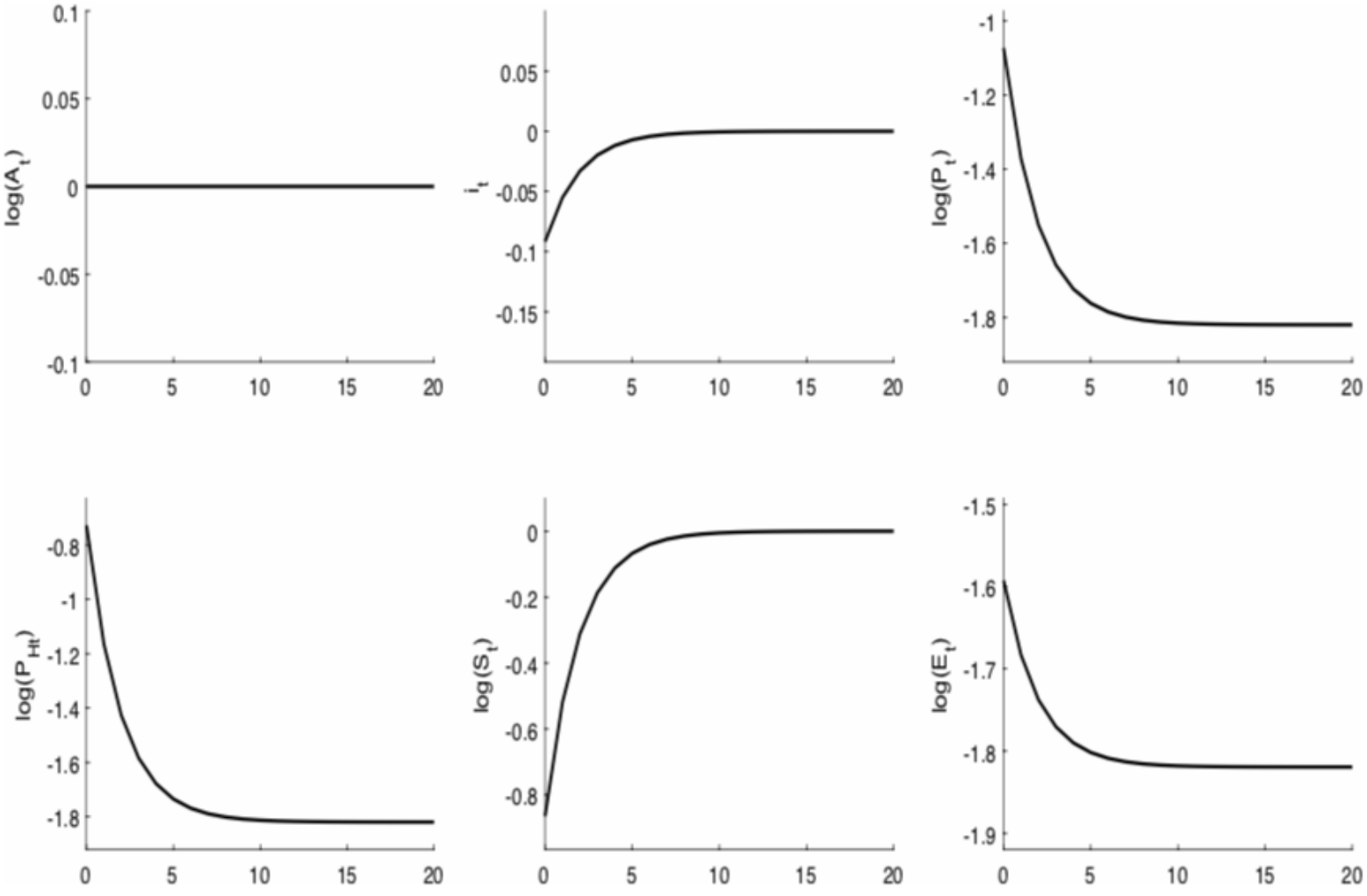
IRFs: productivity shock

- $A \uparrow \rightarrow C \uparrow$, not as much due to sticky price.
- Labor $N = Y/A$ falls due to being more productive, but not much extra demand.
- Risk sharing: $C \uparrow$ implies $Q \uparrow$ (Home depreciation), $S \uparrow$.
- $A \uparrow \rightarrow MC \downarrow \rightarrow P_H \downarrow$.
- Extra: Milton Friedman's argument for float exchange rate:
  - Suppose prices are completely sticky.
  - Shock happens $\rightarrow$ desired reset price changes, but cannot due to sticky price.
  - Exchange rate movement provides a mean to adjust.

IRFs: monetary shock



IRFs: monetary shock



IRFs: monetary policy shock

- Contractionary MP shock $\rightarrow$ Y, C goes down (demand channel)
- Risk sharing $Q\downarrow$,$S\downarrow$. TOT movement amplifies contractionary effect.
- Interest rate actually drops to respond to Y and C.
- Rationale for currency war?
  - Can countries use monetary expansion to stimulate their economies?
  - "Beggar-thy-neighbor" policy: use MP shock to devalue the currency.
  - Here: it seems to work. When will it not work?

Local Currency Pricing & Monetary Policy Implications

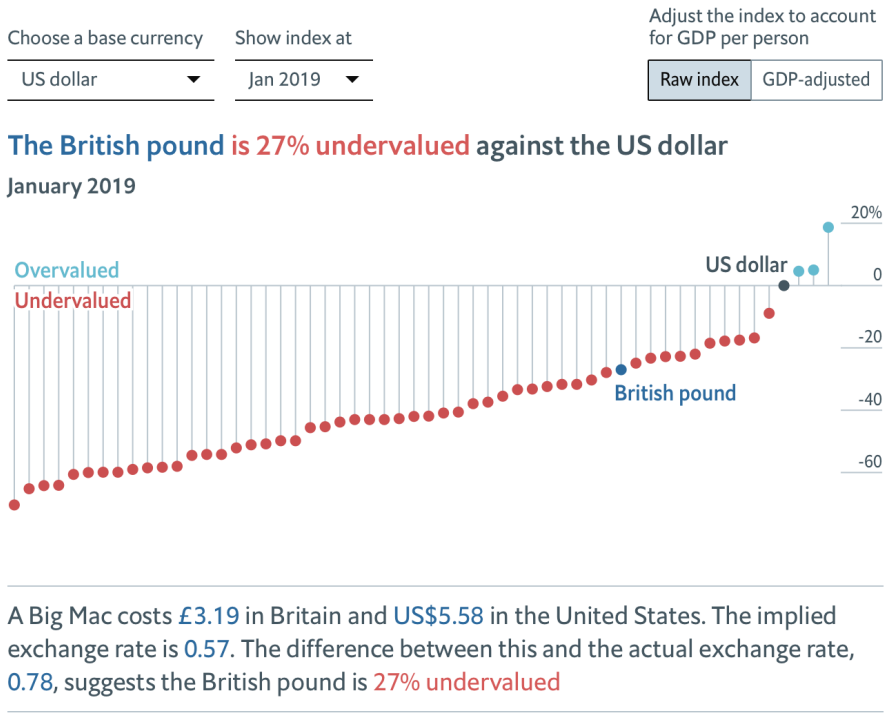
Pricing regimes

- IRFs and optimal policy crucially depends on the way firms price.
- Three main paradigms:
  - Producer Currency Pricing: Home firms set p_H in Home currency, then let foreign prices be the same, adjusting for exchange rate: $p^*_{H,t} = p_H - e_t$. This is called the Law of One Prive (LOP).
  - Local Currency Pricing: Firms set p_H and p_F separately. When shocks happen, may not keep LOP.
  - Dominant Currency Pricing: Every one sets their price in US dollars, then adjusting for exchange rate (if any).
    - Gopinath (2016): for the US, 90% of imports and 97% of exports are denominated in dollars.
- Note: if prices are fully flexible, doesn't matter which paradigm.

The Big Mac Index: violation of LOP

The Big Mac index

Country		2000 —— 2019	Under/over valued, %
Switzerland	Franc		18.7
Norway	Krone		5.0
Sweden	Krona		4.6
United States	US$		BASE CURRENCY
Canada	C$		-8.9
Euro area	Euro		-16.8
Denmark	Krone		-17.5
Israel	Shekel		-17.8
Brazil	Real		-18.5
Australia	A$		-22.0
Lebanon	Pound		-22.7
Uruguay	Peso		-22.8
Singapore	S$		-23.3



Source:
https://www.economist.com/news/2019/01/10/the-big-mac-index

Gopinath (2016): PCP intuition

- Consider Argentina exporting to/importing from the US.
- Under PCP, Argentinian exports are sticky in pesos $\overline{P}^{peso}_{Ar,Ex}$, and Argentinian imports in dollars $\overline{P}^{\$}_{Ar,Im}$.
- Thus, US importers face dollar price $P^{\$}_{Ar,Ex} = \overline{P}^{peso}_{Ar,Ex}/\mathcal{E}_{peso/\$}$. Argentinian importers face peso price $P^{peso}_{Ar,Im} = \overline{P}^{\$}_{Ar,Im} \cdot \mathcal{E}_{peso/\$}$.
- Easy to see 100% ERPT: a 1% depreciation of $\mathcal{E}_{peso/\$}$ leads to 1% increase in $P^{peso}_{Ar,Im}$ and ~1% decrease in $P^{\$}_{Ar,Ex}$.
- Thus, Argentinian imports contract while Argentinian exports boom. Unclear/insignificant change in total trade.

Gopinath (2016): LCP intuition

- Consider Argentina exporting to/importing from the US.
- Under PCP, Argentinian exports are sticky in dollars $\overline{P}^{\$}_{Ar,Ex}$, and Argentinian imports in peso $\overline{P}^{peso}_{Ar,Im}$.
- Thus, US importers face dollar price $\overline{P}^{\$}_{Ar,Ex}$. Argentinian importers face peso price $\overline{P}^{peso}_{Ar,Im}$.
- Easy to see 100% ERPT: in the short-run, moving $\mathcal{E}$ does not affect prices in either country. Thus, unclear/insignificant change in trade volume.

LCP intuition

- Many predictions of the standard SOENK can be flipped if prices are sticky in the destination currency (LCP).
- Suppose an expansionary monetary policy shock.
  - PCP: TOT depreciates. LCP: TOT appreciates.

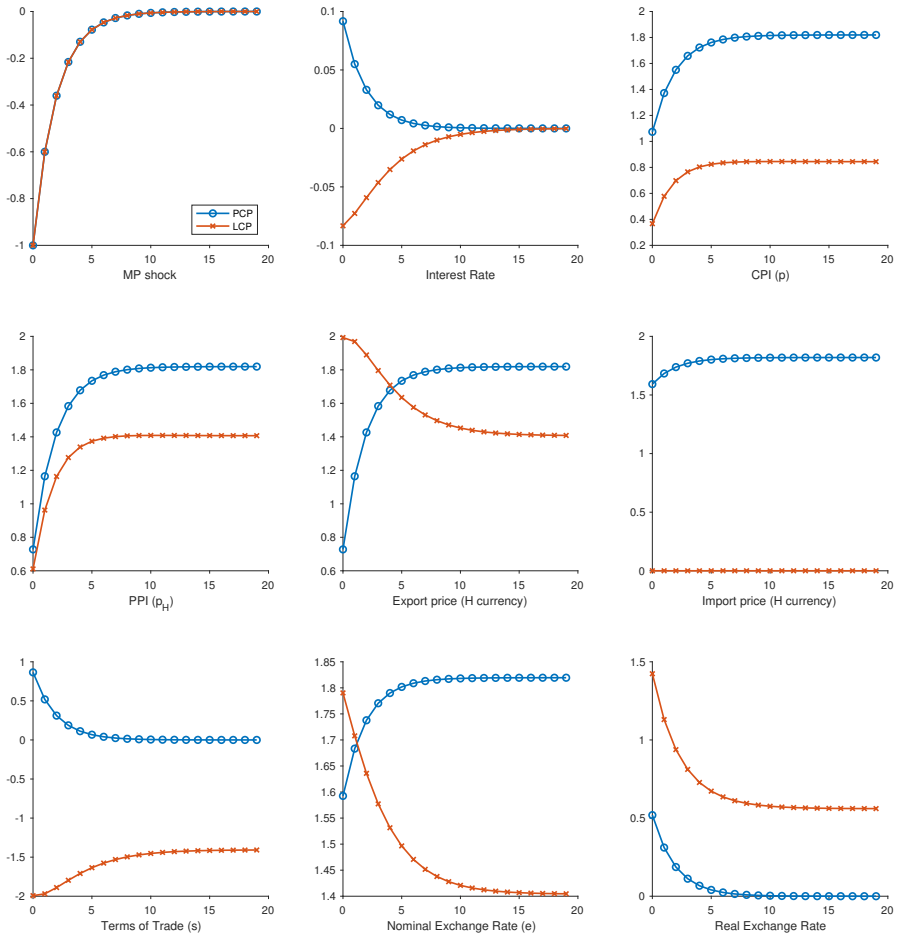
$$S^{PCP} \uparrow = \frac{\overline{P}_F^* \mathcal{E} \uparrow}{\overline{P}_H}, \quad S^{LCP} \downarrow = \frac{\overline{P}_F}{\overline{P}_H^* (MC \uparrow) \mathcal{E} \uparrow}$$

  - Output & consumption:
    - C goes up more in LCP than PCP, Y goes up less.
    - LCP removes traditional expenditure switching effect of home depreciation.

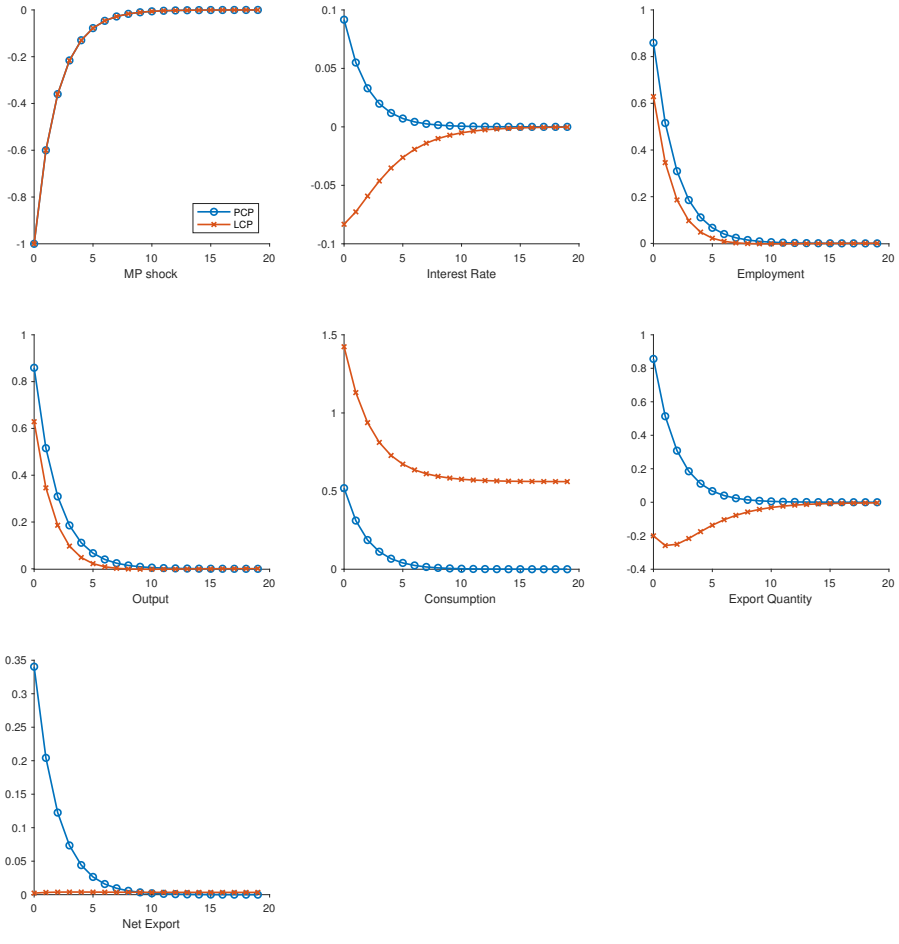
LCP intuition (continued)

- Net exports: MP expansion $\rightarrow$ trade surplus in PCP, but trade deficit in LCP.
  - Again, via TOT channel.
- LOP deviation: LCP home goods at home become cheaper relative to abroad. PCP: no action.
  - Implication for which price index optimal MP should target. PCP: target PPI. LCP: target CPI due to currency misalignment.
- "Currency war" does not work if you are a small nation trading with the US (at least in the short run.)
  - US customers, facing prices fixed in US dollars, do not have incentives to buy more Turkish goods.
  - But Turkish importers face higher import prices since US exports are denominated also in US dollars.

Monetary shock, PCP vs. LCP



Monetary shock, PCP vs. LCP



Gopinath (2016): International Price System

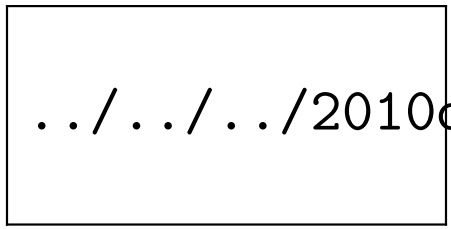


Figure: The effect of 10% home currency devaluation, Gopinath (2016)

Gopinath (2016): World currency of invoicing

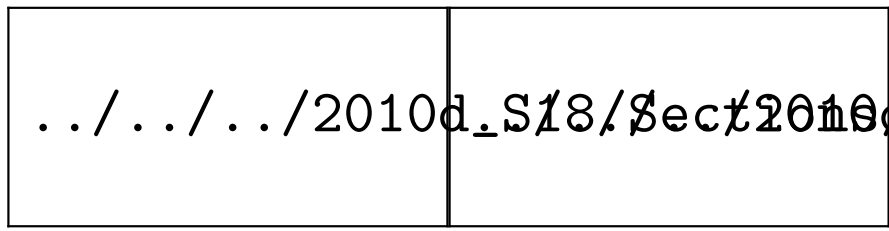


Figure: Overwhelming share of world trade invoiced in dollar, Gopinath (2016)

Policy implications

In this international price system, where dollar dominates as a currency of invoicing:

- Inflation sensitivity (to ER shocks) is well-proxied by fraction of imports denominated in foreign currency.
  - US has ~90% imports denominated in dollars, thus ER shocks matter little to US inflation.
  - But a dollar appreciation (and depreciation of other currencies) has strong inflationary impact on other countries.
- Monetary policy spillover:
  - A US tightening which makes dollar appreciate can raise inflation in RoW, forcing those countries to raise rates too to combat inflation.
  - But MP in other countries matter little to the US.
- Internationalization of currency:
  - China's push for yuan to be an international currency may help China insulate from ER shocks.