Monetary policy in the open economy

NBER Heterogeneous-Agent Macro Workshop

Ludwig Straub

Spring 2022

Today

So far, we focused on closed economy models of fiscal and monetary policy.

Today: Monetary policy in an *open* economy. What changes?

- Exports & imports are new **source** and **destination** for demand
- Extent is controlled by **exchange rate** $\rightarrow$ new transmission mechanisms

Slides based on Galí and Monacelli (2005) and Auclert et al. (2021) but hopefully useful to organize this literature more broadly.

Other interesting recent work in this area: de Ferra et al. (2020), Cugat (2019), Giagheddu (2020), Zhou (2022), Kekre and Lenel (2020), Guo et al. (2021)

Proceed in three steps

1. Introduce model that nests both HA & RA setting
   - RA model will correspond almost literally to seminal Galí and Monacelli (2005) model
2. Study effect of **exchange rate shocks** (due to capital flows)
   - first RA, then HA
   - will see that RA = HA for some value of trade elasticity χ
   - but likely that short run χ smaller, leading to RA $\neq$ HA
3. Study effect of **monetary policy**
   - this is what Galí and Monacelli (2005) focus on
   - will see that again RA = HA for some (other) value of trade elasticity χ

Roadmap

1. HANK meets Gali-Monacelli
2. Capital flows and exchange rates
3. Monetary policy and exchange rates
4. Conclusion

HANK meets Gali-Monacelli

Model overview

- Discrete time, small open economy (SOE) model
  - No aggregate uncertainty + small shocks (first order perturb. wrt aggregates)
- Two goods
  - "Home": H, produced at home. Price P_{Ht} at home, P^*_{Ht} abroad
  - "Foreign": F, produced abroad. Price P_{Ft} at home, $P^*_{Ft} \equiv 1$ abroad
  - Consumed in bundles. Price P_t of bundle at home, $P^*_t \equiv 1$ abroad
  - Nominal rigidities in wages
- Two classes of agents
  - large mass of foreign households
  - mass 1 of domestic households, **possibly subject to idiosyncratic income risk**

Households' consumption behavior

- Foreign households have fixed real C^*. Domestic **HA**: **intertemporal problem**

$$\max_{\{c_{it}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left\{ \frac{c_{it}^{1-\sigma}}{1-\sigma} - v(N_t) \right\}$$

$$c_{it} + a_{it} = (1 + r_t) a_{it-1} + e_{it} Z_t \qquad a_{it+1} \geq 0 \qquad C_t \equiv \int c_{it} di$$

  - a_{it} = position in domestic mutual fund
  - with **RA:** complete markets across hh & countries $\Rightarrow C_t^{-\sigma} = \beta\,(1 + r_{t+1})\, C_{t+1}^{-\sigma}$

- Both domestic & foreign have CES bundle, solve **intratemporal problem**

$$C_{Ht} = (1-\alpha) \left(\frac{P_{Ht}}{P_t} \right)^{-\eta} C_t \qquad C_{Ht}^* = \alpha \left(\frac{P_{Ht}^*}{P^*} \right)^{-\gamma} C^*$$

- Domestic production and market clearing: $Y_t = N_t = C_{Ht} + C_{Ht}^*$

Prices and nominal rigidities

- Exchange rates: nominal $\mathcal{E}_t$, real $Q_t \equiv \mathcal{E}_t / P_t$, $\uparrow$ is depreciation

- Standard nominal wage rigidity [Erceg et al. 2000, Auclert et al. 2018]

$$\pi_{wt} = \kappa_w \left(v'\left(N_t\right) - \frac{\epsilon - 1}{\epsilon} \frac{W_t}{P_t} u'\left(C_t\right) \right) + \beta \pi_{wt+1}$$

- For now, flexible prices everywhere else: at home ...

$$P_{Ft} = \mathcal{E}_t \qquad P_{Ht} = \mu \cdot W_t$$

- ... and abroad (as in producer currency pricing, PCP)

$$P^*_{Ht} = \frac{P_{Ht}}{\mathcal{E}_t}$$

- Consider dollar currency pricing (DCP) in Auclert et al. (2021)

Monetary policy and assets

- Three types of assets
  - zero net supply: nominal home & foreign bonds
  - positive supply: shares in H firms $v_t = (v_{t+1} + \text{div}_{t+1})/(1 + r_t^{ante})$
  - asset market clearing $\qquad A_t = v_t + NFA_t$
- Domestic central bank sets nominal rate i_t on nominal home bonds
  - for now, it targets CPI-based real interest rate, $i_t = r_t^{ante} + \pi_{t+1}$
- Interest rate on foreign bonds is i_t^*, shocks to $i_t^* \equiv$ shocks to β abroad
- Mutual fund & foreigners invest freely in all assets
  - equalized $\mathbb{E}$ returns $\Rightarrow$ return on mutual fund is $r_{t+1} = r_t^{ante}\ \forall t \geq 0$
  - UIP holds

$$1 + i_t = (1 + i_t^*)\,\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \qquad 1 + r_t^{ante} = (1 + i_t^*)\,\frac{Q_{t+1}}{Q_t}$$

Benchmark model calibration

- Calibrate $\alpha = 0.40$ and balanced trade as in Gali-Monacelli
- Initial mutual fund portfolio invested 100% in domestic stocks
- **Allow for general substitution elasticities η, γ for now**
- Quarterly persistence of i_t^* and m.p. shocks ϵ_t of $\rho = 0.85$
- Standard calibration for HA part
  - EIS $\sigma^{-1} = 1$
  - target Peruvian data on MPCs and income risk [Hong 2020]
  - β heterogeneity to get reasonable average MPC & distribution
- Note: **HA model already stationary**, no need for debt-elastic interest rate [Schmitt-Grohé and Uribe 2003]

Capital flows and exchange rates

Setup

- Consider a temporary shock $i_t^* \uparrow$

$\rightarrow$ Effect on path of real exchange rate: (long-run PPP)

$$dQ_t = \frac{1}{1+r} \sum_{s \geq 0} di^*_{t+s}$$

so $Q_t \uparrow$, $\frac{P_{Ht}}{P_t} \downarrow$, and $\frac{P_{Ht}}{\mathcal{E}_t} \downarrow$ (real depreciation)

$\rightarrow$ Effect on demand for home goods:

$$Y_t = (1-\alpha) \left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C_t + \alpha \left(\frac{P_{Ht}}{\mathcal{E}_t}\right)^{-\gamma} C^*$$

- **Next:** **RA**, then **HA**

Textbook RA complete markets model

- In **RA** : complete markets + r constant $\Rightarrow C_t = C$ (Why?)

$$Y_t = (1-\alpha)\left(\frac{P_{Ht}}{P_t}\right)^{-\eta} C + \alpha\left(\frac{P_{Ht}}{\mathcal{E}_t}\right)^{-\gamma} C^*$$

- Linearize around SS with $Y = C = C^* = 1$:

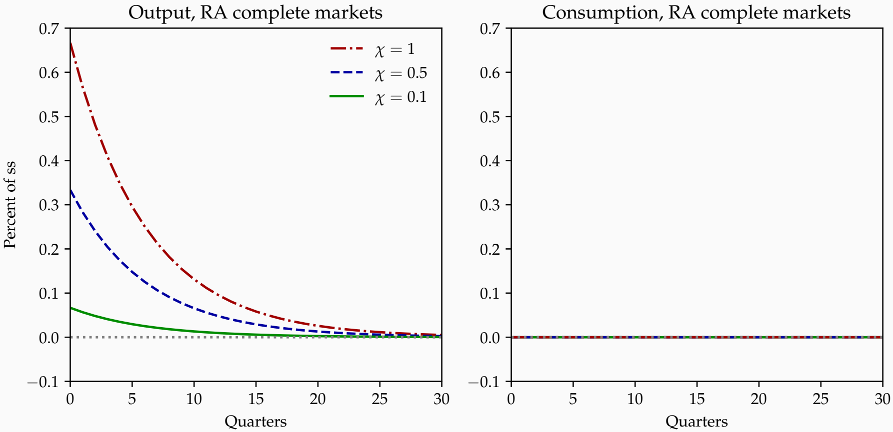
$$dY_t = \frac{\alpha}{1-\alpha}\left(\underbrace{\eta(1-\alpha)}_{H \text{ exp. switching}} + \underbrace{\gamma}_{F \text{ exp. switching}}\right) dQ_t$$

- Define **trade elasticity** $\chi \equiv \eta(1-\alpha) + \gamma$, use bold for time paths:

$$d\mathbf{Y} = \frac{\alpha}{1-\alpha}\chi d\mathbf{Q}$$

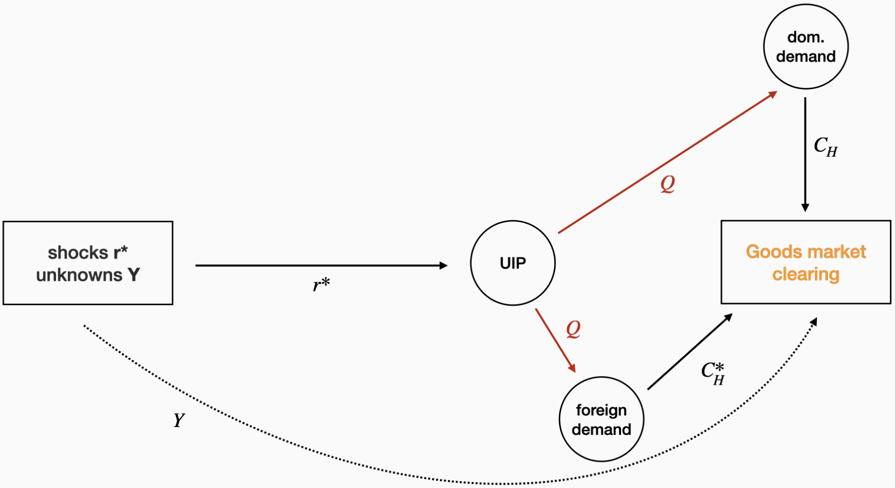
[sum of elasticities of imports and exports to P_F/P_H, cf Marshall-Lerner condition]

Representative agent: Exchange rate shock



(i_t^* shock of quarterly persistence $\rho = 0.85$ and impact effect of 1% on Q.)

Visualization (DAG)



What changes with heterogeneous agents?

- In **HA**, C_t is affected by Z_t and r_t (through dividends):

$$Z_t = \frac{W_t}{P_t} N_t = \frac{1}{\mu} \frac{P_{Ht}}{P_t} Y_t \qquad \text{div}_t = \left(1 - \frac{1}{\mu}\right) \frac{P_{Ht}}{P_t} Y_t$$

- As usual, we can write

$$C_t = \mathcal{C}_t \left(\{Z_t, r_t\}\right)$$

- But since r_t is entirely determined by $\text{div}_t = \left(1 - \frac{1}{\mu}\right) \frac{P_{Ht}}{P_t} Y_t$ here, we'll write

$$C_t = \tilde{\mathcal{C}}_t \left(\left\{ \frac{P_{Hs}}{P_s} Y_s \right\}\right)$$

- Two effects of the exchange rate
    - relative price $\frac{P_{Ht}}{P_t}$ falls $\rightarrow$ **real income channel**
    - production Y_t changes $\rightarrow$ (Keynesian) **multiplier channel**

International Keynesian cross

- To linearize, we define here $M_{t,s} \equiv \frac{\partial \tilde{C}_t}{\partial Y_s}$ (Jacobian), stacked as $\mathbf{M}$

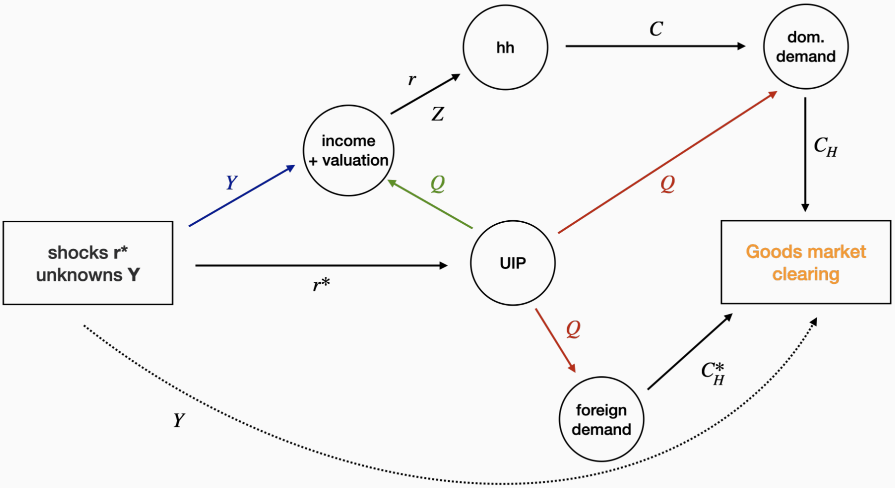
Theorem

$d\mathbf{Y}$ solves an "international Keynesian cross" type equation

$$d\mathbf{Y} = \underbrace{\frac{\alpha}{1-\alpha}\chi d\mathbf{Q}}_{\text{Expenditure switching}} - \underbrace{\alpha \mathbf{M} d\mathbf{Q}}_{\text{Real income}} + \underbrace{(1-\alpha)\mathbf{M} d\mathbf{Y}}_{\text{Multiplier}}$$

- Use this to solve the model & decompose sources of effects on $d\mathbf{Y}$
- Entire role of heterogeneity encoded in $\mathbf{M}$ matrix, RA corresponds to $\mathbf{M} = 0$

Visualization (DAG)



General equilibrium neutrality result for $\chi = 1$

Theorem

$\chi = 1 \quad \Rightarrow \quad d\mathbf{Y}^{HA} = d\mathbf{Y}^{RA} = \frac{\alpha}{1-\alpha} d\mathbf{Q}$

Heterogeneity is ***irrelevant*** *for output effect of exchange rate*

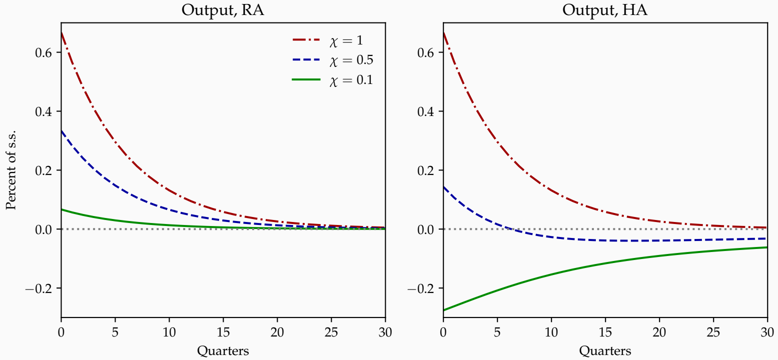
- How to prove? Just plug guess into "international Keynesian cross":

$$\frac{\alpha}{1-\alpha} d\mathbf{Q} = \frac{\alpha}{1-\alpha} d\mathbf{Q} - \alpha \mathbf{M} d\mathbf{Q} + (1-\alpha)\mathbf{M} \frac{\alpha}{1-\alpha} d\mathbf{Q}$$

- **Multiplier channel** undoes **real income channel**
- Intuition: Marshall-Lerner condition, net exports unchanged if $\chi = 1$
- More generally, for $d\mathbf{Q} \geq 0$, can show $d\mathbf{Y}^{HA} < d\mathbf{Y}^{RA}$ if and only if $\chi < 1$.

Contractionary devaluations in output for low χ

- When χ is small, the fall in consumption overwhelms expenditure switching:



→ Open economy **HA** model can generate **contractionary depreciations**!

→ When is this likely? If substitution away from imports is hard ... energy?

Monetary policy and exchange rates

Monetary policy and heterogeneity in open economy

- Monetary policy moves exchange rates, too
- How does monetary transmission change with HA?
- We study this by considering shocks to r_t^{ante} directly (Taylor rule very similar)

Monetary policy shocks

- Stack dr_t^{ante}, dQ_t again, into $d\mathbf{r}^{ante}, d\mathbf{Q}$. Generalized version of result above:

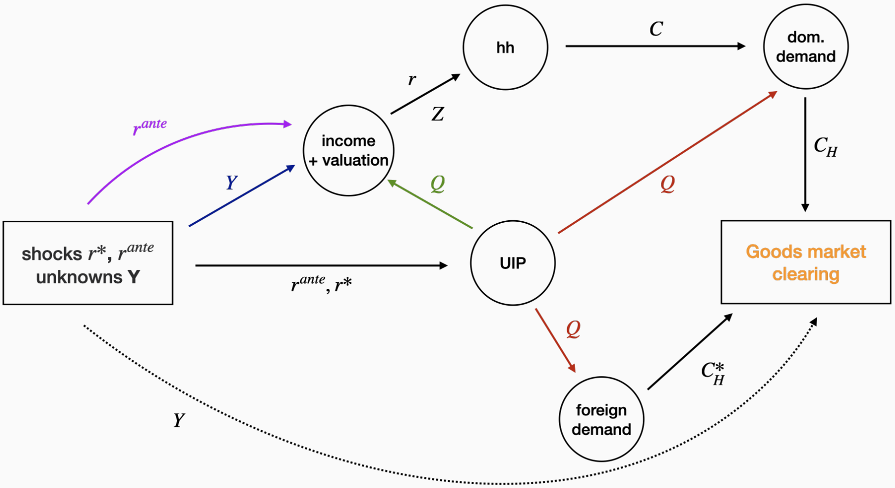
Theorem

$d\mathbf{Y}$ still solves an international Keynesian cross

$$d\mathbf{Y} = \underbrace{(1-\alpha)\,\mathbf{M}^r d\mathbf{r}^{ante}}_{\text{Interest rate channel}} + \underbrace{\frac{\alpha}{1-\alpha}\chi d\mathbf{Q}}_{\text{Expenditure switching}} - \underbrace{\alpha \mathbf{M} d\mathbf{Q}}_{\text{Real income}} + \underbrace{(1-\alpha)\mathbf{M} d\mathbf{Y}}_{\text{Multiplier}}$$

- Previous channels reappear b/c $d\mathbf{r}^{ante}$ moves real exchange rate $d\mathbf{Q}$
- New **interest rate channel**, capturing direct effect of dr_t^{ante} on C_{Ht}
  - mainly intertemporal substitution

Visualization of the four channels (DAG)



Neutral case is now higher: $\chi = 2 - \alpha$

- Well understood from closed economy that r channel weaker in HA

  [Werning 2015, McKay et al. 2016, Kaplan et al. 2018]

- Natural to suspect that HA $<$ RA for $\chi = 1$, previous neutrality result breaks...

... but there is still neutrality with a higher threshold $\chi = 2 - \alpha$:

Theorem

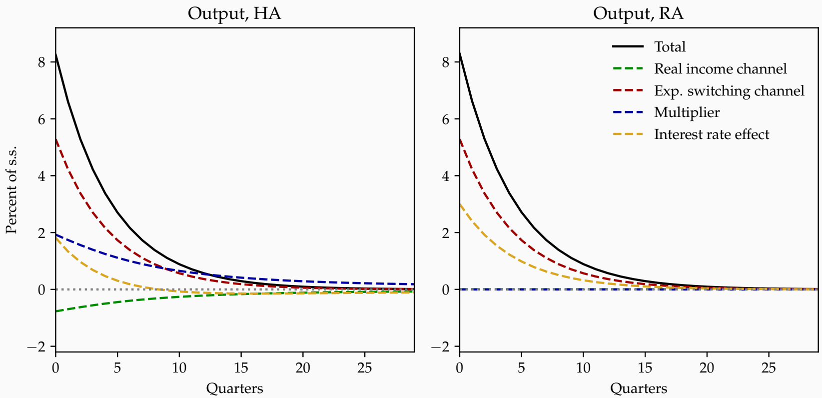
Let $\sigma = 1$ and $\{dr_t^{ante}\}$ be any small monetary policy shock:

- $\chi = 2 - \alpha \Rightarrow$ *all aggregate quantities and prices are identical in HA and RA*
- $\chi < 2 - \alpha \Rightarrow$ *accommodative shocks are weaker in HA, $d\mathbf{Y}^{HA} < d\mathbf{Y}^{RA}$*

Intuition: $\chi = 2 - \alpha$ incl. Cole-Obstfeld case $\sigma = \gamma = \eta = 1$, where NFA = 0

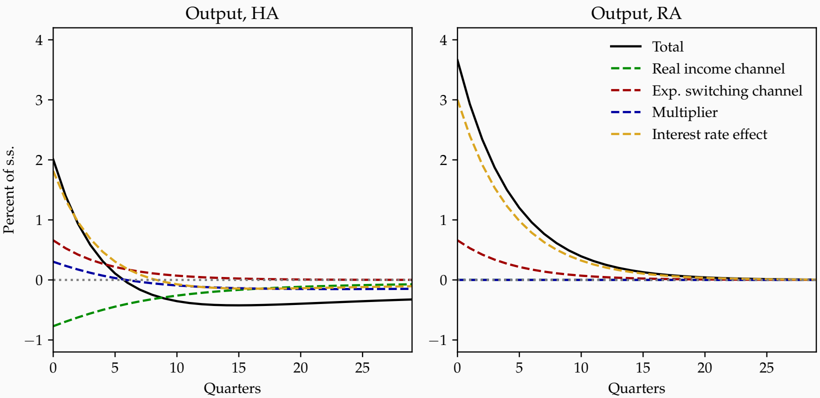
Then apply closed economy neutrality result in Werning (2015)

Monetary policy channels for $\chi = 2 - \alpha$



- Real income channel + weaker r channel undone by multiplier effect
- What if χ smaller?

Monetary policy channels with smaller χ

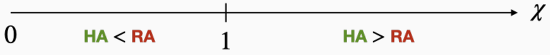


- With smaller χ, real income and interest rate effect pull down $d\mathbf{Y}$ over time!
- **Monetary easing "steals" demand from the future.**

Conclusion

Summary

Exchange rate shocks (r^* shocks, UIP shocks):



Monetary policy shocks:

References

Auclert, A., Rognlie, M., Souchier, M., and Straub, L. (2021). Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel. Working Paper 28872, National Bureau of Economic Research,.

Auclert, A., Rognlie, M., and Straub, L. (2018). The Intertemporal Keynesian Cross. Working Paper 25020, National Bureau of Economic Research,.

Cugat, G. (2019). Emerging Markets, Household Heterogeneity, and Exchange Rate Policy. *Manuscript*.

de Ferra, S., Mitman, K., and Romei, F. (2020). Household Heterogeneity and the Transmission of Foreign Shocks. *Journal of International Economics*, 124:1–18.

Erceg, C. J., Henderson, D. W., and Levin, A. T. (2000). Optimal Monetary Policy with Staggered Wage and Price Contracts. *Journal of Monetary Economics*, 46(2):281–313.

Galí, J. and Monacelli, T. (2005). Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies*, 72(3):707–734.

Giagheddu, M. (2020). The Distributional Implications of Fiscal Devaluations. Working Paper 3651258, Social Science Research Network,.

Guo, X., Ottonello, P., and Perez, D. (2021). Monetary Policy and Redistribution in Open Economies. Working Paper 28213, National Bureau of Economic Research,.

Hong, S. (2020). MPCs and Liquidity Constraints in Emerging Economies. *Manuscript*.

Kaplan, G., Moll, B., and Violante, G. L. (2018). Monetary Policy According to HANK. *American Economic Review*, 108(3):697–743.

Kekre, R. and Lenel, M. (2020). Dollar Demand and International Risk Sharing. *Manuscript*.

McKay, A., Nakamura, E., and Steinsson, J. (2016). The Power of Forward Guidance Revisited. *American Economic Review*, 106(10):3133–3158.

Schmitt-Grohé, S. and Uribe, M. (2003). Closing Small Open Economy Models. *Journal of International Economics*, 61(1):163–185.

Werning, I. (2015). Incomplete Markets and Aggregate Demand. Working Paper 21448, National Bureau of Economic Research,.

Zhou, H. (2022). Open Economy, Redistribution, and the Aggregate Impact of External Shocks. *Working Paper*.