Monetary policy in the open economy

NBER Heterogeneous-Agent Macro Workshop

Ludwig Straub

Spring 2022
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 $\chi$
   - but likely that short run $\chi$ 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 $\chi$
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**

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

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

- $a_{it} =$ 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 **intragetemoral problem**

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

- 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
  \[ \pi_{wt} = \kappa_w \left( v'(N_t) - \epsilon \frac{1}{\epsilon} \frac{W_t}{P_t} u'(C_t) \right) + \beta \pi_{wt+1} \]  
  \[ \text{[Erceg et al. 2000, Auclert et al. 2018]} \]

- For now, flexible prices everywhere else: at home ...
  \[ P_{Ft} = \mathcal{E}_t \quad P_{Ht} = \mu \cdot W_t \]

- ... 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 $v_t = (v_{t+1} + \text{div}_{t+1})/(1 + r^{ante}_t)$
  - Asset market clearing $A_t = v_t + NFA_t$

- Domestic central bank sets nominal rate $i_t$ on nominal home bonds
  - For now, it targets CPI-based real interest rate, $i_t = r^{ante}_t + \pi_{t+1}$

- Interest rate on foreign bonds is $i^*_t$, shocks to $i^*_t \equiv$ shocks to $\beta$ abroad

- Mutual fund & foreigners invest freely in all assets
  - Equalized $E$ returns $\Rightarrow$ return on mutual fund is $r_{t+1} = r^{ante}_t \forall t \geq 0$
  - UIP holds
    
    $1 + i_t = (1 + i^*_t) \frac{E_{t+1}}{E_t}$
    
    $1 + r^{ante}_t = (1 + i^*_t) \frac{Q_{t+1}}{Q_t}$
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** $\eta, \gamma$ for now
- Quarterly persistence of $i_t^*$ and m.p. shocks $\epsilon_t$ of $\rho = 0.85$
- Standard calibration for HA part
  - EIS $\sigma^{-1} = 1$
  - target Peruvian data on MPCs and income risk [Hong 2020]
  - $\beta$ 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
• Consider a temporary shock $i_t^* \uparrow$

→ 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 $\frac{P_{Ht}}{\varepsilon_t} \downarrow$ (real depreciation)

→ Effect on demand for home goods:

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

• **Next**: RA, then HA
Textbook RA complete markets model

• In RA: complete markets + r constant ⇒ $C_t = C$ (Why?)

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

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

$$dY_t = \frac{\alpha}{1 - \alpha} \left( \eta (1 - \alpha) + \gamma \right) dQ_t$$

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

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

[sum of elasticities of imports and exports to $P_F/P_H$, cf Marshall-Lerner condition]
Representative agent: Exchange rate shock

\[ \chi = 1 \]
\[ \chi = 0.5 \]
\[ \chi = 0.1 \]

\( i^*_t \) shock of quarterly persistence \( \rho = 0.85 \) and impact effect of 1% on \( Q \).
Visualization (DAG)

- Shocks $r^*$ and unknowns $Y$
- UIP
- Foreign demand $Q$
- Goods market clearing $C_H$
- Domestic demand $C_H$

Connections:
- $r^*$ from shocks to UIP
- $Q$ from UIP to foreign demand
- $Q$ from UIP to goods market clearing
- $C_H$ from foreign demand to goods market clearing
- $Y$ from shocks to UIP

Note: The diagram illustrates the interactions between shocks, UIP, foreign demand, and goods market clearing.
What changes with heterogeneous agents?

- In **HA**, $C_t$ is affected by $Z_t$ and $r_t$ (through dividends):
  
  $$Z_t = \frac{W_t}{P_t} N_t = \frac{1}{\mu} \frac{P_{Ht}}{P_t} Y_t$$
  
  $$\text{div}_t = \left( 1 - \frac{1}{\mu} \right) \frac{P_{Ht}}{P_t} Y_t$$

- As usual, we can write
  
  $$C_t = C_t (\{Z_t, r_t\})$$

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

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

Theorem

d$Y$ solves an “international Keynesian cross” type equation

$$dY = \frac{\alpha}{1 - \alpha} \chi dQ - \alpha M dQ + (1 - \alpha) M dY$$

- Expenditure switching
- Real income
- Multiplier

• Use this to solve the model & decompose sources of effects on $dY$

• Entire role of heterogeneity encoded in $M$ matrix, RA corresponds to $M = 0$
Visualization (DAG)

- shocks $r^*$
- unknowns $Y$
- income + valuation
- $r^*$
- $Y$
- $r$
- $Z$
- $Q$
- $Q$
- $C$
- $C_H$
- dom. demand
- Goods market clearing
- UIP
- foreign demand
- $C^*_H$
General equilibrium neutrality result for \( \chi = 1 \)

<table>
<thead>
<tr>
<th>Theorem</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi = 1 ) \quad \Rightarrow \quad dY^{HA} = dY^{RA} = \frac{\alpha}{1-\alpha}dQ )</td>
</tr>
</tbody>
</table>

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

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

  \[
  \frac{\alpha}{1-\alpha}dQ = \frac{\alpha}{1-\alpha}dQ - \alphaMdQ + (1-\alpha)M\frac{\alpha}{1-\alpha}dQ
  \]

- **Multiplier channel** undoes **real income channel**

- Intuition: Marshall-Lerner condition, net exports unchanged if \( \chi = 1 \)

- More generally, for \( dQ \geq 0 \), can show \( dY^{HA} < dY^{RA} \) if and only if \( \chi < 1 \).
Contractionary devaluations in output for low $\chi$

- When $\chi$ is small, the fall in consumption overwhelms expenditure switching:

  $\rightarrow$ Open economy HA model can generate contractionary depreciations!

  $\rightarrow$ 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 $dr^{ante}, dQ$. Generalized version of result above:

**Theorem**

$dY$ still solves an international Keynesian cross

$$dY = (1 - \alpha)M^r dr^{ante} + \frac{\alpha}{1 - \alpha}\chi dQ - \alpha MdQ + (1 - \alpha)MdY$$

- Previous channels reappear b/c $dr^{ante}$ moves real exchange rate $dQ$
- 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 $\text{HA} < \text{RA}$ 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, $dY^{\text{HA}} < dY^{\text{RA}}$

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 $\chi$ smaller?
Monetary policy channels with smaller $\chi$

- With smaller $\chi$, real income and interest rate effect pull down $dY$ over time!
- Monetary easing “steals” demand from the future.
Conclusion
Exchange rate shocks ($r^*$ shocks, UIP shocks):

\[0 \quad \text{HA < RA} \quad 1 \quad \text{HA > RA}\]

Monetary policy shocks:

\[0 \quad \text{HA < RA} \quad 2 - \alpha \quad \text{HA > RA}\]
References


References


