



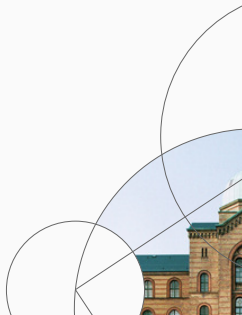
# 13. I-HANK

Adv. Macro: Heterogenous Agent Models

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# Introduction

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- **So far:**
  - How does heterogeneity matter for business cycles and policy in **closed economies**
- **Today:**
  - Extend to **small open economy** (SOE) setting
  - $\Rightarrow$  The *International* HANK Model (*IHANK*)
- **Literature:**
  - Auclert, Rognlie, Souchier, & Straub (2024) »Exchange rates and monetary policy with heterogeneous agents: Sizing up the real income channel«
  - Druedahl, Ravn, Sunder-Plassmann, Sundram, & Waldstrøm (2024) »The Transmission of Foreign Demand Shocks«
  - Druedahl, Ravn, Sunder-Plassmann, Sundram, & Waldstrøm (2024) »Fiscal Multipliers in Small Open Economies With Heterogeneous Households«

# **IHANK Model**

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# Small Open Economy HANK Model

- The »Small Open economy« version of the NK model:  
**Gali-Monacelli (2005)**
  - Adds role for *capital flows, trade and exchange rates* in the NK model
- IHANK model:
  - Take Gali-Monacelli
  - Add sticky wages
  - Add heterogeneous agents

# Model components

- **Households**

- Standard HA: Face idiosyncratic income risk + borrowing constraint
- Choose between consumption of domestic and foreign *tradeable* goods

- **Firms**

- Produce domestic *tradeable* good using labor
- Have market power

- **Unions**

- Decide on labor supply for HHs subject to wage adjustment cost

- **Mutual fund**

- Collect household savings and invest in available assets (domestic firm equity + **foreign bonds**)
- $\Rightarrow$  Free capital flows

- **Central bank**

- **Foreign economy** (mostly exogenous)

- **Household problem:**

$$v_t(z_{it}, a_{it-1}) = \max_{c_{it}} \frac{c_{it}^{1-\sigma}}{1-\sigma} - \varphi \frac{\ell_{it}^{1+\nu}}{1+\nu} + \beta \mathbb{E}_t [v_{t+1}(z_{it+1}, a_{it})]$$

$$\text{s.t. } a_{it} + c_{it} = (1 + r_t^a) a_{t-1} + Z_t z_{it}$$

$$\log z_{it+1} = \rho_z \log z_{it} + \psi_{it+1}, \psi_t \sim \mathcal{N}(\mu_\psi, \sigma_\psi), \mathbb{E}[z_{it}] = 1$$

$$a_{it} \geq 0$$

- **Active decisions:** Consumption-saving,  $c_{it}$  (and  $a_{it}$ )
- **Union decision:** Labor supply,  $\ell_t$
- **Aggregate Consumption:**  $C_t^{hh} = \int c_{it} d\mathcal{D}_{it}$
- **Consumption function:**  $C_t^{hh} = C^{hh}(\{r_s^a, Z_s\}_{s=0}^\infty)$

# Consumption basket

- Consumption  $c_{it}$  is a basket composed of:
  - Domestic goods  $c_{H,it}$
  - Foreign goods  $c_{F,it}$
- CES preferences over these with weight  $\alpha$  on imports:

$$c_{it} = \left[ \alpha^{1/\eta} c_{F,it}^{\frac{\eta-1}{\eta}} + (1-\alpha)^{1/\eta} c_{H,it}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

- **FOCs:**

$$c_{F,it} = \alpha \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} c_{it}, \quad c_{H,it} = (1-\alpha) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} c_{it},$$

- with  $P_t = \text{CPI}$ :

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



# Aggregate consumption basket

- Aggregating we get:

$$C_{F,t} = \alpha \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} C_t^{hh}, \quad C_{H,t} = (1 - \alpha) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t^{hh}$$

- Only need aggregate consumption to calculate demand for domestic and foreign goods
- Possible because CES preferences are homothetic
  - All households choose the same consumption basket:
$$\frac{c_{F,it}}{c_{it}} = \alpha \left( \frac{P_{F,t}}{P_t} \right)^{-\eta}$$
- If preferences are non-homothetic HH problem is more complicated

# Non-homothetic preferences

- If preferences for  $\nu(c_{F,it}, c_{H,it})$  are **non-homothetic** rich and poor households will hold different consumption baskets
- Need to solve more complicated problem (see appendix in Auclert et al 2024)

$$v_t(z_{it}, a_{it-1}) = \max_{c_{F,it}, c_{H,it}} \nu(c_{F,it}, c_{H,it}) - \varphi \frac{\ell_{it}^{1+\nu}}{1+\nu} + \beta \mathbb{E}_t[v_{t+1}(z_{it+1}, a_{it})]$$
$$a_{it} + \frac{P_{F,t}}{P_{it}} c_{F,it} + \frac{P_{H,t}}{P_{it}} c_{H,it} = (1 + r_t^a) a_{t-1} + Z_t z_{it}$$
$$\log z_{it+1} = \rho_z \log z_{it} + \psi_{it+1}, \psi_t \sim \mathcal{N}(\mu_\psi, \sigma_\psi), \mathbb{E}[z_{it}] = 1$$
$$a_{it} \geq 0$$

- where  $P_{it}$  is the ideal price index associated with the consumption basket of individual  $i$

- In baseline model assume **law of one price**
  - Prices of the same product are equalized across countries once converted into same currency
- Implies that the **price of foreign goods in domestic currency**  $P_{F,t}$  is:

$$P_{F,t} = P_{F,t}^* E_t$$

- where  $P_{F,t}^*$  = price of foreign goods in foreign,  $E_t$  = nominal exchange rate
- Note: Usual macro convention, an increase in  $E_t$  corresponds to a **depreciation**
  - So  $E_t = 7,46$  between DKK and EURO for instance

- Production and profits:

$$Y_t = L_t$$

$$\Pi_t = \frac{P_{H,t}}{P_t} Y_t - \frac{W_t}{P_t} L_t$$

- First order condition:

$$\frac{P_{H,t}}{P_t} \frac{1}{\mu} = w_t$$

# Mutual fund and assets

- Mutual fund collect households savings  $A_t$
- Invest in available assets
  - Firm equity
  - Foreign bonds  $B_t^*$  (assumption: free capital flows)

- **Problem:**

$$\max_{v_{j,t}, B_t^*} \int (\Pi_{j,t+1} + p_{j,t+1}^D) v_{j,t} + \frac{(1 + i_t^*)}{1 + \pi_{t+1}} \frac{E_{t+1}}{E_t} B_t^* - (1 + r_{t+1}^a) A_t$$

$$\text{s.t.} \quad \int p_{j,t}^D v_{j,t} dj + B_t^* = A_t$$

- **FOCs** (no arbitrage conditions):

$$p_t^D = \frac{\Pi_{t+1} + p_{t+1}^D}{1 + r_t}$$

$$1 + r_t = \frac{Q_{t+1}}{Q_t} (1 + r_t^*), \quad (\text{UIP})$$

- where  $r_t = r_{t+1}^a$  the ex-ante interest rate,  $r_t^*$  is the foreign real interest rate,  $Q_t = \frac{E_t}{P_t} P_t^*$  is the **real exchange rate**

- Everybody works the same:

$$\ell_t = L_t^{hh}$$

- Maximization subject to wage adjustment cost imply a **New Keynesian Wage (Phillips) Curve** (NKWPC or NKWC)

$$\pi_t^w = \kappa \left( \varphi (L_t^{hh})^\nu - \frac{1}{\mu} w_t (C_t^{hh})^{-\sigma} \right) + \beta \pi_{t+1}^w$$

- **1. Floating exchange rate:**

- Will assume float for most of today. Then business as usual:

$$i_t = i_{ss} + \phi \pi_t, \quad 1 + r_t = \frac{1 + i_t}{1 + \pi_{t+1}}$$

- (Note that it might be more suited for CB to target PPI  $\pi_{H,t}$ )

- **2. Fixed exchange rate**

$$E_t = E_{ss}$$

- Central bank chooses nominal interest rate such that the nominal exchange rate is fixed
- Can also be implemented with a Taylor-type rule:

$$i_t = i_{ss} + \phi_E (E_t - E_{ss})$$

- with  $\phi_E \rightarrow \infty$

# Foreign Economy

- Because we focus on a *small open economy* domestic shocks does not affect the foreign economy
  - Foreign interest rate  $r_t^*$  is exogenous
  - Foreign price  $P_{F,t}^*$  is exogenous
- Foreign demand for domestic goods given by Armington/CES demand:

$$C_{H,t}^* = \alpha \left( \frac{P_{H,t}^*}{P_{F,t}^*} \right)^{-\eta^*} M_t^*$$

- where  $M_t^*$  is overall demand for foreign goods (shifter)
- $C_{H,t}^*$  is overall demand for goods from Home country
- Law of one price:  $P_{H,t}^* = \frac{P_{H,t}}{E_t}$



# Trade and current account

- Define  $GDP_t = \frac{P_{H,t}}{P_t} Y_t$ . Net exports are:

$$NX_t = GDP_t - C_t^{hh}$$

- The net foreign asset position is

$$NFA_t = A_t^{hh} - \underbrace{p_t^D}_{= D_F^t} \quad \text{?}$$

- The current account is:

$$CA_t = NX_t + r_t^a NFA_{t-1}$$

- Current account and net foreign asset position are related by [Walras]:

$$NFA_t - NFA_{t-1} = CA_t$$

# Market clearing

1. Labor market:  $L_t = L_t^{hh}$
2. Goods market (Version 1)

$$Y_t = C_{H,t} + C_{H,t}^*$$

3. Goods market (Version 2)

$$GDP_t = C_t^{hh} + NX_t$$

$$\text{with } NX_t = \frac{P_{H,t}}{P_t} C_{H,t}^* - \frac{P_{F,t}}{P_t} C_{F,t}$$

*C > Asset market ?*

# International Keynesian Cross

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## Sequence-space - goods market

- Linearizing goods mkt'  $Y_t = C_{H,t} + C_{H,t}^*$ :

$$d\mathbf{Y} = d\mathbf{C}_H + d\mathbf{C}_H^*$$

- Linearize CES demand  $C_{H,t}, C_{H,t}^*$  around ss:

$$C_{H,t} = (1 - \alpha) \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} C_t^{hh} \Rightarrow d\mathbf{C}_H = (1 - \alpha) d\mathbf{C}^{hh} - \eta(1 - \alpha) d \left( \frac{P_H}{P} \right)$$

$$C_{H,t}^* = \alpha \left( \frac{P_{H,t}^*}{P_{F,t}^*} \right)^{-\eta^*} M_t^* \Rightarrow d\mathbf{C}_H^* = \alpha d\mathbf{M}^* - \eta^* \alpha d \left( \frac{P_H^*}{P_F^*} \right)$$

- For now assume no change in foreign demand,  $d\mathbf{M}^* = 0$

$$d\mathbf{Y} = (1 - \alpha) d\mathbf{C}^{hh} - \eta(1 - \alpha) d \left( \frac{P_H}{P} \right) - \eta^* \alpha d \left( \frac{P_H^*}{P_F^*} \right)$$

## Sequence-space - trade elasticity

- Linearizing the price index + LOOP gives  $dP_{H,t} - dP_t = -\frac{\alpha}{1-\alpha}dQ_t$  and  $dP_{H,t}^* = dP_{H,t} - dE_t$  to get:
- so  $dP_{H,t}^* = dP_{H,t} - dP_t - dQ_t = -dQ_t - \frac{\alpha}{1-\alpha}dQ_t = -\frac{1}{1-\alpha}dQ_t$

$$\begin{aligned}d\mathbf{Y} &= (1 - \alpha) d\mathbf{C}^{hh} + \eta(1 - \alpha) \frac{\alpha}{1 - \alpha} dQ_t + \eta^* \frac{\alpha}{1 - \alpha} d\mathbf{Q} \\ &= (1 - \alpha) d\mathbf{C}^{hh} + \chi \frac{\alpha}{1 - \alpha} d\mathbf{Q}\end{aligned}$$

- with  $\chi = \eta(1 - \alpha) + \eta^*$  being the *trade elasticity*
  - Captures the elasticity of net exports to changes in relative prices (the real EXR  $Q$ )
  - Typically called *expenditure switching*
  - If the DKK appreciates ( $d\mathbf{Q} \downarrow$ ) against the USD both DK HHs and US HHs will **substitute toward** US goods ( $d\mathbf{Y} \downarrow$ )

## Sequence-space - HHs

- What can we say about  $d\mathbf{C}^{hh}$ ? Consumption function is  $C^{hh}(\{r_s^a, Z_s\}_{s=0}^\infty)$ :

$$d\mathbf{C}^{hh} = \mathbf{M}^{r^a} dr^a + \mathbf{M} dZ$$

- Use firm FOC + production function

$Z_t = w_t L_t = \frac{P_{H,t}}{P_t} Y_t \Rightarrow dZ_t = -\frac{\alpha}{1-\alpha} dQ_t + dY_t + \text{small valuation effect}$   
effect  $\mathbf{M}^{r^a} \approx \mathbf{M}^r$ :

$$d\mathbf{C}^{hh} = \mathbf{M}^r dr + \mathbf{M} dY - \frac{\alpha}{1-\alpha} \mathbf{M} dQ$$

# Sequence-space - Keynesian Cross

- Putting it together:

$$dY = \underbrace{(1 - \alpha)M^r dr}_{1. \text{ Interest rate}} + \underbrace{(1 - \alpha)M dY}_{2. \text{ Multiplier}} + \underbrace{\chi \frac{\alpha}{1 - \alpha} dQ}_{3. \text{ Exp. switching}} - \underbrace{\alpha M dQ}_{4. \text{ Real income}}$$

1. Standard  $r$  effect: Scaled down by  $1 - \alpha$  since some of domestic demand goes to foreign goods (imports)
2. Standard multiplier: Scales with MPC matrix  $M$  and home bias  $1 - \alpha$
3. **Expenditure switching**: An appreciation of the EXR ( $Q \downarrow$ ) causes substitution away from home's goods  $\rightarrow$  less demand for  $Y$
4. **Real income channel of EXR**: Appreciation ( $Q \downarrow$ ) causes foreign goods to be cheaper in home currency  $\Rightarrow$  Reduces  $PF, P$ , raises real income  $Z$

# Monetary Policy

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# Sequence-space - Keynesian Cross

- Use the Keynesian Cross to analyze monetary policy with heterogeneous agents
  - Reference: Auclert, Rognlie, Souchier, & Straub (2024) »Exchange rates and monetary policy with heterogeneous agents: Sizing up the real income channel«
- Fundamental difference in the open economy is that monetary policy affect EXR through **UIP**:

$$1 + r_t = \frac{Q_{t+1}}{Q_t} (1 + r^*)$$

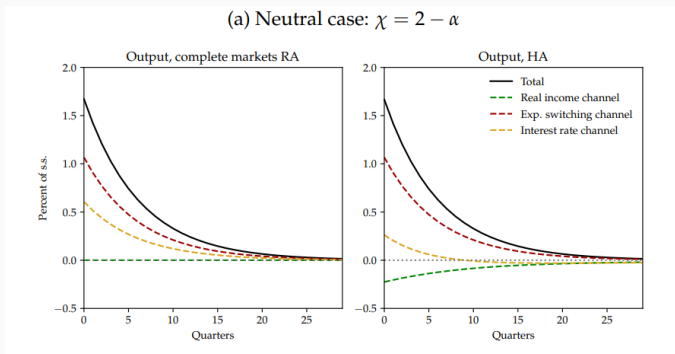
- For given foreign rate  $r^*$  an increase in domestic real rate  $r_t$  will attract foreign capital flows  $\Rightarrow$  Appreciation of  $Q_t$ 
  - To first-order we have  $dQ_t = -\sum_{s \geq t}^{\infty} dr_s$  for a constant  $r^*$

# HANK-RANK equivalence

- In closed economy monetary policy was equally effective in HANK/RANK
  - Under some assumption (log utility, no gov bonds ...)
- Not obvious here since a reduction in  $r$  implies a depreciation which:
  - Decreases demand in HANK due to real income effect
  - Increases demand for domestic goods through expenditure switching
- Turns out that these effects **balance each other exactly** if trade elasticity  $\chi = 2 - \alpha$ 
  - If  $\chi < 2 - \alpha$  then the real income effect dominates and monetary policy *less* effective in HANK
  - If  $\chi > 2 - \alpha$  then expenditure switching dominates and monetary policy is *more* effective in HANK

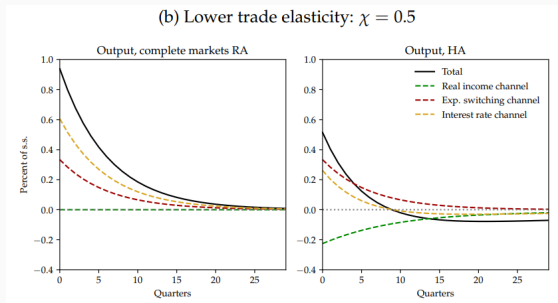
# Monetary policy - $\chi = 2 - \alpha$

- Output response in HANK/RANK with neutrality,  $\chi = 2 - \alpha$



# Monetary policy - $\chi < 2 - \alpha$

- Empirically we expect the trade elasticity to be **low** in the short run
  - Takes time for firms/households to respond to changes in relative prices
  - But *probably* larger in the long run ( $\chi > 2 - \alpha$ )
- Output response in HANK/RANK with  $\chi = 0.5 < 2 - \alpha$ 
  - Monetary policy **less** effective in HANK



# Fiscal Policy

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- Monetary policy in HANK likely to be **less effective** in **open economy**
- What about **fiscal policy**?
  - Recall: In closed economy HANK implied larger fiscal multipliers (/w deficit financing)
- Take model from before, add government + Taylor rule

# Keynesian cross with G

- Keynesian cross:

$$\begin{aligned}
 dY = & \underbrace{dG}_{\text{1. Gov. consumption}} - \underbrace{(1 - \alpha)M dT}_{\text{2. Taxes}} + \underbrace{(1 - \alpha)M^r dr}_{\text{3. Interest rate}} \\
 & + \underbrace{(1 - \alpha)M dY}_{\text{4. Multiplier}} + \underbrace{\chi \frac{\alpha}{1 - \alpha} dQ}_{\text{5. Exp. switching}} - \underbrace{\alpha M dQ}_{\text{6. Real income}}
 \end{aligned}$$

- Note, with a constant  $r$ -rule,  $dr = 0$  this *almost* reverts to closed economy Cross:

$$dY = dG - (1 - \alpha)M dT + (1 - \alpha)M dY$$

- In fact **isomorphic** to closed economy Cross with  $\tilde{M} \equiv (1 - \alpha)M$

$$dY = dG - \tilde{M} dT + \tilde{M} dY$$

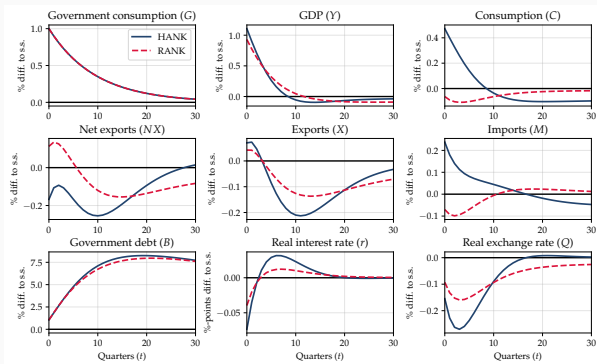
# Fiscal policy in the open economy

- Do we expect fiscal policy to be more or less effective in HANK vs. RANK?
- **More effective:**
  - Positive spending shock  $dG > 0$  forces CB to raise  $r$  implying an appreciation ( $dQ < 0$ )
  - Foreign goods become cheaper, raises real income  $\Rightarrow$  More demand
- **Less effective:**
  - Appreciation of EXR implies expenditure switching, so drop in NX
  - Multiplier effect  $MdY$  is weaker in SOE since a share  $\alpha$  is spend on foreign goods
- Ultimately, a **quantitative question**
- ... but some analytical results in paper, for instance:
  - In limit  $\alpha \rightarrow 1$  (fully open economy) HANK/RANK equivalence since multiplier effects do not matter



# Fiscal spending shocks

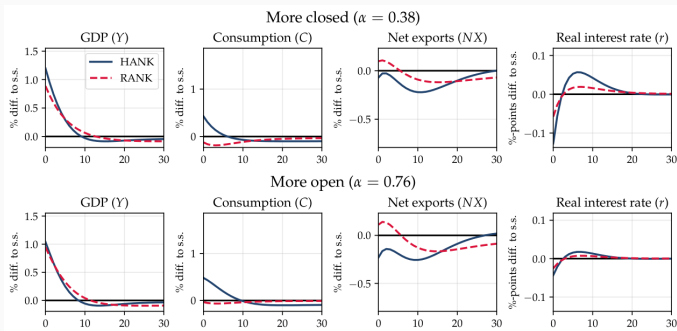
- Main result with deficit financed G shock:



- Relatively similar fiscal multiplier
  - HANK produces **much** larger C response
  - ... But this gets counteracted by larger drop in net exports

# Fiscal spending shocks - openness

- How does fiscal multiplier vary with openness  $\alpha$ ? (plot IRFs for first and third quartile of  $\frac{\text{Imports}}{\text{GDP}}$  across sample of OECD countries.)



# Foreign Demand Shocks

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# Foreign Demand Shocks

- So far: How HANK affects transmission of **policy**
- Now: How does HANK affect transmission of **shocks/disurbances?**
- Focus on a shock to **foreign demand for domestic goods**
  - E.g. how does a recession in germany affect Denmark via trade spillovers?
  - Turns out to have important implications for transmission with HA as opposed to RA
  - Main ref: Druedahl, Ravn, Sunder-Plassmann, Sundram, & Waldstrøm (2024) »The Transmission of Foreign Demand Shocks«
- Other shocks often studied in open economy context:
  - Foreign monetary policy shocks
  - Capital flow shocks (»sudden stops«)
  - Import price shocks

# Motivaton

- Motivation: Go back to international Kenyesian Cross with foreign demand  $\mathbf{M}^*$

$$d\mathbf{Y} = (1-\alpha)\mathbf{M}^r d\mathbf{r} + (1-\alpha)\mathbf{M} d\mathbf{Y} + \chi \frac{\alpha}{1-\alpha} d\mathbf{Q} - \alpha \mathbf{M} d\mathbf{Q} + \alpha d\mathbf{M}^*$$

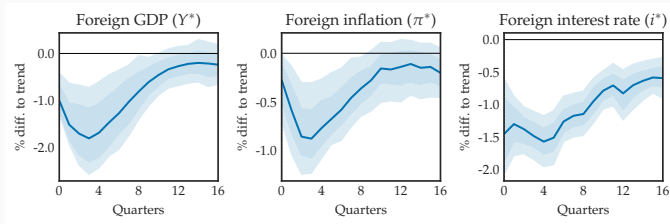
- Can solve this for response of  $\mathbf{C}$  (see appendix):

$$d\mathbf{C} = \left[ \underbrace{\mathbf{M}}_{\text{Labor income } (> 0)} + \underbrace{\frac{\alpha}{1-\alpha} \mathbf{M} \mathbf{G}^{Q,Y}}_{\text{Real income of EXR } (\leq 0)} + \underbrace{\mathbf{M}^r \mathbf{G}^{r,Q} \mathbf{G}^{Q,Y}}_{\text{Intertemporal sub. } (< 0)} \right] \mathcal{M} d\mathbf{M}^*$$

- RANK with  $\mathbf{M} \approx 0$  predicts  $d\mathbf{C} > 0$  in response to a negative foreign demand shock  $d\mathbf{M}^* < 0$
- HANK can potentially get  $d\mathbf{C} < 0$  (**co-movement**) if labor income channel is strong enough
- What is sign of  $\text{cov}(d\mathbf{C}, d\mathbf{M}^*)$  empirically?

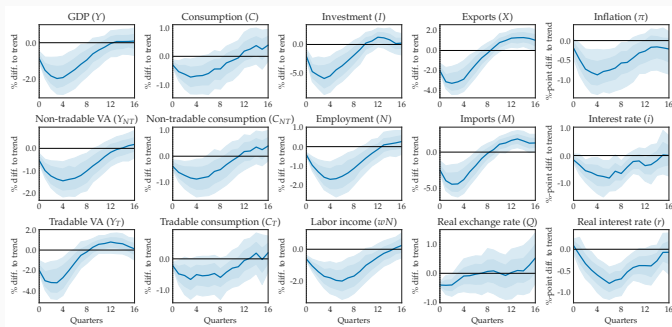
# Empirical estimates of foreign demand shock

- Panel of 38 OECD countries, focus on 31 SOE's
- Trade-weighted country  $i$  specific "foreign economy" ( $Y_{i,t}^*, \pi_{i,t}^*, i_{i,t}^*$ )
- Use *sign-restrictions* to get foreign demand shock
  - $dY_{i,t}^*, d\pi_{i,t}^*, di_{i,t}^*$  all have same sign in first year
- Estimated foreign shock



# Spillover effects

- Use estimated shock in foreign trading partners to estimate effects on domestic, SOE economy
- Estimate dynamic OLS/LP  $y_{c,t+h} = \beta_h i_{c,t}^* + \alpha_h \pi_{c,t}^* + \Theta_h M_{c,t}^*$  where  $y$  = domestic outcomes (GDP, C ...)



# Why foreign demand shocks?

- Why focus specifically on a **foreign demand shock**?
  - Provides very clean testable implications for HANK and RANK
  - domestic  $r$  increases in response to  $dM^* < 0$
  - Almost always the case since monetary policy does not face output/inflation tradeoff with demand shock
- Not true for foreign monetary policy shock or supply shock
- What about domestic demand shock (G)?
  - Identification more difficult
  - Literature ambiguous on whether  $C$  increases or decreases



# Model

- **Next:** Go to medium scale HANK model to see if we can replicate empirical evidence
- Model features:
  - Two sectors (tradeable and non-tradeables) + input-output production structure
  - Government
  - Sticky prices and wages
  - Dynamic trade elasticities
- Feed in estimated foreign demand shock, compare with empirics

- Household problem:

$$V_t(e_t, a_{t-1}, \beta, s) = \max_{c_t, a_t} \frac{c_t^{1-\sigma}}{1-\sigma} - \nu \frac{L_{s,t}^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} + \beta_t \mathbb{E}_t [V_{t+1}(e_{t+1}, a_t, \beta, s)]$$

s.t.

$$c_t + a_t = (1 + r_t^a) a_{t-1} + (1 - \tau_t) w_{s,t} L_{s,t} e_t + T_t$$

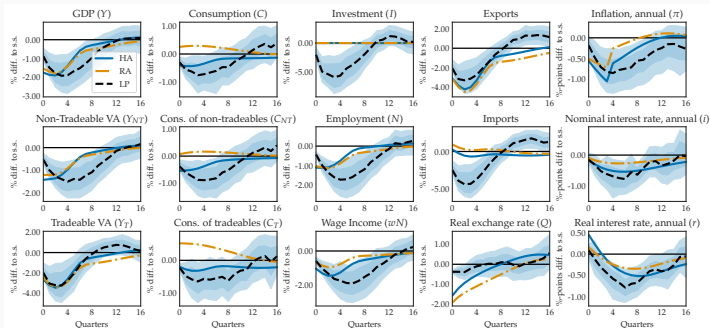
$$a_t \geq 0$$

$$\ln e_t = \rho_e \ln e_{t-1} + \epsilon_t^e, \quad \epsilon_t^e \sim \mathcal{N}(0, \sigma_e^2)$$

- Markov matrix for  $s$  is  $P^s = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ 
  - HHs cannot move sectors. Harsh assumption, but consistent with short-run dynamics. Can alleviate by changing  $P^s$
  - Could also have endogenous sector choice at HH level

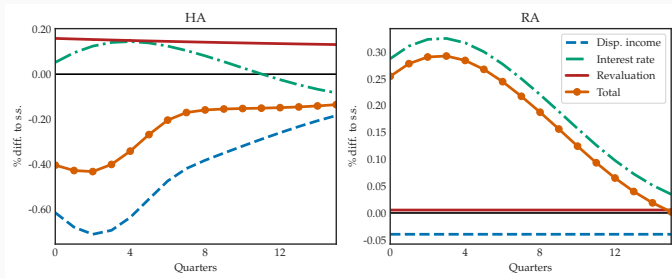
# Model fit - floating

- Effects of foreign demand shock with a floating EXR



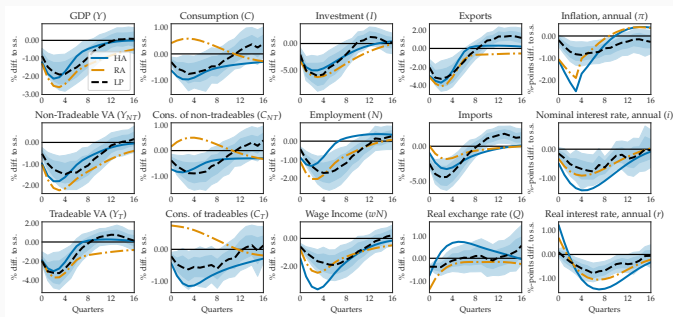
# Decomposition

- Decompose  $d\mathbf{C}$  into effects from interest rate, labor income and capital gain effects



# Model fit - floating /w investment

- HANK response amplified by investment
- Note: Getting investment response right requires exogenous shock to investment



## Fixed exchange rate

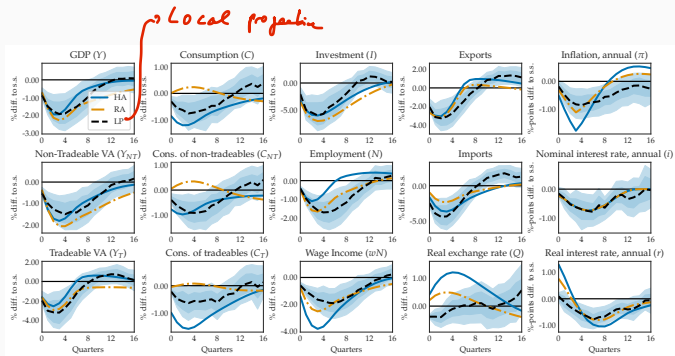
- The Taylor rule is crucial to obtain  $i_t \downarrow$ ,  $r_t \downarrow$ , and  $C_t \uparrow$  in RANK
- Does this mean that our result changes under a fixed exchange rate?
- **No**

$$1 + i_t = 1 + i_t^* \Leftrightarrow 1 + r_t = \frac{1 + i_t^*}{1 + \pi_{t+1}}$$

- A foreign demand shock entails a decline in  $i_t^*$  (in both model and data).
- UIP forces central bank in SOE to reduce  $i_t$ , so  $r_t \downarrow$  (unless  $\pi_{t+1} \downarrow\downarrow$ )

# Model fit - fixed

- Similar outcomes with fixed EXR



- Foreign demand shock implies domestic recession for HHs in all sectors  $\Rightarrow$  Welfare loss
- Exercise: Calibrate policy shocks (monetary and fiscal policy separately) to stabilize agg.  $C$  following foreign demand shock

	$C$	$C_T^{hh}$	$C_{NT}^{hh}$
Foreign demand	-1.00	-1.27	-0.91
Public consumption	1.00	0.08	1.32
Monetary policy	1.00	1.01	1.00

- Monetary policy has symmetric effects across sectors  $\Rightarrow$  Well suited here
- Fiscal policy loads on NT sector  $\Rightarrow$  Very asymmetric effects, barely helps HHs in T sector
  - Issues for countries fixed EXRs or in monetary unions
  - Need targeted transfers



# Conclusion

- How does heterogeneity affect transmission of shocks and policies in SOEs?
  - Monetary policy - Likely to be less effective due to real income channel of EXR
  - Fiscal policy - Closer to RANK multipliers due to crowding out of NX
  - Foreign demand shocks - larger transmission to domestic spending

- Covered 3 papers here: Other papers in the litterature on HANK in open economies include:
  1. Guo, X., Ottonello, P., & Perez, D. J. (2023) *Monetary policy and redistribution in open economies*
    - Redistributinal effects of monetary policy in SOEs
  2. Aggarwal, R., Auclert, A., Rognlie, M., & Straub, L. (2023). *Excess savings and twin deficits: The transmission of fiscal stimulus in open economies*
    - Fiscal stimulus in a multi-country model
  3. De Ferra, S., Mitman, K., & Romei, F. (2020). *Household heterogeneity and the transmission of foreign shocks*
    - Effects of exchange rate depreciations when HHs have foreign currency debt
  4. Bayer, C., Kriwoluzky, A., Müller, G. J., & Seyrich, F. (2024). *A HANK<sup>2</sup> model of monetary unions*. *Journal of Monetary Economics*
    - A 2-country HANK model

## Summary

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# Summary and next week

- **Today:** Small open economy HANK models
- **Next week:**
  - Advanced HANK topics (**research frontier**)
  - Q&A
  - Exam
- **Homework:**
  1. Work on assignment