13. I-HANK

Adv. Macro: Heterogenous Agent Models

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Introduction

Introduction

- **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

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)

Households

- **Household problem:**

$$
\begin{aligned}
v_t(z_{it}, a_{it-1}) &= \max_{c_{it}} \frac{c_{it}^{1-\sigma}}{1-\sigma} - \varphi \frac{\ell_{it}^{1+\nu}}{1+\nu} + \beta \mathbb{E}_t \left[v_{t+1}(z_{it+1}, a_{it}) \right] \\
\text{s.t. } a_{it} + c_{it} &= (1 + r_t^a) a_{t-1} + Z_t z_{it} \\
\log z_{it+1} &= \rho_z \log z_{it} + \psi_{it+1} \quad , \psi_t \sim \mathcal{N}(\mu_\psi, \sigma_\psi), \ \mathbb{E}[z_{it}] = 1 \\
a_{it} &\geq 0
\end{aligned}
$$

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

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 α 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**:

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

- with P_t =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:

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

- 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 $\nu\left(c_{F,it}, c_{H,it}\right)$ 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)

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

$$a_{it} + \frac{P_{F,t}}{P_{it}} c_{F,it} + \frac{P_{H,t}}{P_{it}} c_{H,it} = (1 + r_t^a) a_{t-1} + Z_t z_{it}$$

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

$$a_{it} \geq 0$$

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

Prices

- 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

Firms

- **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**:

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

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

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

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

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

- 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**

Union

- 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)

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

Central bank

- **1. Floating exchange rate:**
- Will assume float for most of today. Then business as usual:

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

- (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:

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

- with $\phi_E \to \infty$

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

$$NFA_t = A_t^{hh} - p_t^D$$

- 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)

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

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

International Keynesian Cross

Sequence-space - goods market

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

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

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

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

$$C^*_{H,t} = \alpha\left(\frac{P^*_{H,t}}{P^*_{F,t}}\right)^{-\eta^*} M^*_t \Rightarrow d\boldsymbol{C}^*_H = \alpha d\boldsymbol{M}^* - \eta^*\alpha d\left(\frac{\boldsymbol{P}^*_H}{\boldsymbol{P}^*_F}\right)$$

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

$$d\boldsymbol{Y} = (1-\alpha)\, d\boldsymbol{C}^{hh} - \eta\,(1-\alpha)\, d\left(\frac{\boldsymbol{P}_H}{\boldsymbol{P}}\right) - \eta^*\alpha d\left(\frac{\boldsymbol{P}^*_H}{\boldsymbol{P}^*_F}\right)$$

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 $dP^*_{H,t} = dP_{H,t} - dP_t - dQ_t = -dQ_t - \frac{\alpha}{1-\alpha} dQ_t = -\frac{1}{1-\alpha} dQ_t$

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

- 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 ($d\boldsymbol{Q} \downarrow$) against the USD both DK HHs and US HHs will **substitute toward** US goods ($d\boldsymbol{Y} \downarrow$)

Sequence-space - HHs

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

$$d\boldsymbol{C}^{hh} = \boldsymbol{M}^{r^a} d\boldsymbol{r}^a + \boldsymbol{M} d\boldsymbol{Z}$$

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

$$d\boldsymbol{C}^{hh} = \boldsymbol{M}^{\boldsymbol{r}} d\boldsymbol{r} + \boldsymbol{M} d\boldsymbol{Y} - \frac{\alpha}{1-\alpha} \boldsymbol{M} d\boldsymbol{Q}$$

Sequence-space - Keynesian Cross

- Putting it together:

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

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 $\boldsymbol{M}$ and home bias $1-\alpha$
3. **Expenditure switching**: An appreciation of the EXR ($Q \downarrow$) causes substitution away from home's goods -> 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

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:**

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

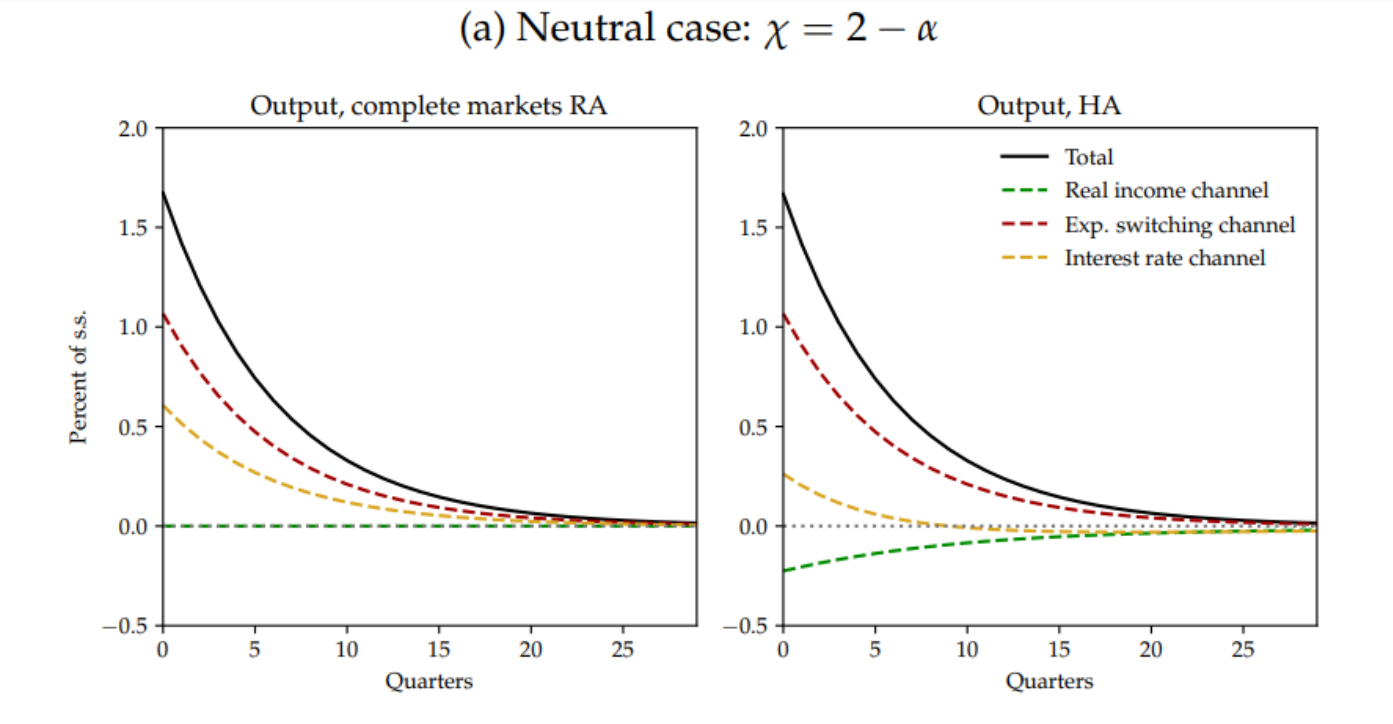
- For given foreign rate r^* an increase in domestic real rate r_t will attract foreign capital flows $\Rightarrow$ Appreciation of Q_t
  - To first-order we have $dQ_t = -\sum_{s \geq t}^{\infty} dr_s$ for a constant r^*

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

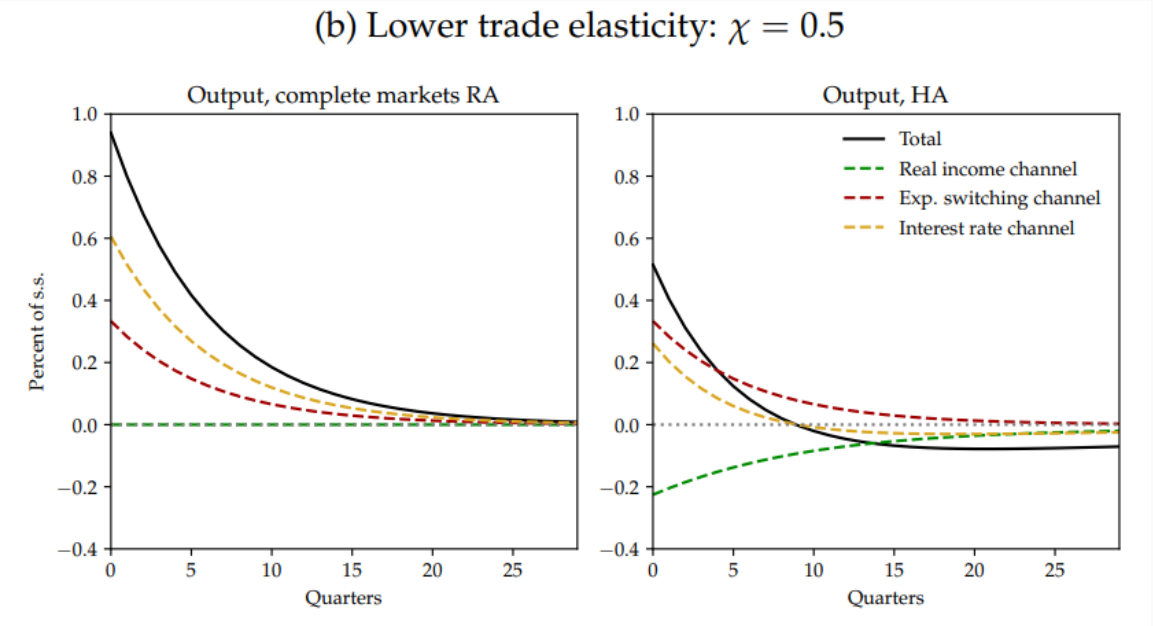
Monetary policy - $\chi = 2 - \alpha$

- 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

Fiscal Policy

- 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:

$$d\boldsymbol{Y} = \underbrace{d\boldsymbol{G}}_{\text{1. Gov. consumption}} - \underbrace{(1-\alpha)\boldsymbol{M}d\boldsymbol{T}}_{\text{2. Taxes}} + \underbrace{(1-\alpha)\boldsymbol{M}^{r}d\boldsymbol{r}}_{\text{3. Interest rate}}$$
$$+ \underbrace{(1-\alpha)\boldsymbol{M}d\boldsymbol{Y}}_{\text{4. Multiplier}} + \underbrace{\chi\frac{\alpha}{1-\alpha}d\boldsymbol{Q}}_{\text{5. Exp. switching}} - \underbrace{\alpha\boldsymbol{M}d\boldsymbol{Q}}_{\text{6. Real income}}$$

- Note, with a constant r-rule, $d\boldsymbol{r} = 0$ this *almost* reverts to closed economy Cross:

$$d\boldsymbol{Y} = d\boldsymbol{G} - (1-\alpha)\boldsymbol{M}d\boldsymbol{T} + (1-\alpha)\boldsymbol{M}d\boldsymbol{Y}$$

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

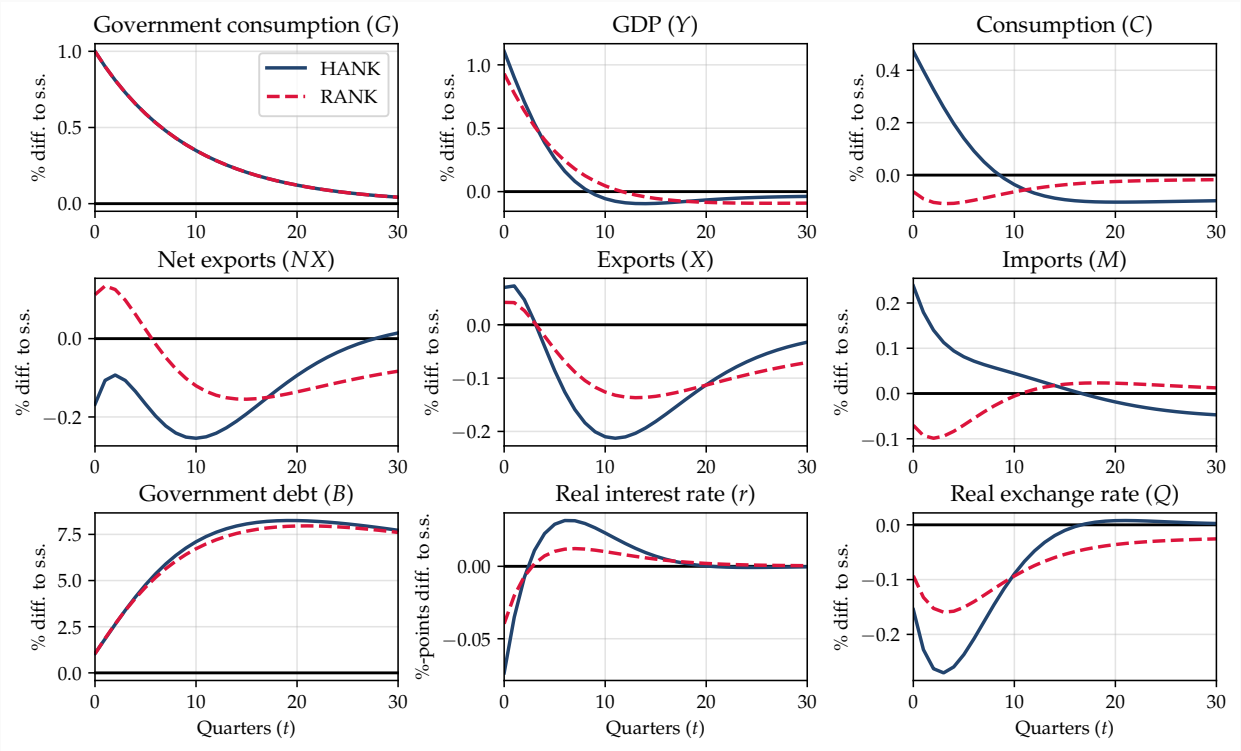
$$d\boldsymbol{Y} = d\boldsymbol{G} - \tilde{\boldsymbol{M}}d\boldsymbol{T} + \tilde{\boldsymbol{M}}d\boldsymbol{Y}$$

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 $d\boldsymbol{G} > 0$ forces CB to raise $\boldsymbol{r}$ implying an appreciation ($d\boldsymbol{Q}<0$)
  - Foreign goods become cheaper, raises real income $\Rightarrow$ More demand
- **Less effective:**
  - Appreciation of EXR implies expenditure switching, so drop in NX
  - Multiplier effect $\boldsymbol{M}d\boldsymbol{Y}$ is weaker in SOE since a share α is spend on foreign goods
- Ultimately, a **quantitative question**
- ... but some analytical results in paper, for instance:
  - In limit $\alpha \to 1$ (fully open economy) HANK/RANK equivalence since multiplier effects do not matter

Fiscal spending shocks

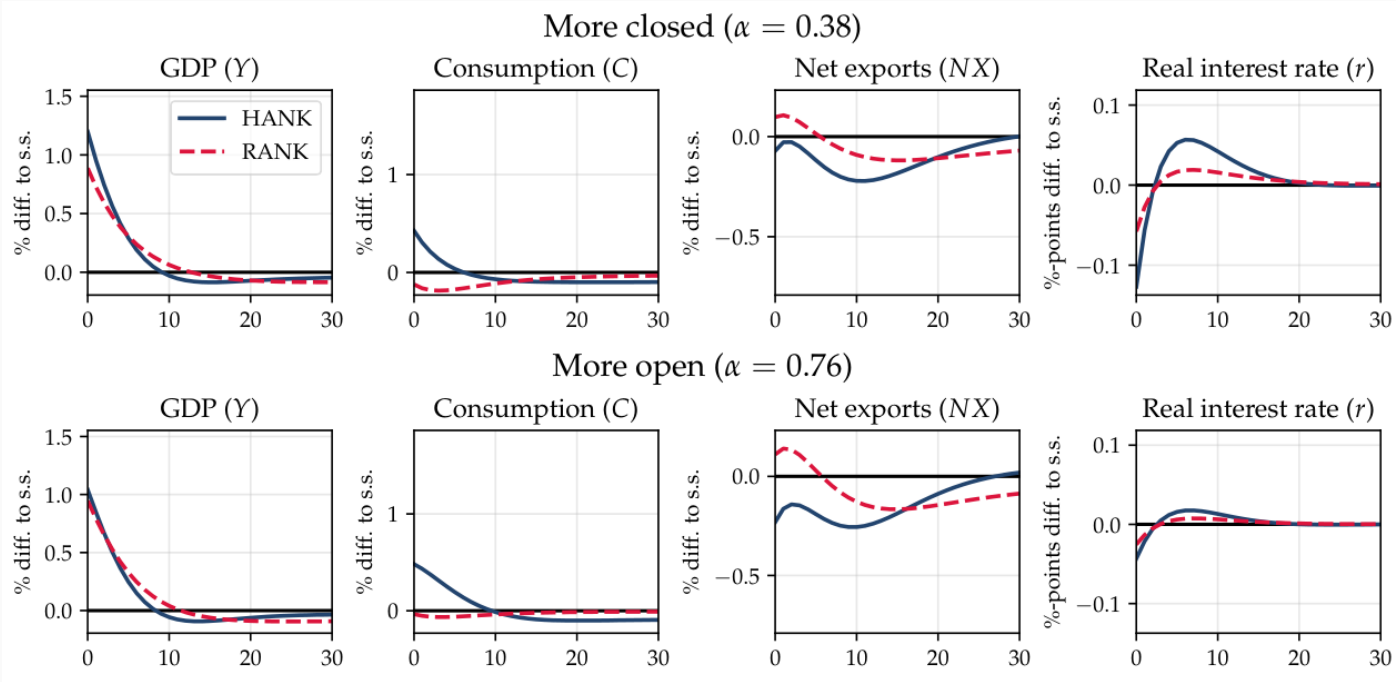
- Main result with deficit financed G shock:



- 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 α? (plot IRFs for first and third quartile of $\frac{Imports}{GDP}$ across sample of OECD countries.)



Foreign Demand Shocks

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 $\boldsymbol{M}^*$

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

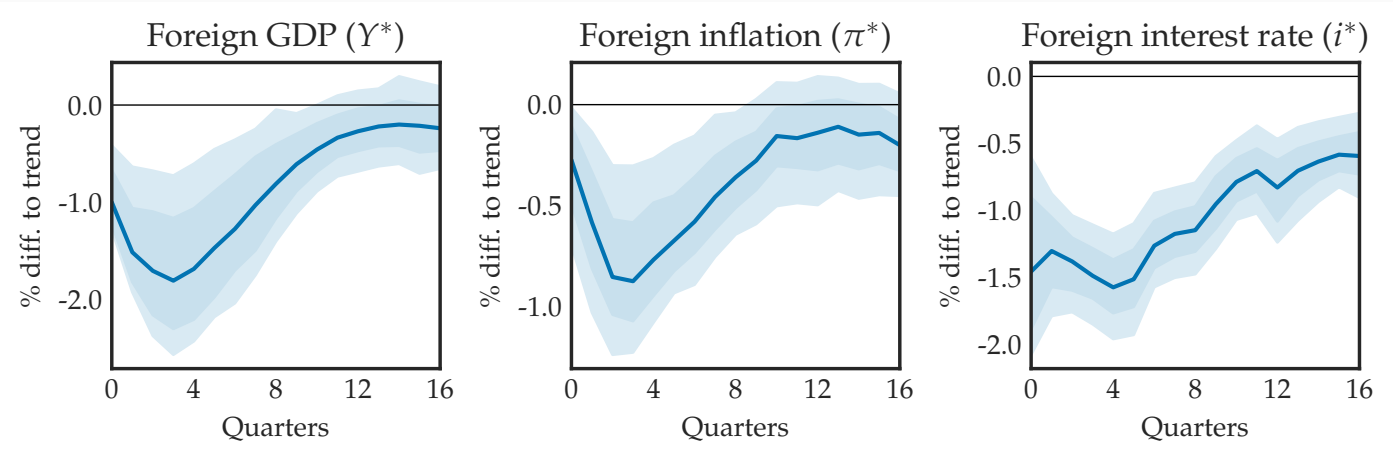
- Can solve this for response of $\boldsymbol{C}$ (see appendix):

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

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

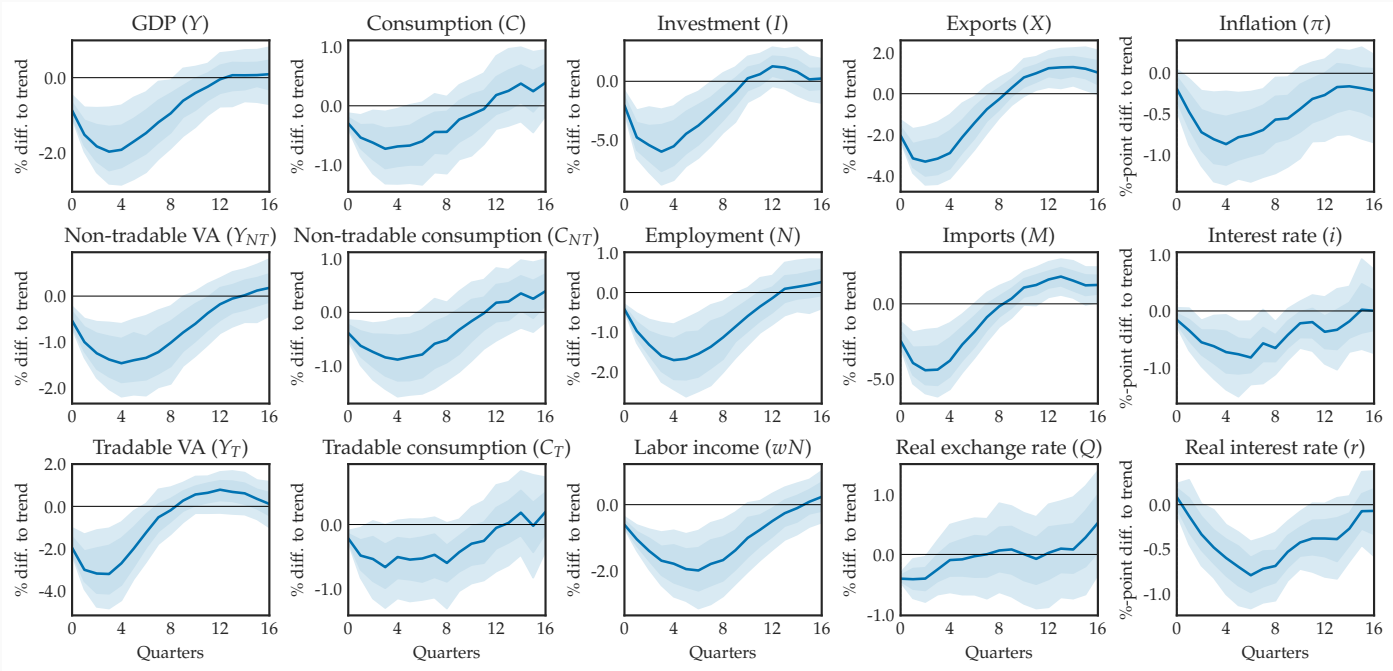
Empirical estimates of foreign demand shock

- Panel of 38 OECD contries, 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 parters to estimate effects on domestic, SOE economy
- Estimate dyanmic 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 $d\boldsymbol{M}^* < 0$
  - 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 block

- Household problem:

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

$$\text{s.t.}$$

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

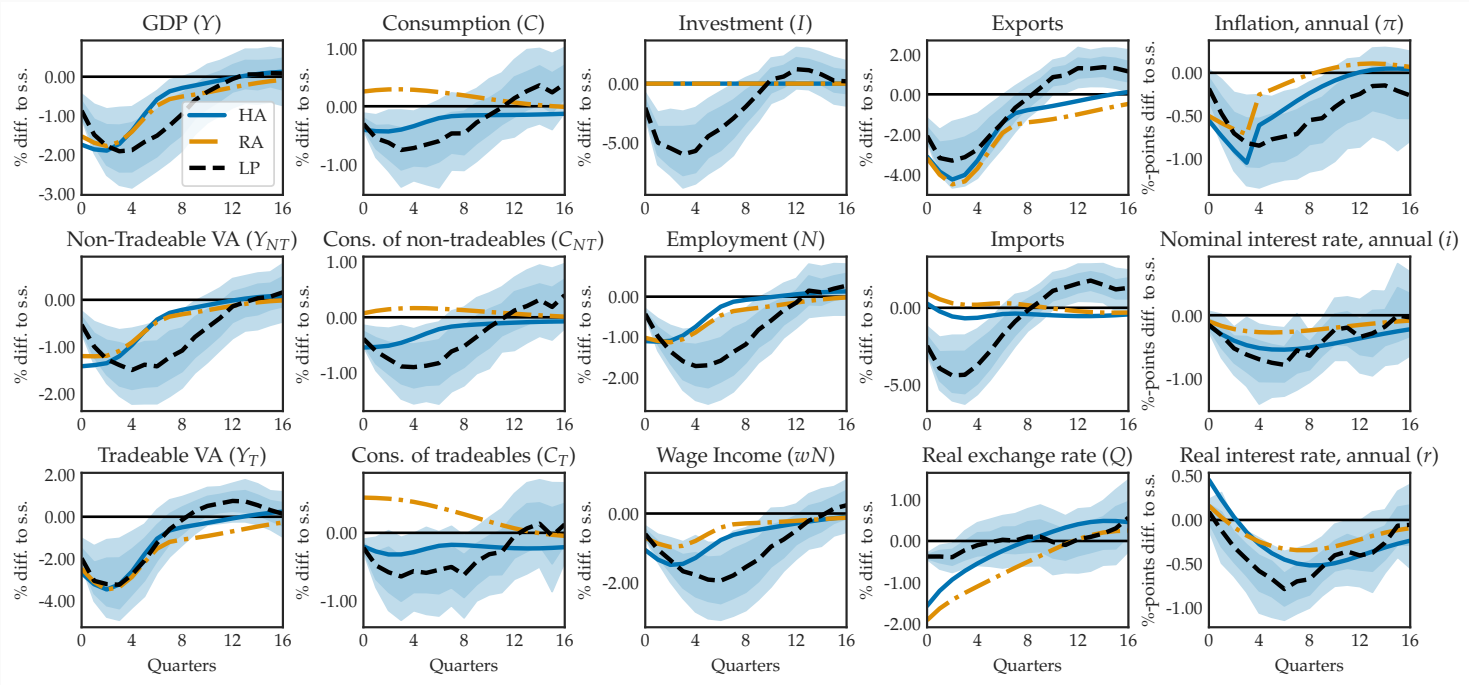
$$a_t \geq 0$$

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

- 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 endogoues sector choice at HH level

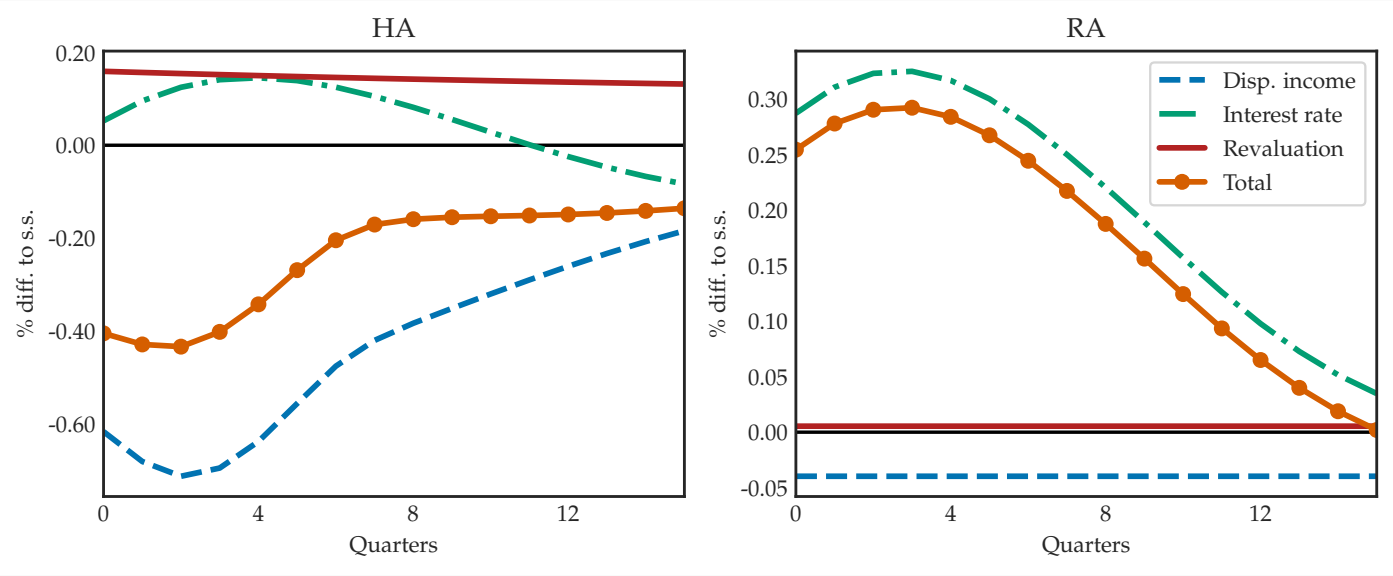
Model fit - floating

- Effects of foreign demand shock with a floating EXR



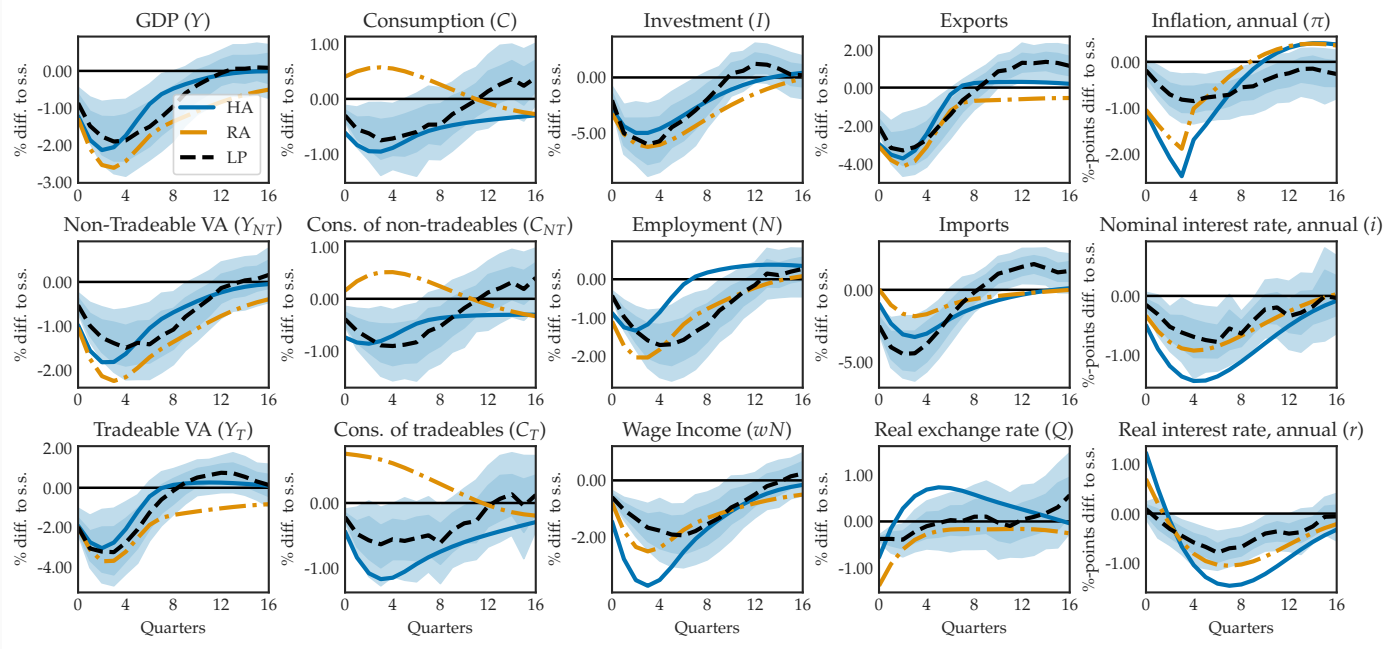
Decomposition

- Decompose $d\boldsymbol{C}$ 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

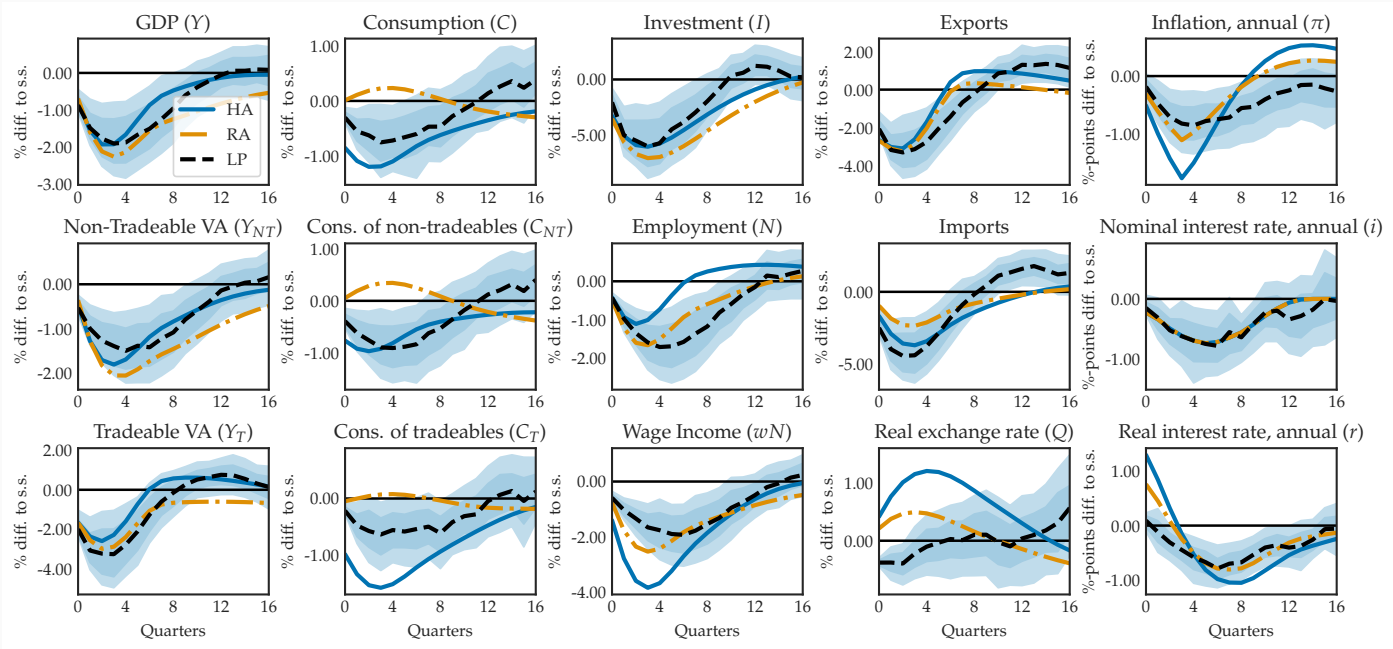
- The Taylor rule is crucial to obtain $i_t \downarrow$, $r_t \downarrow$, and $C_t \uparrow$ in RANK
- Does this mean that our result changes under a fixed exchange rate?
- **No**! UIP condition + Fisher equation:

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

- 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



Policy

- Foreign demand shock implies domestic recession for HHs in all sectors $\Rightarrow$ Welfare loss
- Exercise: Calibrate policy shocks (monetary and fiscal policy seperatly) 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

IHANK - litterature

- 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*
   - Redistributional 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^2 model of monetary unions*. Journal of Monetary Economics
   - A 2-country HANK model

Summary

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