# Consumption Heterogeneity and Monetary Policy in Open Economy

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- With household heterogeneity, the monetary policy transmission mechanism is changed.
- The role of household heterogeneity, however, is less explored along the international dimension.
- In this paper, we study how the consumption heterogeneity affects monetary policy transmission mechanism and the choice of optimal monetary policy in open economy.

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  - The benchmark model assumes the same degree of heterogeneity for the two countries. This assumption is released in the extended model.
- We explore the monetary policy transmission mechanism and optimal policy under various pricing strategies (PCP, LCP).

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  - There is spillover effect on foreign output, and the magnitude also depends on $n$.
  - PPI targeting is still the optimal monetary policy and can restore the economy to the efficient equilibrium.

# Results with LCP

- Under LCP, there are sizeable ranges of household heterogeneity $n$ in which monetary policy become ineffective. But the ranges differ from the PCP case.
- Under LCP, however, due to currency misalignment, output gap cannot be closed, consequently, heterogeneity becomes a new distortion faced by policy makers. This makes CPI inflation targeting no longer optimal in most cases (unless there is no home bias).

# Related literature

- Optimal monetary policy in open economies:
  - Prices are preset one period in advance: Obstfeld and Rogoff (2002), Devereux and Engel (2003), Giancarlo Corsetti and Paolo Pesenti (2005), and Gali and Monacelli (2005).
  - Calvo price-setting: Clarida, Gali and Gertler (2002), Engel (2011), Fujiwara and Wang (2017), Chen, Devereux, Shi and Xu (2021).
- Heterogeneous Agents New Keynesian model: Bilbiie (2008), Kaplan, Moll, and Violante (2018), Debortoli and Gali (2018)...
- Heterogeneous Agents in open economies: Prasad and Zhang (2015), Farhi and Werning (2017), Ferra, Mitman and Romei (2020), Auclert, Rognlie, Souchier and Straub (2021), Guo, Ottonello and Perez (2021)...

# Model setup

- We build a two-country DSGE model, with complete international market and without home bias.
- We consider the incomplete *domestic* asset market:
  - A constant measure $1 - n$ of households, is "Ricardian"—unconstrained access to the financial market.
  - A fraction $n$ of households referred to "Keynesian"—"hand to mouth".
  - in the benchmark model, we consider $n = n^*$ but allow asymmetric case in the extension.
- Two pricing strategy (PCP and LCP) are discussed.
- We first focus on the effect of monetary policy shocks and then study the optimal monetary policy.

# Household

- Let $s \in \{R, K\}$ specify the household type ("Ricardian" and "Keynesian"). The utility is

$$E\sum_{t=0}^{\infty}\beta^t[\ln(C_t^s) - \eta\frac{(L_t^s)^{1+\omega}}{1+\omega}] \quad (1)$$

$$C_t^s = [C_{h,t}^s]^{\frac{1}{2}}[C_{f,t}^s]^{\frac{1}{2}} \quad (2)$$

The consumption index

$$C_{ht}^s = [\int_0^1 C_{ht}^s(i)^{\frac{\varepsilon}{\varepsilon-1}}di]^{\frac{\varepsilon-1}{\varepsilon}};\ C_{ft}^s = [\int_0^1 C_{ft}^s(i)^{\frac{\varepsilon}{\varepsilon-1}}di]^{\frac{\varepsilon-1}{\varepsilon}} \quad (3)$$

# Ricardian household

The budget constraint for Ricardian household is given by

$$P_t^R C_t^R + B_{t+1} + Q_t^e S_t^R + \sum_{\zeta^{t+1} \in Z_{t+1}} Q(\zeta^{t+1}|\zeta^t) D_{hh}(\zeta^{t+1}) + S_t \sum_{\zeta^{t+1} \in Z_{t+1}} Q^*(\zeta^{t+1}|\zeta^t) D_{hf}^*(\zeta^{t+1})$$
$$= W_t L_t^R + (1 + i_t) B_t + (D_t^e + Q_t^e) S_{t-1}^R + D_{hh}(\zeta^t) + S_t D_{hf}^*(\zeta^t) \quad (4)$$

The optimal choice of bond, consumption and labor:

$$\frac{1}{1 + i_t} = E_t \Lambda_{t,t+1} = E_t \beta \frac{C_t^R}{C_{t+1}^R} \frac{P_t}{P_{t+1}} \quad (5)$$

$$W_t \frac{1}{C_t^R P_t} = \eta (L_t^R)^\omega \quad (6)$$

The risk sharing condition:

$$\frac{1}{C_t^R P_t} = \frac{1}{S_t C_t^{R*} P_t^*} \quad (7)$$

# Keynesian household

- They consume their labor income each period, as they do not have access to asset markets:

$$P_t C_t^K = W_t L_t^K \tag{8}$$

- We assume no idiosyncratic shocks as in Bilbiie (2008) and Debortoli and Gali (2018). The household maximizes (1) subject to the (8).
- The optimal labor supply by Keynesian household:

$$W_t \frac{1}{C_t^K P_t} = \eta (L_t^K)^{\omega} \tag{9}$$

- The above two equations imply $L_t^K$ is constant $L_t^K = \eta^{-\frac{1}{1+\omega}}$.

# Heterogeneity

- In equilibrium, the aggregate consumption is

$$C_t = (1-n)C_t^R + nC_t^K \tag{10}$$

- The heterogeneity is defined as

$$H_t \equiv \frac{C_t^R}{C_t}$$

- The Euler equation of Ricardian households can be rewritten as

$$\begin{aligned}\frac{1}{1+i_t} &= E_t\beta(\frac{C_{t+1}^R}{C_t^R})^{-1}\frac{P_t}{P_{t+1}} \\ &= E_t\beta(\frac{C_{t+1}}{C_t})^{-1}(\frac{H_{t+1}}{H_t})^{-1}\frac{P_t}{P_{t+1}}\end{aligned} \tag{11}$$

- The risk sharing condition can be expressed in aggregate consumption:

$$\frac{(C_t H_t)^{-1}}{P_t} = \frac{(C_t^* H_t^*)^{-1}}{S_t P_t^*} \tag{12}$$

# Production with Producer Currency Pricing

- Each firm $i$ in the home economy has the following production technology.

$$Y_t(i) = Z_t L_t(i) \tag{13}$$

where $Z_t = exp(\theta_t)$ is a country-specific productivity shock, and $\theta_t$ is distributed with mean zero and variance $\sigma_\theta^2$.

- Calvo type pricing: the firm maximizes the following objective function,

$$\max_{P^o_{hht}(i)} E_t \sum_{j=0}^{\infty} \kappa^j \beta_{t,t+j}[((1-\tau)P^o_{hht}(i) - MC_{t+j}(i))Y_{t+j}(i)]$$

- And the optimal price level

$$\frac{P^o_{hht}(i)}{P_{hht}} = \frac{1}{1-\tau}\frac{\varepsilon}{\varepsilon-1}\frac{E_t \sum_{j=0}^{\infty}(\beta\kappa)^j \frac{C_{t+j}^{R-\rho}}{C_t^{R-\rho}}(\frac{P_{hht+j}}{P_{hht}})^{\lambda} mc_{t+j} Y_{t+j}}{E_t \sum_{j=0}^{\infty}(\beta\kappa)^j \frac{C_{t+j}^{R-\rho}}{C_t^{R-\rho}}(\frac{P_{hht+j}}{P_{hht}})^{\lambda-1} Y_{t+j} p_{hht+j}} \tag{14}$$

- With PCP, $P^o_{hht} = S_t P^{o*}_{hft}$.

# Production with Local Currency Pricing

- Calvo type pricing: the firm maximizes the following objective function,

$$\max_{P^o_{hht}(i), P^{o*}_{hf,t}(i)} E_t \sum_{j=0}^{\infty} \kappa^j \beta_{t,t+j} \left[ \begin{array}{c} ((1-\tau)P^o_{hht}(i) - MC_{t+j}(i))C_{h,t+j}(i) \\ +((1-\tau)S_{t+j}P^{o*}_{hf,t}(i) - MC_{t+j}(i))C^*_{h,t+j}(i) \end{array} \right]$$

- The optimal price level

$$\frac{P^o_{hht}(i)}{P_{hht}} = \frac{1}{1-\tau}\frac{\varepsilon}{\varepsilon-1}\frac{E_t \sum_{j=0}^{\infty}(\beta\kappa)^j \frac{C_{t+j}^{R-\rho}}{C_t^{R-\rho}}(\frac{P_{hht+j}}{P_{hht}})^{\lambda} mc_{t+j} C_{ht+j}}{E_t \sum_{j=0}^{\infty}(\beta\kappa)^j \frac{C_{t+j}^{R-\rho}}{C_t^{R-\rho}}(\frac{P_{hht+j}}{P_{hht}})^{\lambda-1} C_{ht+j} p_{hht+j}} \tag{15}$$

$$\frac{P^{o*}_{hft}(i)}{P^*_{hft}} = \frac{1}{1-\tau}\frac{\varepsilon}{\varepsilon-1}\frac{E_t \sum_{j=0}^{\infty}(\beta\kappa)^j \frac{C_{t+j}^{R-\rho}}{C_t^{R-\rho}}(\frac{P^*_{hft+j}}{P^*_{hft}})^{\lambda} mc_{t+j} C^*_{ht+j}}{E_t \sum_{j=0}^{\infty}(\beta\kappa)^j e_{t+j} \frac{C_{t+j}^{R-\rho}}{C_t^{R-\rho}}(\frac{P^*_{hft+j}}{P^*_{hft}})^{\lambda-1} C^*_{ht+j} p^*_{hft+j}} \tag{16}$$

- With LCP, $P^o_{hht} \neq S_t P^{o*}_{hft}$. And the deviation from LOOP:

$$d_t = \frac{S_t P^*_{hft}}{P_{hht}}, d^*_t = \frac{P_{fht}}{S_t P^*_{fft}} \tag{17}$$

# Equilibrium

- The goods market:

$$Y_t = \frac{1}{2}\frac{P_t C_t}{P_{hht}}\Delta_{hh,t} + \frac{1}{2}\frac{P_t^* C_t^*}{P_{hft}^*}\Delta_{hf,t}^* \tag{18}$$

$$Y_t^* = \frac{1}{2}\frac{P_t^* C_t^*}{P_{fft}^*}\Delta_{ff,t}^* + \frac{1}{2}\frac{P_t C_t}{P_{fht}}\Delta_{fh,t} \tag{19}$$

Where $\Delta_{xx,t}$ is the price dispersion.

- Labor market:

$$L_t = (1-n)L_t^R + nL_t^K \tag{20}$$

$$L_t^* = (1-n)L_t^{*R} + nL_t^{*K} \tag{21}$$

- The term of trade:

$$Q_t = \frac{P_{fh,t}}{S_t P_{hf,t}^*}$$

# Solution method

- We normalized wage, marginal cost, prices and divide them by the CPI price level in the relevant country, which are labelled as lower case letters. That is, $w_t = \frac{W_t}{P_t}, mc_t = \frac{MC_t}{P_t}$, $p_{hht} = \frac{P_{hht}}{P_t}$.
- We log-linearize the flexible price equilibrium around ▸ The steady state.
- Equations independent of pricing strategies:
  - From Ricardian and Keynesian households' labor supply functions:

$$\widehat{C}_t^K = \widehat{w}_t \tag{22}$$

$$\widehat{C}_t^R = \widehat{w}_t - \omega \widehat{L}_t^R \tag{23}$$

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  - Using definition of heterogeneity, the production function, and the labor market condition, we have

$$\widehat{H}_t = \frac{-n}{1-n}\omega(\widehat{Y}_t - \theta_t)$$

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  - Heterogeneity are proportional to the output gap!

# Flexible price equilibrium

- The price set by a firm is a constant markup over marginal cost, so the real wage is simply given by $\widehat{p}^{fb}_{hht} = \widehat{w}^{fb}_t - \theta_t$.
- The real exchange rate $\widehat{e}^{fb}_t = 0$, the risk-sharing condition gives us

$$\widehat{C}^{R,fb}_t = \widehat{C}^{R*,fb}_t \tag{24}$$

- The nature rate of domestic interest:

$$\widehat{r}^{fb}_t = E_t(\widehat{Y}^{fb}_{t+1}) - \widehat{Y}^{fb}_t = E_t\Delta\theta_{t+1} \tag{25}$$

- From the goods market clear condition and risk-sharing condition:

$$\widehat{Y}^{fb}_t = \widehat{C}^{fb}_t + \frac{1}{2}(\widehat{q}^{fb}_t + \widehat{H}^{fb}_t - \widehat{H}^{*,fb}_t) = \widehat{C}^{R,fb}_t + \frac{1}{2}(\widehat{q}^{fb}_t - \widehat{H}^{fb}_t - \widehat{H}^{*,fb}_t) \tag{26}$$

The solution to the flexible price equilibrium: flexible solution.

# Monetary shocks with PCP

- We consider an nominal interest rate rule, by which the domestic real interest rate equals its natural rate and monetary shock.

$$\widehat{i}_t = E_t \pi_{hh,t+1} + \widehat{\mu}_t + \widehat{r}_t^{fb}$$

where the monetary shock $\widehat{\mu}_t$ is i.i.d. shock.

- Using euler equations and market clearing conditions, we solve outputs in terms of real interest rate and productivity shocks.

$$\widehat{Y}_t - \widehat{Y}_t^{fb} = E_t(\widehat{Y}_{t+1} - \widehat{Y}_{t+1}^{fb}) - \frac{1+\delta}{2\delta}(\widehat{r}_t - \widehat{r}_t^{fb}) - \frac{1-\delta}{2\delta}(\widehat{r}_t^* - \widehat{r}_t^{*fb}) \quad (27)$$

$$\widehat{Y}_t^* - \widehat{Y}_t^{fb*} = E_t(\widehat{Y}_{t+1}^* - \widehat{Y}_{t+1}^{fb*}) - \frac{1+\delta}{2\delta}(\widehat{r}_t^* - \widehat{r}_t^{*fb}) - \frac{1-\delta}{2\delta}(\widehat{r}_t - \widehat{r}_t^{fb}) \quad (28)$$

where $\delta = 1 - \frac{n\omega}{1-n}$.

▸ PCP solution

# Monetary shocks with PCP, cont.

## Proposition

*In a two-agent and two-country model, when the share of Keynesian household $n \in (\frac{1}{\omega+1}, \frac{1}{\frac{\omega}{2}+1})$, there exist a monetary trap, in which an expansionary monetary policy reduces output.*

To understand the intuition: we rewrite the good market clear condition (assuming no productivity shocks) as

$$\widehat{Y}_t = \frac{1}{\delta}\widehat{C}_t^R + \frac{1}{2}\widehat{q}_t \tag{29}$$

where $\delta = 1 - \frac{n\omega}{1-n}$.

- The first term captures the "aggregate consumption effect", while the second term captures the "term of trade effect" which is unique in open economy.
- The "aggregate consumption effect" can be positive or negative depending on $n$, while the "term of trade effect" is always positive.

# Intuition

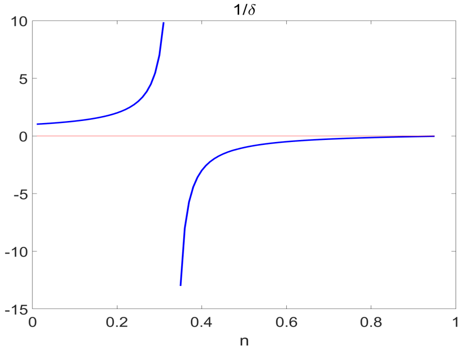
- Lower interest rate, $\widehat{C}_t^R \uparrow$ but $\widehat{C}_t = (1-n)\widehat{C}_t^R + n\widehat{C}_t^K$. When $n$ is small enough, $\widehat{C}_t^R$ drives up $\widehat{C}_t$. But when $n$ is large enough, the sign of $\widehat{C}_t$ depends on $\widehat{C}_t^K$. Recall that

$$\widehat{C}_t^K = \widehat{w}_t \tag{30}$$

$$\widehat{C}_t^R = \widehat{w}_t - \omega \widehat{L}_t^R \tag{31}$$

- **Bilbiie (2008) "Inverted aggregate demand logic":** It's impossible to have $\widehat{C}_t^K \uparrow$ when $n$ is large enough: If consumption demand increase, Ricardian households increase their labor supply $\widehat{L}_t^R$ since $\widehat{L}_t = (1-n)\widehat{L}_t^R$. But this is may imply $\widehat{C}_t^R \downarrow$ since $-\omega \widehat{L}_t^R$ dominates $\widehat{w}_t$. This contradicts with the fact that $\widehat{C}_t^R \uparrow$ when interest rate is lower.$\Rightarrow$ Aggregate consumption effect turns negative.
- But in open economy, we have the **positive** term of trade effect: $\widehat{q}_t \uparrow$: when there is an interest rate cut in the home country, the relative price of home goods to foreign goods becomes cheaper.

# The aggregate consumption effect changes with $n$




where $\omega = 0.5$

- So the aggregate consumption effect is positive when $n$ is small.
- It turns large and negative when $n$ gets larger. It will dominate the term of trade effect, so the economy is in the policy trap.
- When $n$ keeps increasing, the aggregate consumption effect is still negative but becomes smaller since $\delta = 1 - \frac{n\omega}{1-n}$. So it is dominated by term of trade effect and the economy exits the monetary trap.

# Monetary shocks with PCP: Spillover

## Proposition

*For any $n > 0$, there are positive or negative spillover effect of monetary shock, depending on $n$, the fraction of Keynesian households. When $n < \frac{1}{\omega+1}$, there is positive spillover effect of home monetary shock for foreign country. When $n > \frac{1}{\omega+1}$, the spillover effect is negative.*

The result deviates from CGG (2002) when there are Keynesian households.

$$\widehat{Y}_t^* = \frac{1}{\delta}\widehat{C}_t^{R*} - \frac{1}{2}\widehat{q}_t \tag{32}$$

- Risk sharing implies that the aggregate consumption effect is positive. But the term of trade effect is negative.
- When $n$ is small, aggregate consumption effect dominates. When $n$ is large, the term of trade effect dominates.

# Monetary shocks with LCP

- Combining the goods market condition and Euler equation, have

$$\widehat{Y}_t - \widehat{Y}_t^{fb} = E_t(\widehat{Y}_{t+1} - \widehat{Y}_{t+1}^{fb}) - \frac{1}{2\delta}\widehat{\mu}_t - \frac{1}{2\delta}\widehat{\mu}_t^* + t.i.p \qquad (33)$$

LCP solution

## Proposition

*With household heterogeneity, under LCP setting, when $n < \frac{1}{w+1}$, an expansionary monetary shock in home or foreign country can increase home output; However, when $n > \frac{1}{w+1}$, an expansionary monetary shock in home or foreign country reduce the home output.*

To understand the intuition: we rewrite the good market clear condition (assuming no productivity shocks) as

$$\widehat{Y}_t = \frac{1}{\delta}(\widehat{C}_t^R - \frac{1}{2}\widehat{e}_t) + \frac{1}{2}(\widehat{q}_t + \widehat{e}_t) \quad (34)$$

- Again, there are two effect, the aggregate consumption effect and the relative price effect.
- In the LCP case, the foreign Ricardian consumption increases less due to real exchange rate depreciation. So change in global Ricardian consumption is given by $(\widehat{C}_t^R - \frac{1}{2}\widehat{e}_t)$.
- The relative price term in the LCP case includes both term of trade and the real exchange rate and it is equal to $\hat{Y}_t - \hat{Y}_t^*$ and therefore cannot be affected by monetary policies.
- So only the aggregate consumption effect will play a role, like in the closed economy case (Bilbiie, 2008).

# Optimal monetary policy under PCP

- The global (second-order approximated) welfare loss function with household heterogeneity:

$$W_0 = \left\{ \begin{array}{c} \frac{1+\omega}{2}(\widehat{Y}_t - \theta_t)^2 - \frac{1}{2}\frac{1-n}{n}\left[(\frac{1}{\omega})^2\right](\widehat{H}_t)^2 + \frac{1+\omega}{2}(\widehat{Y}_t^* - \theta_t^*)^2 \\ -\frac{1}{2}\frac{1-n}{n}\left[(\frac{1}{\omega})^2\right](\widehat{H}_t^*)^2 + \frac{1}{4}(\widehat{H}_t^* - \widehat{H}_t)^2 + \frac{\lambda}{2\delta}\pi_{hh,t}^{*2} + \frac{\lambda}{2\delta}\pi_{ff,t}^{*2} \end{array} \right\} \quad (35)$$

- Note that heterogeneity measures $\widehat{H}_t$ and $\widehat{H}_t^*$ show up in the loss function.
- The planner choose $\left\{ \widehat{Y}_t, \widehat{Y}_t^*, \pi_{hh,t}, \pi_{ff,t}^*, \widehat{q}_t \right\}$ to minimize the global loss, subject to the following NKPCs and resource constraint:

$$\pi_{hh,t} = \widetilde{\kappa}\left[(1+\omega)\,\widehat{Y}_t - (1+\omega)\,\theta_t + \frac{1}{2}(\widehat{H}_t^* - \widehat{H}_t)\right] + \beta E_t \pi_{hh,t+1} \quad (36)$$

$$\pi_{ff,t}^* = \widetilde{\kappa}\left[(1+\omega)\,\widehat{Y}_t^* - (1+\omega)\,\theta_t^* - \frac{1}{2}(\widehat{H}_t^* - \widehat{H}_t)\right] + \beta E_t \pi_{ff,t+1}^* \quad (37)$$

$$\widehat{Y}_t = \widehat{Y}_t^* + \widehat{q}_t \quad (38)$$

- The planner also know:

$$\widehat{H}_t = \frac{-n\omega}{1-n}(\widehat{Y}_t - \theta_t) \quad (39)$$

# Optimal monetary policy under PCP, cont.

**Proposition**

*The solution to the global planer's problem under PCP restores the economy to the flexible price equilibrium. PPI inflation stabilization can close both the output gap and eliminate the household heterogeneity*

# Optimal monetary policy under LCP

- The global (second-order approximated) welfare loss function with household heterogeneity:

$$W_0 = \left\{ \begin{array}{c} \frac{1+\omega}{2}(\widehat{Y}_t - \theta_t)^2 + \frac{1+\omega}{2}(\widehat{Y}_t^* - \theta_t^*)^2 - \frac{1}{2}\frac{1-n}{n}(\frac{1}{\omega})^2\left[(\widehat{H}_t)^2 + (\widehat{H}_t^*)^2\right] \\ +\frac{1}{8}(\widehat{d}_t + \widehat{H}_t^* - \widehat{H}_t)^2 + \frac{1}{8}(\widehat{d}_t^* - \widehat{H}_t^* + \widehat{H}_t)^2 \\ +\frac{\varepsilon}{2\widetilde{\kappa}}\left[\frac{1}{2}\pi_{hh,t}^2 + \frac{1}{2}\pi_{fh,t}^2 + \frac{1}{2}\pi_{hf,t}^{*2} + \frac{1}{2}\pi_{ff,t}^{*2}\right] \end{array} \right\} \tag{41}$$

- Notice that, besides the heterogeneity measures $\widehat{H}_t$ and $\widehat{H}_t^*$, there are also $d_t$ and $d_t^*$ terms. These are deviation from LOOP terms for home and foreign goods, as in the open economy literature like Engel (2011).
- The planner choose $\left\{\widehat{Y}_t, \widehat{Y}_t^*, \pi_{hh,t}, \pi_{ff,t}^*, \widehat{q}_t\right\}$ to minimize the global loss, subject to the NKPCs and resource constraint.

# Optimal monetary policy under LCP, cont.

## Proposition

*When there are household heterogeneity ($n > 0$) but with no home bias,CPI inflation is the optimal monetary policy under LCP case.*

With LCP, the output gap cannot be closed, but the relative output is independent of monetary policy. So monetary policy can ignore consumption heterogeneity and choose CPI targeting as optimal monetary policy.

## Proposition

*When there is household heterogeneity ($n > 0$) and home bias ($v \neq 1$),CPI inflation is not the optimal monetary policy under the LCP case.*

# Extension with asymmetric heterogeneity

- $n \neq n^*$

$$\widehat{H}_t = \frac{-n}{1-n}\omega(\widehat{Y}_t - \theta_t)$$
$$\widehat{H}_t^* = \frac{-n^*}{1-n^*}\omega(\widehat{Y}_t^* - \theta_t^*)$$

$$\frac{(C_t H_t)^{-1}}{P_t} = \frac{(C_t^* H_t^*)^{-1}}{S_t P_t^*} \tag{42}$$

# Extension: monetary shocks in PCP case

- Focusing on the case $1 > \frac{n\omega}{1-n}$ means that $\delta > 0$ and $\delta^* > 0$

$$\widehat{Y}_t = E_t \widehat{Y}_{t+1} - \frac{\left(2 - \frac{n^*\omega}{1-n^*}\right)}{2 - \frac{n^*\omega}{1-n^*} - \frac{n\omega}{1-n}} \widehat{r}_t - \frac{\left(\frac{n^*\omega}{1-n^*}\right)}{2 - \frac{n^*\omega}{1-n^*} - \frac{n\omega}{1-n}} \widehat{r}_t^* \qquad (43)$$

**Proposition**

*Heterogeneity in the domestic country magnifies the impact of domestic monetary shocks*

**Proposition**

*Without domestic heterogeneity, the impact of domestic monetary shocks is unaffected by foreign heterogeneity*

# Extension: monetary shocks in PCP case

- Focusing on the case $1 > \frac{n\omega}{1-n}, 1 > \frac{n^*\omega}{1-n^*}$

$$\widehat{Y}_t^* = E_t \widehat{Y}_{t+1}^* - \frac{\left(2 - \frac{n\omega}{1-n}\right)}{2 - \frac{n^*\omega}{1-n^*} - \frac{n\omega}{1-n}} \widehat{r}_t^* - \frac{\left(\frac{n\omega}{1-n}\right)}{2 - \frac{n^*\omega}{1-n^*} - \frac{n\omega}{1-n}} \widehat{r}_t \tag{44}$$

### Proposition

*The spillover of monetary shocks is increased by heterogeneity in the source country or the host country*

### Proposition

*The spillover of monetary shocks is zero if there is no heterogeneity in the source country*

### Proposition

*The spillover of monetary shocks is more sensitive to heterogeneity in the source country than in the host country*

# Extension: optimal monetary policy in PCP, cont.

**Proposition**

*The solution to the global planer's problem under PCP restores the economy to the flexible price equilibrium. PPI inflation stabilization can close both the output gap and eliminate the household heterogeneity*

# Extension: optimal monetary policy in LCP case, cont.

**Proposition**

*When there are household heterogeneity* $(n > 0)$ *but* $n \neq n^*$ *and without home bias,CPI inflation is not the optimal monetary policy under the LCP case.*

# Conclusion

- This paper incorporates household heterogeneity (Ricardian vs Keynesian) into standard two-country open economy macro model and studies how consumption heterogeneity affects the transmission mechanism of monetary policy and the choice of optimal monetary policy in open economy.
- We find that, under both PCP and LCP, there will be an sizeable range of consumption heterogeneity, in which monetary policy become ineffective. Meanwhile, the spillover effects of monetary shocks in open economy also change dramatically and could be positive or negative under both PCP and LCP case, depending on the degree of consumption heterogeneity.

# Conclusion cont.

- The impact of consumption heterogeneity on the choice of optimal monetary policy varies with currency of export pricing and asymmetric heterogeneity.
- For example, PPI is still the optimal monetary policy under PCP and restores the economy to the efficient equilibrium. However, under LCP, consumption heterogeneity will create a new distortion that cannot be corrected by monetary policy. We show that without asymmetric heterogeneity, CPI is the optimal monetary policy. And with asymmetric heterogeneity, CPI cannot be optimal monetary policy.

# The steady state

- The steady state is given by

$$1 + i^{ss} = \frac{1}{\beta}, S = 1$$

$$D^{e,ss} = 0, H^{ss} = 1$$

$$Y = C^{ss} = C^{R,ss} = C^{K,ss}, L^{R,ss} = L^{K,ss} = \eta^{-\frac{1}{1+\omega}}$$

In this steady state, dividend is zero and allocate is efficient, and agents are homogeneous.

back

# Flexible price solution

## Proposition

*With household heterogeneity, the solution to the flexible price equilibrium can still achieve the efficient equilibrium in the standard new open macro model (CGG2002).*

$$\widehat{H}_t^{fb} = \widehat{H}_t^{*,fb} = 0$$
$$\widehat{q}_t^{fb} = \widehat{Y}_t^{fb} - \widehat{Y}_t^{fb*} = (\theta_t - \theta_t^*)$$
$$\widehat{Y}_t^{fb} = \theta_t, \qquad \widehat{Y}_t^{fb*} = \theta_t^*$$
$$\widehat{C}_t^{fb} = \widehat{C}_t^{*,fb} = \widehat{C}_t^{R,fb} = \widehat{C}_t^{R*,fb} = \frac{1}{2}(\theta_t + \theta_t^*)$$

back

# Monetary shocks with PCP, cont.

The equilibrium allocations under PCP are given,

$$\widehat{Y}_t - \widehat{Y}_t^{fb} = -\frac{1+\delta}{2\delta}u_t - \frac{1-\delta}{2\delta}u_t^* \tag{45}$$

$$\widehat{Y}_t^* - \widehat{Y}_t^{fb*} = -\frac{1+\delta}{2\delta}u_t^* - \frac{1-\delta}{2\delta}u_t \tag{46}$$

$$\widehat{q}_t = \widehat{Y}_t - \widehat{Y}_t^* = \widehat{Y}_t^{fb} - \widehat{Y}_t^{fb*} + u_t^* - u_t$$

$$\widehat{C}_t^R = \widehat{C}_t^{R*} = (\frac{1}{2} - \frac{n\omega}{1-n})(\widehat{Y}_t + \widehat{Y}_t^*) + \frac{n\omega}{1-n}(\theta_t + \theta_t^*) \tag{47}$$

$$\widehat{H}_t = \frac{-n\omega}{1-n}(\widehat{Y}_t - \theta_t) \tag{48}$$

$$\widehat{H}_t^* = \frac{-n\omega}{1-n}(\widehat{Y}_t^* - \theta_t^*) \tag{49}$$

back

# Monetary shocks with LCP

- The deviation from law of one price, terms of trade, and their relationship with real exchange rate are given by

$$\widehat{d}_t = \widehat{p}^*_{hf,t} + \widehat{e}_t - \widehat{p}_{hh,t} \tag{50}$$

$$\widehat{d}^*_t = \widehat{p}_{fh,t} - \widehat{e}_t - \widehat{p}^*_{ff,t} \tag{51}$$

$$\widehat{q}_t = -\widehat{q}^*_t = \widehat{p}_{fh,t} - \widehat{p}^*_{hf,t} - \widehat{e}_t \tag{52}$$

$$\widehat{e}_t = \frac{1}{2}(\widehat{d}_t - \widehat{d}^*_t) \tag{53}$$

- The risk-sharing condition

$$\widehat{C}^R_t = \widehat{C}^{*,R}_t + \widehat{e}_t \tag{54}$$

- The goods market clearing condition

$$\widehat{Y}_t = \frac{1}{2}\widehat{C}_t + \frac{1}{2}(\widehat{C}_t + \widehat{H}_t - \widehat{H}^*_t - \widehat{e}_t) + \frac{1}{2}(\widehat{q}_t + \widehat{e}_t)$$

back