Tractable Heterogeneous Agents Models

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Intro

- Set up baseline HANK model.
- Show how to make it tractable. (Very similar in spirit to T(H)ANK).
- Compare to Representative Agent New Keynesian (RANK) model
  - determinacy, responses to macro and policy shocks

Readings for this session

- [Ravn and Sterk, 2020] (simplified substantially)

- Material from this session is based upon Vincent Sterk's notes.

Model Overview

Agents:

- Households
  - face idiosyncratic income risk, decide on consumption, saving and labour supply
- Firms
  - produce, set prices subject to adjustment cost
- Monetary authority
  - set nominal interest rate
- Fiscal authority

Households

Infinitely-lived, **risk averse** and ex-ante identical. Household $i \in [0, 1]$ maximizes:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U\left(C_t(i), N_t(i)\right), \beta \in (0, 1)$$

- $C_t(i) \equiv \int_0^1 \left(C_t(i,j)^{\frac{\varepsilon-1}{\varepsilon}} dj\right)^{\frac{\varepsilon}{\varepsilon-1}}$, where $\varepsilon > 1$: consumption basket with price $P_t = \int_0^1 \left(P_t(j)^{1-\varepsilon} dj\right)^{\frac{1}{1-\varepsilon}}$.
- $N_t(i)$: hours worked.
- Households are either
  - employed $\left(\mathbf{1}_t^e(i) = 1\right)$: freely choose $N_t(i)$ or
  - unemployed $\left(\mathbf{1}_t^e(i) = 0\right)$: $N_t(i) = 0$ produce ϑ at home (benefit). Assume that parameters are such that $\vartheta < 1_t^e(i) w_t N_t(i)$ **is not good to be unemployed**. (should be checked).
- Transition probabilities are constant and exogenous (for now):
  - p^{eu}: job loss probability
  - p^{ue}: job finding probability
  - unemployment rate given by $u = \frac{p^{eu}}{p^{ue} + p^{eu}}$

Households

- Households can hold liquid bonds ($B_t(i)$) at no transaction cost but subject to a no-borrowing constraint:
  $$B_t(i) \geq 0$$
  alternatively, generalize:
  $$B_t(i) \geq \underbrace{\chi w_t \mathbf{1}_t^e(i)}_{\text{\% of wage income}}$$
  where $\chi \leq 0$.
- Households also own shares in the firms (illiquid).
  - To simplify the algebra later on, we assume that a household only receives dividends when employed.
- Budget constraint
  $$C_t(i) + B_t(i) = \mathbf{1}_t^e(i)\left(w_t N_t(i) + \frac{Div_t}{1-u}\right) + \left(1 - \mathbf{1}_t^e(i)\right)\vartheta + \frac{R_{t-1}}{\Pi_t} B_{t-1}(i) - T_t,$$
  where w_t is the real wage per effective unit of labor, R_t is the gross nominal interest rate, Π_t is the inflation rate, Div_t are dividends, and T_t is a lump-sum tax. Households choose $C_t(i)$, $N_t(i)$ and $B_t(i)$.

Firms

- Produce goods varieties with technology $Y_t(j) = A_t N_t(j)$, where A_t follows an exogenous process (TFP shock).
- Set prices, subject to Rotemberg (1982) cost of price adjustment by $Adj_t(j) = \phi \left(\frac{P_t(j) - P_{t-1}(j)}{P_{t-1}(j)} \right)^2 Y_t$.
- Maximize present value of dividends, where $Div_t(j) = \frac{P_t(j)}{P_t} Y_t(j) - w_t N_t(j) - Adj_t(j)$.
- Phillips Curve:

$$1 - \varepsilon + \varepsilon \frac{w_t}{A_t} = \phi \left(\Pi_t - 1 \right) \Pi_t - \phi \mathbb{E}_t \Lambda_{t+1} \frac{Y_{t+1}}{Y_t} \left(\Pi_{t+1} - 1 \right) \Pi_{t+1}$$

  where we assume for simplicity that $\Lambda_{t,t+1} = \beta$.[1]

[1] If $\bar{\Pi} = 0$ it does not matter up to first order.

Government

- Constant government debt policy: $B_t = \bar{B}$. We abstract from government consumption and investment.

- Government budget constraint:

$$\frac{R_{t-1}}{\Pi_t}\bar{B} = \bar{B} + T_t$$

- Central bank sets policy according to the following rule:

$$R_t = z_t \bar{R} \left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\xi}$$

where z_t is an exogenous monetary policy shock with value 1 in the steady state.

Market Clearing

- bonds:

$$\int_0^1 B_t(i)di = \bar{B}$$

- goods:

$$\int_0^1 C_t(i)di + \int_0^1 Adj_t(j)dj = A_t \int_0^1 N_t(j)dj + u\vartheta$$

- labor:

$$\int_0^1 N_t(i)di = \int_0^1 N_t(j)dj$$

Preferences and Home Production

- Utility function

$$U(C,N) = \frac{C_t(i)^{1-\sigma}}{1-\sigma} - \kappa \frac{N^{1+\varphi}}{1+\varphi}$$

- First-order condition for labor:

$$\kappa N_t(i)^{\varphi} = w_t C_t(i)^{-\sigma}$$

- Warning: σ here is the inverse of the IES, the opposite of what we had in TANK set up.

ZL-HANK

- We now render the model tractable ([Krusell et al., 2011], [Ravn and Sterk, 2020]). Suppose that $\bar{B} = 0$. Zero Liquidity (ZL-HANK). It follows directly that $T_t = 0$.
- Unemployed would like to borrow but are borrowing-constrained.
  - Employed cannot save *in equilibrium*.[2]
  - Everyone sets $B_t(i) = 0$. Trivial wealth distribution.
- All households consume their current incomes: $C_t(i) = \mathbf{1}_t^e \left(w_t N_t(i) + \frac{Div_t}{1-u} \right) + (1 - \mathbf{1}_t^e)\,\vartheta$.

[2] It does not mean that they are hand-to-mouth. They would like to save so R_t needs to adjust to avoid so.

ZL-HANK

- Note: no heterogeneity within groups of employed and unemployed. Hence, within the two groups everyone makes the same consumption and labor supply decisions.

- Euler equations for households resp. employed and unemployed:

$$C_{e,t}^{-\sigma} \geq \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left(\rho^{eu} C_{u,t+1}^{-\sigma} + (1 - p^{eu}) \, C_{e,t+1}^{-\sigma} \right)$$
$$C_{u,t}^{-\sigma} \geq \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left((1 - p^{ue}) \, C_{u,t+1}^{-\sigma} + p^{ue} C_{e,t+1}^{-\sigma} \right)$$

  where $C_{e,t} = w_t N_{e,t} + \frac{Div_t}{1-u}$ and $C_{u,t} = \vartheta$.

- Hold with strict inequality iff the borrowing constraint binds.

ZL-HANK

- Euler equations for employed and unemployed in equilibrium:

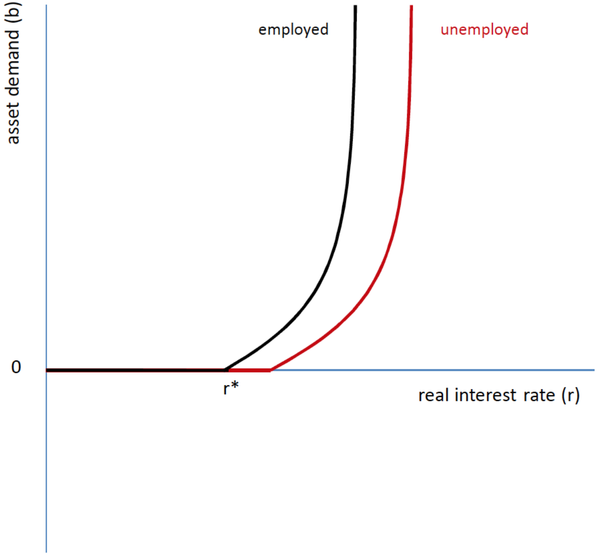
$$\begin{aligned} C_{e,t}^{-\sigma} &= \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left(p^{eu} C_{u,t+1}^{-\sigma} + (1 - p^{eu}) \, C_{e,t+1}^{-\sigma} \right) \\ C_{u,t}^{-\sigma} &> \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left((1 - p^{ue}) \, C_{u,t+1}^{-\sigma} + p^{ue} C_{e,t+1}^{-\sigma} \right) \end{aligned}$$

- At the equilibrium interest rate, unemployed like to borrow but hit the constraint.

- Equilibrium interest rate adjusts such that employed choose $B_{e,t} = 0$.

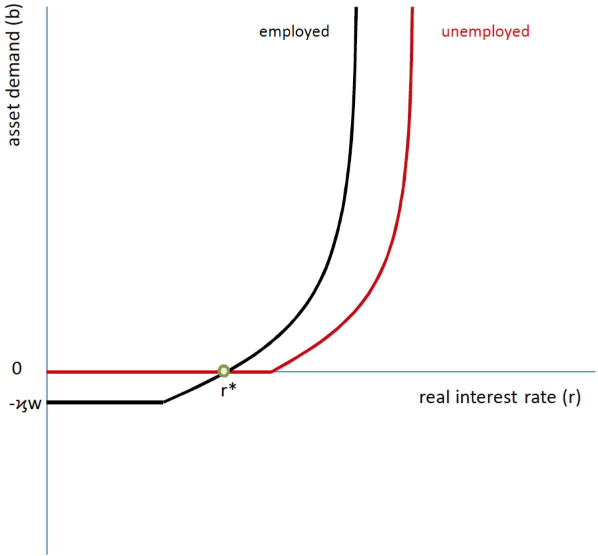
- Employed determine the equilibrium real interest rate.

ZL-HANK: Sterk and Ravn (2020)



ZL-HANK: Sterk and Ravn (2020)

Alternative assumption on borrowing limit



ZL-HANK: model summary

$$
\begin{aligned}
C_{e,t}^{-\sigma} &= \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left(p^{eu} \vartheta^{-\sigma} + \left(1 - p^{eu}\right) C_{e,t+1}^{-\sigma} \right) \\
C_{e,t} &= w_t N_{e,t} + \frac{Div_t}{1-u} \\
N_{e,t} &= \left(\frac{w_t}{\kappa} C_{e,t}^{-\sigma} \right)^{\frac{1}{\varphi}} \\
1 - \varepsilon + \varepsilon \frac{w_t}{A_t} &= \phi \left(\Pi_t - 1\right) \Pi_t - \phi \mathbb{E}_t \beta \frac{Y_{t+1}}{Y_t} \left(\Pi_{t+1} - 1\right) \Pi_{t+1} \\
Div_t &= \left(A_t - w_t\right) (1-u) N_{e,t} - Adj_t \\
Adj_t &= \phi \left(\Pi_t - 1\right)^2 Y_t \\
Y_t &= A_t (1-u) N_{e,t} \\
R_t &= z_t \bar{R} \left(\Pi_t\right) \xi^{\xi}
\end{aligned}
$$

ZL-HANK: model summary

Simplify by substituting adjustment costs and dividends:

$$
\begin{aligned}
C_{e,t}^{-\sigma} &= \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left(p^{eu} \vartheta^{-\sigma} + \left(1 - p^{eu}\right) C_{e,t+1}^{-\sigma} \right) \\
C_{e,t}^{\frac{\varphi+\sigma}{\varphi}} &= A_t \left(\frac{w_t}{\kappa} \right)^{\frac{1}{\varphi}} \left(1 - \frac{\phi}{1-u} \left(\Pi_t - 1\right)^2 \right) \\
1 - \varepsilon + \varepsilon \frac{w_t}{A_t} &= \phi \left(\Pi_t - 1\right) \Pi_t - \phi \mathbb{E}_t \beta \frac{Y_{t+1}}{Y_t} \left(\Pi_{t+1} - 1\right) \Pi_{t+1} \\
R_t &= z_t \bar{R} \left(\Pi_t\right)^{\xi}
\end{aligned}
$$

ZL-HANK: model summary

Representative Agent (RANK) version: set $p^{eu} = u = 0$.

$$
\begin{aligned}
C_{e,t}^{-\sigma} &= \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left(p^{eu} \vartheta^{-\sigma} + \left(1 - p^{eu}\right) C_{e,t+1}^{-\sigma} \right) \\
C_{e,t}^{\frac{\varphi+\sigma}{\varphi}} &= A_t (1 - u) \left(\frac{w_t}{\kappa} \right)^{\frac{1}{\varphi}} \left(1 - \phi \left(\Pi_t - 1 \right)^2 \right) \\
1 - \varepsilon + \varepsilon \frac{w_t}{A_t} &= \phi \left(\Pi_t - 1 \right) \Pi_t - \phi \mathbb{E}_t \beta \frac{Y_{t+1}}{Y_t} \left(\Pi_{t+1} - 1 \right) \Pi_{t+1} \\
R_t &= z_t \bar{R} \left(\Pi_t \right)^{\xi}
\end{aligned}
$$

Notes:

- constant u in second equation is not interesting (you can re-scale κ).
- more interesting are the additional terms in the Euler equation.
- otherwise the RANK and ZL-HANK are equivalent.

Does market Incompleteness matter?

steady state

- First consider the **steady state** without aggregate uncertainty:

$$C_e^{-\sigma} = \beta \frac{R}{\Pi} \left(p^{eu} \vartheta^{-\sigma} + \left(1 - \rho^{eu}\right) C_e^{-\sigma} \right)$$

$$\frac{1}{\beta} = \frac{R}{\Pi} \underbrace{\left(p^{eu} \left(\frac{\vartheta}{C_e} \right)^{-\sigma} + \left(1 - p^{eu}\right) \right)}_{\text{wedge}}$$

- RANK: $p^{eu} = 0 \Rightarrow$ wedge $= 1 \Rightarrow \frac{R}{\Pi} = \frac{1}{\beta}$.
  - real interest rate equals the subjective discount rate
- ZL-HANK: wedge > 1 since $\vartheta < C_e \Rightarrow \frac{R}{\Pi} < \frac{1}{\beta}$
  - real interest rate lies below the subjective discount rate because of a precautionary saving motive due to unemployment risk and incomplete markets.
  - magnitude depends on the probability of unemployment and the income loss given unemployment

Does market Incompleteness matter?

steady state with binding ZLB

- Consider now a steady state in which the Zero Lower Bound (ZLB) on the nominal interest rate binds ($R = 1$).
- RANK: Euler equation implies:
$$\Pi = \beta < 1$$
must have negative inflation! (missing deflation puzzle)
- ZL-HANK: Euler equation implies:
$$\Pi = \beta\left(p^{eu}\left(\frac{\vartheta}{C_e}\right)^{-\sigma} + (1 - p^{eu})\right) >< 1$$
market incompleteness can reconcile ZLB with positive inflation.

Does market Incompleteness matter?

Fluctuations

- How does the modified Euler equation change the model outside of the steady state?
- Log-linearize the Euler Equation:

$$-\sigma \widehat{C}_{e,t} + \sigma \beta R \left(1 - p^{eu}\right) E_t \widehat{C}_{e,t+1} = \widehat{R}_t - E_t \widehat{\Pi}_{t+1}$$

- Iterate forward:

$$\widehat{C}_{e,t} = -\frac{1}{\sigma} \sum_{k=0}^{\infty} \left(\beta R \left(1 - \rho^{eu}\right)\right)^k \left(\widehat{R}_{t+k} - E_t \widehat{\Pi}_{t+k+1}\right)$$

- Discount factor $\beta R \left(1 - p^{eu}\right) < 1$ in the Euler Equation ($\beta R = 1$ in RANK)
  - Interpretation [McKay et al., 2016]: households ”less forward looking” due to borrowing constraints
  - alleviates Forward Guidance Puzzle

Does market Incompleteness matter?

- [Werning, 2015] challenges McKay, Nakamura and Steinsson's interpretation.

- To see his point, consider a slightly modified version of the model in which home production (unemployment benefits) move one-for-one with aggregate income (net of price adjustment costs):
$$\vartheta_t = \gamma \tilde{Y}_t$$
where $\gamma > 0$ and $\widetilde{Y}_t = Y_t - Adj_t = (1-u)C_{e,t}$.

Does market Incompleteness matter?

- The Euler equation can now be written as:

$$C_{e,t}^{-\sigma} = \beta \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} \left(p^{eu} \left(\gamma(1-u) C_{e,t+1} \right)^{-\sigma} + \left(1 - p^{eu}\right) C_{e,t+1}^{-\sigma} \right)$$

  or

$$C_{e,t}^{-\sigma} = \widetilde{\beta} \mathbb{E}_t \frac{R_t}{\Pi_{t+1}} C_{e,t+1}$$

  where $\widetilde{\beta} = \beta \left(p^{eu} \left(\gamma(1-u) \right)^{-\sigma} + (1 - p^{eu}) \right)$ is a modified discount factor. Linearized Euler equation given by:

$$-\sigma \widehat{\mathcal{C}}_{e,t} + \sigma E_t \widehat{C}_{e,t+1} = \widehat{R}_t - E_t \widehat{\Pi}_{t+1}$$

- exactly the same as in representative agent model: $\tilde{\beta}(\beta)$ drops out in the log-linearization.
  - recall Euler equation under constant benefit was given by:

$$-\sigma \widehat{\mathcal{C}}_{e,t} + \sigma \beta R (1 - p^{eu}) E_t \widehat{C}_{e,t+1} = \widehat{R}_t - E_t \widehat{\Pi}_{t+1}$$

Does market Incompleteness matter?

- We have seen two slightly different ZL-HANK models:
  - model 1: constant unemployment benefit $\rightarrow$ discount in log-linearized Euler equation [McKay-Nakamura-Steinsson], relative to RANK
  - model 2: benefit proportional to aggregate income $\rightarrow$ ZL-HANK and RANK equivalent [Werning]
- Interpretation? Werning: implicit assumption on cyclicality of income risk.
- Write the Euler equation as:

$$\widetilde{Y}_t^{-\sigma} = \beta \mathbb{E}_t \frac{R}{\Pi_{t+1}} \left(p^{eu} \vartheta_{t+1}^{-\sigma} + \left(1 - p^{eu}\right) \widetilde{Y}_{t+1}^{-\sigma} \right)$$

Euler Equation wedge

- Can re-write the Euler equation as:

$$1 = \beta \mathbb{E}_t \frac{R}{\Pi_{t+1}} \left(p^{eu} \left(\frac{\vartheta_{t+1}}{\widetilde{Y}_{t+1}} \right)^{-\sigma} + (1 - p^{eu}) \, \widetilde{Y}_{t+1}^{-\sigma} \right)$$

- note: $\frac{\vartheta_t}{\tilde{Y}_t} < 1$ is the change in income upon job loss.
  - model 1 (MNS): $\frac{\vartheta_t}{\tilde{Y}_t} = \frac{\vartheta}{\tilde{Y}_t} \downarrow$ when $\tilde{Y}_t \uparrow$ (income drop falls in recessions: pro-cyclical income risk)[3]
  - model 2 (Werning): $\frac{\vartheta_t}{\tilde{Y}_t} = \gamma$ (time-invariant income drop: acyclical income risk)
- Werning: results in MNS due to implicit assumption of procyclical income risk
  - empirical studies typically find that income risk is countercyclical
  - therefore, incomplete markets might actually worsen the forward guidance puzzle

[3] risk of loosing your job increases in a boom as the difference between income and benefits is larger.

Cyclicality of income risk

- Why does -intuitively- the cyclicality of income risk matter for Forward Guidance?
- News of future decline in interest rates increases aggregate goods demand today $\Rightarrow$ creates boom
- The boom in turn increases current income, and hence the drop in income upon job loss increases
  - $\Rightarrow$ stronger precautionary savings motive
  - $\Rightarrow$ dampens the increase in aggregate demand

Taking stock

- We considered a stark form of market incompleteness: zero liquidity, no borrowing.
- Effect of market incompleteness shows up as a wedge in the Euler equation
  - lower steady-state real interest rate due to precautionary saving motive
  - may help resolve missing deflation puzzle
- Whether market incompleteness matters also for fluctuations depends critically on the cyclicality of income risk
  - equivalence under constant income risk
  - dampening under pro-cyclical income risk
    - quantitative importance?

Quantitative exercises

- Next: explore quantitative effects of market incompleteness with numerical exercises.
  - calibrate and solve in dynare
- Focus on:
  - determinacy
  - response of TFP shocks and monetary policy shocks

Log-linearized model

- Assume that the central bank targets zero net inflation in the steady state ($\bar{\Pi} = 1$).
- The log-linearized model is given by

$$
\begin{aligned}
-\sigma \widehat{C}_{e,t} + \sigma\beta\bar{R}(1-p^{eu})E_t\widehat{C}_{e,t+1} &= \widehat{R}_t - E_t\widehat{\Pi}_{t+1} \\
\frac{\varepsilon-1}{\phi}\left(\widehat{w}_t - \widehat{A}_t\right) &= \widehat{\Pi}_t - \beta E_t\widehat{\Pi}_{t+1} \\
(\varphi+\sigma)\hat{C}_{e,t} &= \phi\widehat{A}_t + \widehat{w}_t \\
\widehat{R}_t &= \xi\widehat{\Pi}_t + z_t
\end{aligned}
$$

- simplifying, using $\hat{C}_{e,t} = \hat{Y}_t$:

$$
\begin{aligned}
-\sigma\widehat{Y}_t + \sigma\beta\bar{R}(1-p^{eu})E_t\widehat{Y}_{t+1} &= \xi\widehat{\Pi}_t - E_t\widehat{\Pi}_{t+1} + z_t \\
\frac{\varepsilon-1}{\phi}\left((\varphi+\sigma)\hat{Y}_t - (1+\varphi)\widehat{A}_t\right) &= \widehat{\Pi}_t - \beta E_t\widehat{\Pi}_{t+1}
\end{aligned}
$$

Calibration

- ZL-HANK with constant benefits
- Quarterly frequency
- Standard parameters
  - discount factor $\beta = 0.99$
  - risk aversion $\sigma = 1$
  - inverse of Frish elasticity $\varphi = 1$
  - monopolistic competition $\varepsilon = 9$ (steady state markup: 12.5%)
  - price stickiness: $\psi = 93.2$ (avg. price duration of 1 year)
  - coefficient monetary policy rule: $\xi = 1.5$

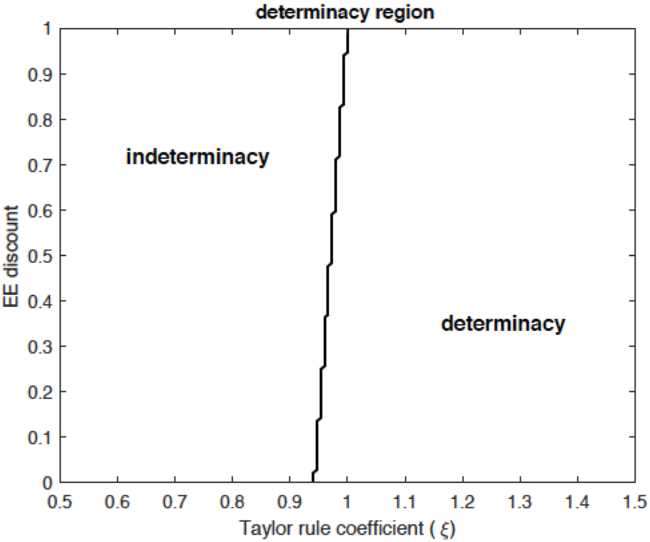
Calibration

- Key parameter: s.s. real interest rate $\bar{R}$
  - RANK: $\bar{R} = \frac{1}{\beta}$
  - ZL-HANK: $\bar{R} = \frac{1}{\beta\left(p^{eu}\left(\frac{\vartheta}{Y}\right)^{-\sigma}+(1-p^{eu})\right)}$
- Let $p^{eu} = 0.03$ and $p^{ue} = 0.6 \Rightarrow u = \frac{p^{eu}}{p^{eu}+p^{ue}} = 0.0476$.
- Empirical literature: consumption drop up to around 20%: $\frac{\vartheta}{Y} = 0.8$
  - $\bar{R} = 1.005 \Rightarrow discount = \beta\bar{R}(1-p^{eu}) = 0.975$
- Notes:
  - better to calibrate to consumption drop upon unemployment than income drop
  - equivalence to RANK under full insurance in steady state ($\frac{\vartheta}{Y} = 1 \Rightarrow \bar{R}\beta = 1$).

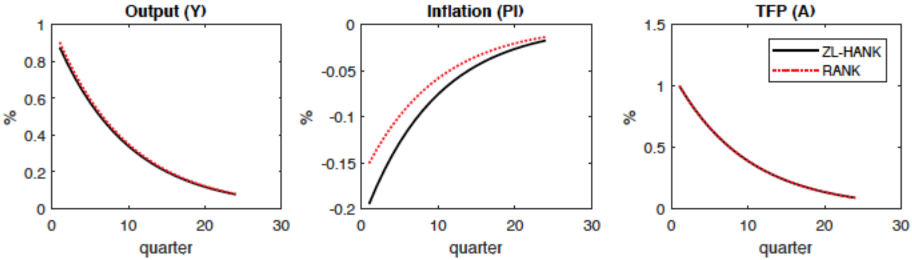
Dynare Code

```
model;

// Euler equation
-sig*Y + sig*beta*Rbar*(1-peu)*Y(+1) = ksi*PI - PI(+1) + zR;

// Price setting equation (Phillips Curve)
((eps-1)/phiR)*((phi+sig)*Y-(1+phi)*A) = PI - beta*PI(+1);

// Evolution shocks
A=rhoA*A(-1)+eA;
z=rhoR*z(-1)+eR;

end;
```

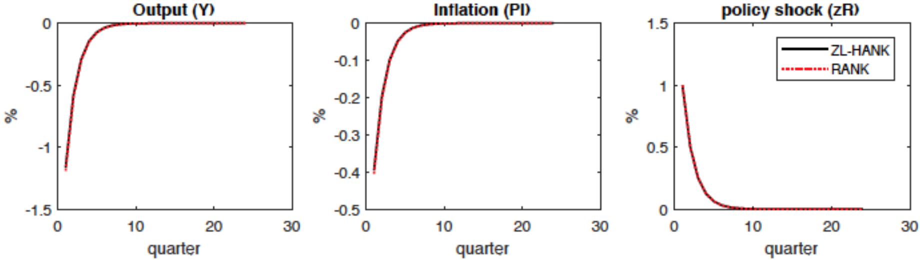
Determinacy



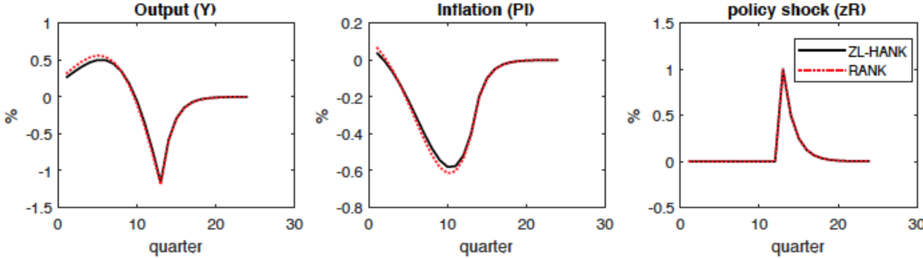
Productivity Shock



Monetary Policy shock (tightening)



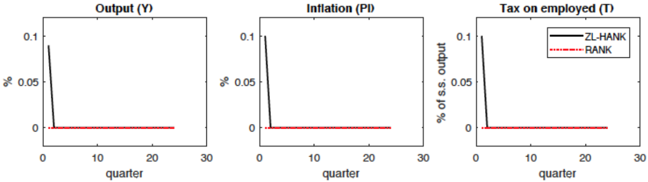
Forward guidance shock



Redistribution Experiment

- one time, unexpected tax on employed, equal to 10% of s.s. of output
- give all the proceeds to unemployed

Redistribution Experiment



Intuition

- unemployed are borrowing constrained $\rightarrow$ high MPC
- employed are unconstrained $\rightarrow$ low MPC
- distribution towards unemployed increases aggregate demand

Marginal Propensity to Consume

- Definition MPC: dollar spent (over a certain time horizon) out of a one-time windfall gain
- What are the MPC's of the households in the model?
  - unemployed: MPC=1 in initial quarter, zero thereafter (entire windfall immediately)
  - employed: needs to be compute numerically

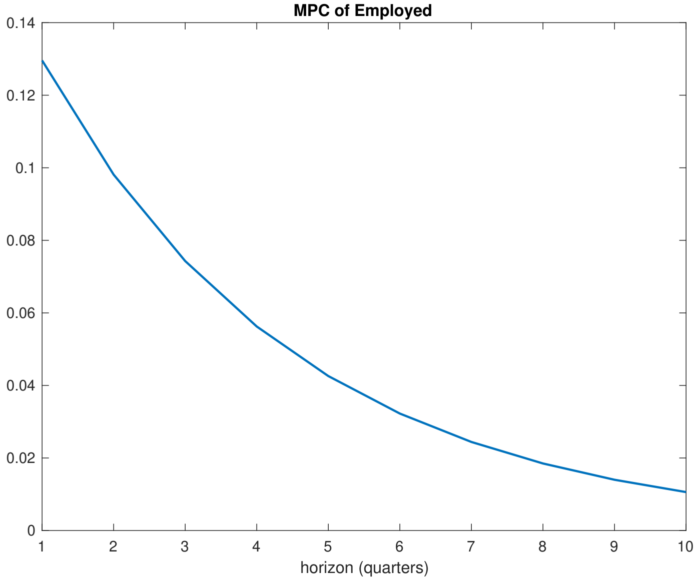
Marginal Propensity to Consume

dynamic consumption response of a household who turns out (ex-post) to be perpetually employed

- Note that the MPC is a thought experiment at the individual level
  - lottery winner (exogenous windfall)
  - drop equilibrium conditions: allow for $B > 0$
    - B=0 is an equilibrium condition in ZL-HANK model!
  - keep all prices fixed (individual takes all prices as given, including wages and interest rates)

Marginal Propensity to Consume

dynamic consumption response of a household who turns out (ex-post) to be perpetually employed

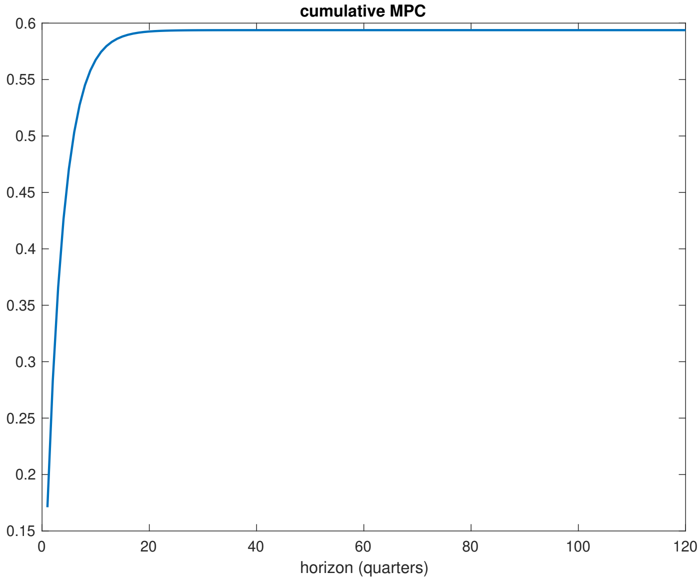


Average Marginal Propensity to Consume in the Economy

- $t = 1$: $M\bar{P}C = u + (1-u)C_{e,t}$
- from $t = 2$ onwards:
  $(1-u)p^{eu}RB_{t-1} + (1-p^{eu})(1-u)C_{e,t} + (1-u)p^{eu}RB_{t-2} + (1-p^{eu})(1-u)C_{e,t-1} \ldots$

$$\sum_{t=2}^{T}(1-p^{eu})^{t-2}(1-u)p^{eu}RB_{t-1} + (1-u)\sum_{t=2}^{T}(1-p^{eu})^{t-1}C_{e,t}$$

Average Marginal Propensity to Consume in the Economy cumulated over time



Summary

- ZL-HANK $\neq$ RANK (e.g. different steady state real interest rate)
- However, responses to macro shocks and effects of monetary policy not necessarily different.
- Key channels
  - cyclicality of idiosyncratic income risk
  - re distributional effects

Codes for this session

- Main folder
  - **RANK_reduced.mod** simulates RANK
  - **ZLHANK_reduced.mod** simulates ZL-HANK reduced
  - **ZLHANK_full.mod** simulates the ZL-HANK with all the equations
  - **session3.m** main file that runs all 3 mod files.

- Folder MPC: reproduces the figures for the MPC exercise.

Krusell, P., Mukoyama, T., and Smith Jr., A. A. (2011).
Asset prices in a Huggett economy.
Journal of Economic Theory, 146(3):812–844.

McKay, A., Nakamura, E., and Steinsson, J. (2016).
The power of forward guidance revisited.
American Economic Review, 106(10):3133–58.

Ravn, M. O. and Sterk, V. (2020).
Macroeconomic Fluctuations with HANK & SAM: an Analytical Approach.
Journal of the European Economic Association.
jvaa028.

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