

Clue to Resolve Forward Guidance Puzzle

How can HANK Resolve Forward Guidance Puzzle?

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Research Question

My Research Question

How can Heterogeneous Agent New Keynesian (HANK) model
Resolve Forward Guidance Puzzle?

- What is Forward Guidance Puzzle?
 - Forward Guidance: a policy tool that central banks announce the likely future course of monetary policy to the public. Standard NK model predicts the large increases in inflation and output by it.
 - Puzzle: In the real, such a policy has only limited success.
- What is Heterogeneous Agent New Keynesian (HANK)?
 - Standard NK model assumes the representative household with rational expectations (Representative Agent NK model, or RANK).
 - On the other hand, HANK allows households to be heterogeneous.

Motivation and Contribution



- Environment
 - Zero lower boundary and Liquidity trap
 - Missing inflation and Adaptive inflation view
- Practice: Difficulties in implementing monetary policy
 - Limited success of forward guidance (e.g., BOJ(2016))
 - Side-effect of large scale quantitative easing policy

This project is so valuable because I can...

- Evaluate the validity of new cutting-edge model (i.e., HANK) which may give a clue to deal with such difficulties
- Provide hands-on analytical methods and tools (codes) which enables us to estimate models which may reflect such a recent environment.

Why is Forward Guidance so Powerful in RANK?

- Based on the discussion in McKay et al. (2016)
- Consider simple standard NK model (of a linear approximation):
 - intertemporal IS curve: $x_t = E_t x_{t+1} - (i_t - E_t \pi_{t+1})$
 - Phillips curve: $\pi_t = \beta E_t \pi_{t+1} + \kappa x_t$
 - Monetary policy rule: $i_t = \phi \pi_t + v_{t,t-j}$
 - where x_t denotes the output gap, π_t denotes inflation, and i_t denotes the nominal interest rate (all variables are percentage deviations from their steady state value)
 - $v_{t,t-j}$ denotes the shock in period t that becomes known in period $t - j$.
- Solve the IS equation forward, then we have

$$x_t = - \sum_{j=0}^{\infty} E_t (i_{t+j} - E_{t+j} \pi_{t+j+1}) \quad (1)$$

Why is Forward Guidance so Powerful in RANK?

- Suppose central bank announces that real interest rate ($r_t = i_t - E_t \pi_{t+1}$) will be lower by 1% for a single quarter 1 year in the future (i.e., $v_{t+4,4} = -0.01$).
 - The shock changes the relative price of consumption between quarters 4 and 5 but any other quarter before quarter 4 and after quarter 4 unchanged.
 - From eq.(1), when $t = 0, 1, 2, \dots, 5$, the output x_t s are

$$\begin{aligned}x_0 &= -(E_0(i_0 - E_0 \pi_1) + \dots + E_4(i_4 - E_4 \pi_5) + \dots) \\&= -(0 + \dots + (-1) + \dots) = 1\end{aligned}$$

...

$$\begin{aligned}x_4 &= -(E_4(i_4 - E_4 \pi_5) + \dots) = -((-1) + 0 + \dots) = 1 \\x_5 &= -(E_5(i_5 - E_5 \pi_6) + \dots) = 0\end{aligned}$$

- Thus, the output gap shows the step-function like shape response to forward guidance. This means that forward guidance could increase output immediately after the announcement and that lasts until forward guidance ends. (= large *cumulative* effect!)



Why HANK resolve Forward Guidance Puzzle?

- RANK predicts that forward guidance changes current output equally large as the response of output to a change in the current real interest rate.
- This prediction seems unrealistic and indeed can't be observed in the empirical evidence (= Forward guidance puzzle).
- The increase in output (i.e., consumption) depends on the assumption that agent (households) can borrow money freely.
- But people are likely to face some risk of hitting a borrowing constraint or idiosyncratic income risk.

Heterogeneous Agent New Keynesian model

- HANK considers the agents who face uninsurable, idiosyncratic income risk and borrowing constraints.



Why HANK resolve Forward Guidance Puzzle?

- Income risk and borrowing constraints are supposed to...
 - Shorten households' planning horizon
 - Reduce households' ability to smooth consumption
- These (realistic) effects are expected to weaken the power of forward guidance.
- Roughly speaking, for the model construction, one can introduce stochastic idiosyncratic productivity ($z_{h,t} \sim \Gamma^z(z)$) and borrowing constraints ($b_{h,t+1} \geq 0$) to households' decision problems.

Decision Problem in RANK

$$\begin{aligned} \max U &= \sum_{t=0}^{\infty} \beta \left[\frac{c_t^{1-\gamma}}{1-\gamma} - \frac{\ell_t^{1+\psi}}{1+\psi} \right] \\ \text{s.t. } c_t + b_{t+1} &= (1+i_t)b_t + w_t \ell_t \end{aligned}$$

Decision Problem in HANK

$$\begin{aligned} \max U &= \sum_{t=0}^{\infty} \beta \left[\frac{c_{h,t}^{1-\gamma}}{1-\gamma} - \frac{\ell_{h,t}^{1+\psi}}{1+\psi} \right] \\ \text{s.t. } c_{h,t} + b_{h,t+1} &= (1+i_t)b_{h,t} + w_t z_{h,t} \ell_{h,t}, \\ b_{h,t+1} &\geq 0 \end{aligned}$$



Methods and Tools

- Estimate HANK and RANK by Bayesian approach with MCMC
 - MCMC needs hundreds of thousands samplings to obtain the posterior distributions of parameters
 - Ahn et al. (2017) provides easy-to-use computational method for solving HANK model (with some Matlab codes) and FRB-NY opens their DSGE model codes in Julia.
 - Use Python to build estimation with some calibration and focus on U.S. case
- Simulate the effect of forward guidance by impulse response and compare the magnitude of both models.
- Quick literature reviews
 - Related to HANK model and/or forward guidance puzzle:
 - Negro et al(2015), Gertler(2017), McKay et al(2016), Kaplan et. al(2018), Farhi and Werning(2019)
 - Estimation method and/or algorithms
 - Sims(2002), Herbst and Schorfheide(2015), Ahn et al(2017)



Data

- The data used for estimation are the inflation rate, the output gap, the nominal interest rate and households' balance sheets (TBD) in the U.S.
 - Inflation rate is based on implicit GDP deflator.
 - Output gap as the deviation from potential real GDP.
 - Nominal interest rate is the Federal Funds Rate.
 - Households' balance sheets are reported in the flow of funds
- All data are available in [FRED](#).

U.S. data

- Data source: Bureau of Economic Analysis and Board of Federal Reserved.
- Data period: Quarterly 1970Q1-2019Q4 ($T = 200$)? (TBD)
- Output gap estimated by Bureau of Economic Analysis

Conclusion



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How can Heterogeneous Agent New Keynesian (HANK) model
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- Expect HANK weakens power of forward guidance
- Results will look like...

Figure: Pseudo Impulse Response

