11. Monetary Policy in HANK

Adv. Macro: Heterogenous Agent Models

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Introduction

Introduction

- **Last Time:**
  - Fiscal policy in the canonical HANK model
- **Today:**
  - Other pillar of stabilization policy: **Monetary policy**
  - Will use as example to study alternatives to **rational expecations** (RE) in HANK
- **Literature:**
  - *Seminal paper*: Kaplan, Moll, Violante (2018) »Monetary policy according to HANK«
  - Auclert Rognlie, Straub (2020) »Micro jumps, macro humps«
  - Alves, Kaplan, Moll, Violante (2020) »A further look at the propagation of monetary policy shocks in HANK«

Monetary Policy in HANK

Monetary Policy

- Introducing heterogeneous agents into the standard NK model **fundamentally** changes the transmission of Fiscal Policy
  - *Potentially* more effective
  - Important whether policy is deficit financed or tax financed
- What about monetary policy?

Model

- **Last time**: Canonical HANK model
- Very close to standard **NK** except for:
  - HA instead of RA
  - Sticky wages
  - Government
- Today: Monetary policy - don't really need a government?
  - Issue: If we remove government no liquidity for households to save in
    - Fine in RA, issue in HA with borrowing constraint at $a = 0$
  - **Solution:** Firm equity

Households

- **Household problem:**

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

- with $Z_t = w_t \ell_t$ - real labor income
- **decisions:** Consumption-saving, c_t (and a_t)
- **Union decision:** Labor supply, ℓ_t
- **Aggregate Consumption:** $C_t^{hh} = \int c_t d\mathcal{D}_t$
- **Consumption function:** $C_t^{hh} = C^{hh} \left(\{ r_s^a, Z_s, \chi_s \}_{s=0}^{\infty} \right)$

Firms

- **Production and profits:**

$$Y_t = L_t$$
$$\Pi_t = Y_t - w_t L_t$$

- Optimize subject to demand curve (monopolistic competition)
- **First order condition:**

$$w_t = \frac{1}{\mu}$$

- where $\mu > 1 =$ markup - firms make positive profits in equilibrium

Mutual fund I

- Mutual fund collect households savings A_t and invest in firm equity
- Firm j has ownership shares $\upsilon_{j,t}$ with price $p^D_{j,t}$
- If you own shares in the firm you get profits/dividends $\Pi_{j,t}$
- Shares sum to 1, $\int \upsilon_{j,t} dj = 1$
- Firms are gonna be symmetric in eq., $p^D_{j,t} = p^D_t$
- Total value of firm equity is then $\int p^D_t \upsilon_{j,t} dj = p^D_t$

Mutual fund II

- **Problem**:

$$\max_{\upsilon_{j,t}} \int \left(\Pi_{j,t+1} + p^D_{j,t+1}\right) \upsilon_{j,t} - \left(1 + r^a_{t+1}\right) A_t$$

- **Subject** to balance sheet:

$$\int p^D_{j,t} \upsilon_{j,t} dj = A_t$$

- **FOC**:

$$p^D_t = \frac{\Pi_{t+1} + p^D_{t+1}}{1 + r_t}$$

- where $r_t = E_t r^a_{t+1}$ the ex-ante interest rate
- Price of equity can be written as (assume $r_t = r$): $p^D_t = \sum_{s=0}^{\infty} (1+r)^{-s} \Pi_{t+s}$
  - Asset price today reflect discounted sum of future profits
- Valuation effects: As with nominal gov bonds:

$$1 + r^a_t = \begin{cases} \frac{\Pi_0 + p^D_0}{p^D_{ss}} & t = 0 \\ 1 + r_{t-1} & t > 0 \end{cases}$$

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)

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

Central bank

- Two options for monetary policy
- **1.** Government bonds are nominel, CB chooses nominel interest rate:

$$i_t = i_{ss} + \phi\pi_t$$

- And fisher equation links nominal rate i to real rate r:

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

- **2. Alternative:** Real rate rule. CB chooses real rate r_t directly

$$r_t = r_{ss} + (\phi - 1)\,\pi_t$$

Market clearing

1. Asset market: $p_t^D = A_t^{hh}$
2. Labor market: $L_t = L_t^{hh}$
3. Goods market: $Y_t = C_t^{hh}$

The consumption function

- Model features a consumption function:

$$C_t^{hh} = C_t^{hh}\left(\{r_s^a, Z_s\}_{s=0}^{\infty}\right) \Rightarrow \boldsymbol{C}^{hh} = C^{hh}\left(\boldsymbol{r}^a, \boldsymbol{Z}\right)$$

- Linearize around steady state:

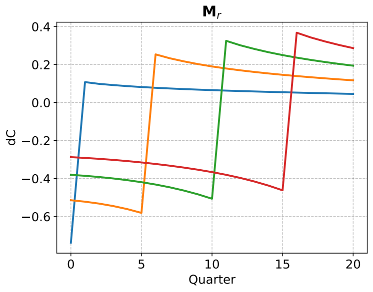
$$d\boldsymbol{C} = \boldsymbol{M} d\boldsymbol{Z} + \boldsymbol{M}_{r^a} d\boldsymbol{r}^a$$

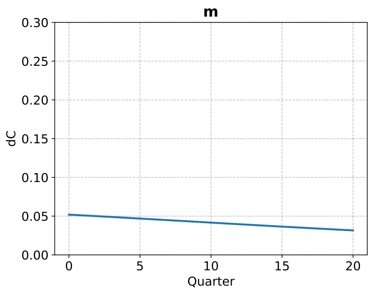
- As discussed in last lecture, can split overall effect of asset returns $d\boldsymbol{r}^a$ into intertemporal substitution effect (ex-ante r) and a capital gain effect at time 0:

$$d\boldsymbol{C} = \boldsymbol{M} d\boldsymbol{Z} + \boldsymbol{M}_r d\boldsymbol{r} + \boldsymbol{m} dcap_0$$

- Note: $\boldsymbol{m}$ is a vector not matrix (multiplies onto scalar $dcap_0$, not vector)

Interest rate Jacobians





Monetary policy in sequence-space

- Write real labor income as $Z_t = w_t L_t = \frac{1}{\mu} Y_t \Rightarrow d\boldsymbol{Z} = \frac{1}{\mu} d\boldsymbol{Y}$
- Linearize goods market clearing:

$$d\boldsymbol{Y} = \boldsymbol{M}_r d\boldsymbol{r} + \frac{1}{\mu}\boldsymbol{M} d\boldsymbol{Y} + \boldsymbol{m} dcap_0$$

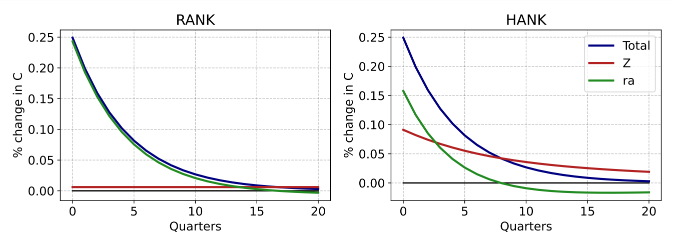
- For small capital gains, solution is:

$$d\boldsymbol{Y} = \left(\boldsymbol{I} - \frac{1}{\mu}\boldsymbol{M}\right)^{-1} \boldsymbol{M}_r d\boldsymbol{r} \equiv \mathcal{M}\boldsymbol{M}_r d\boldsymbol{r}$$

- Note: **can** multiplier invert this PV of columns in $\frac{1}{\mu}\boldsymbol{M}$ is not 1 when $\mu > 1$)
- Monetary policy operates through:
  - **Direct** (partial eq., $\boldsymbol{M}_r$) effect
  - **Indirect** (general eq., $\boldsymbol{M}$) effect
- **Q1**: Sign? Positive/negative?
- **Q2**: Do you expect the effects of monetary policy on output to be larger in HANK then RANK?

HANK-RANK equivalence

- Assume logarithmic utility $u(c) = \log(c)$
- **Proposition**: Above model features **exact** equivalence between RANK and HANK for the response of aggregates w.r.t a monetary policy shock (*Werning 2015*)
- **... but transmission channel is different**
- Decompose $d\boldsymbol{Y}$ into direct and indrect effect using $d\boldsymbol{Y}^j = \boldsymbol{M}^j_{r^a} d\boldsymbol{r^a} + \boldsymbol{M}^j d\boldsymbol{Z}$ for $j \in \{HA, RA\}$



HANK-RANK equivalence

- In basic HANK model:
  - Monetary policy has same effectiveness as in RANK
  - But transmission different: Indirect income effects more important than in RANK
- Exact **equivalence** is the product of a number of simplifying assumptions:
  - Linear production function
  - No investment
  - Log utility
  - Equal incidence of labor income
  - No government debt
- How does the effectiveness of monetary policy look in more realistic models?
  - Kaplan, Moll, Violante (2018) »Monetary policy according to HANK«
  - Auclert Rognlie, Straub (2020) »Micro jumps, macro humps«

KMV 2018

Monetary policy according to HANK

- Kaplan, Moll, Violante (2018) is a seminal paper in the HANK litterature
  - The term HANK originates from this paper
- They study the transmission of monetary policy in medium scale HANK model
- Follows Kaplan & Violante (2014) closely
  - See lecture 2
  - Household can hold both liquid and illiquid assets
  - Model features both **poor** and **wealthy** Hand-to-mouth households

Household problem

- Households solve (here converted to discrete time, paper in cont. time):

$$V_t\left(a_{t-1}, b_{t-1}, z_t\right) = \max_{c_t, a_t, b_t} u\left(c_t, \ell_t\right) + \beta E_t V_{t+1}\left(a_t, b_t, z_{t+1}\right)$$

$$b_t + c_t = (1-\tau_t) w_t z_t \ell_t + \left(1 + r_t^b\right) b_{t-1} - d_t - \chi(d_t, a_{t-1})$$

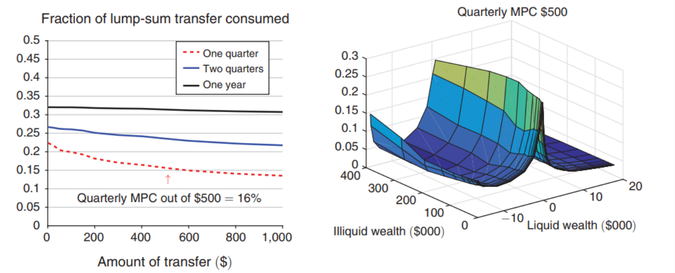
$$a_t = \left(1 + r_t^a\right) a_{t-1} + d_t$$

$$b_t \geq -\bar{b} \quad a_t \geq 0.$$

- with b_t=liquid asset, a_t=illiquid assets, d_t=deposits into illiquid asset
- Return on illiquid asset r_t^a Return on liquid asset r_t^b
  - Household will prefer to hold a_t due to superior return
  - But not good for consumption smoothing as they have to pay adjustment cost to use a_t for smoothing against shocks
  - Some HHs will be wealthy hand-to-mouth

MPCs

- 1) MPCs for different sizes of stimulus checks, 2) MPCs across the wealth distribution



Direct vs indirect effects

- Amplification in HANK (elasticity of $C^{HANK} = -2.9$ vs $C^{RANK} = -2.07$)
- Baseline HANK: Indirect effects account for majority of transmission ($\approx 80\%$)

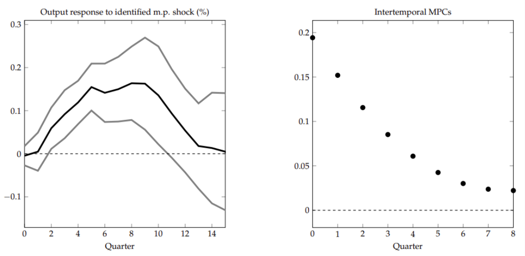
Table 7—Decomposition of the Effect of Monetary Shock on Aggregate Consumption

	Baseline (1)	$\omega = 1$ (2)	$\omega = 0.1$ (3)	$\frac{\varepsilon}{\theta} = 0.2$ (4)	$\phi = 2.0$ (5)	$\frac{1}{\nu} = 0.5$ (6)
Change in r^b (pp)	−0.28	−0.34	−0.16	−0.21	−0.14	−0.25
Elasticity of Y	−3.96	−0.13	−24.9	−4.11	−3.94	−4.30
Elasticity of I	−9.43	7.83	−105	−9.47	−9.72	−9.79
Elasticity of C	−2.93	−2.06	−6.50	−2.96	−3.00	−2.87
Partial eq. elasticity of C	−0.55	−0.45	−0.99	−0.57	−0.59	−0.62
Component of percent change in C due to						
Direct effect: r^b	19	22	15	19	20	22
Indirect effect: w	51	56	51	51	51	38
Indirect effect: T	32	38	19	31	31	45
Indirect effect: r^a and q	−2	−16	15	−2	−2	−4

Expectations

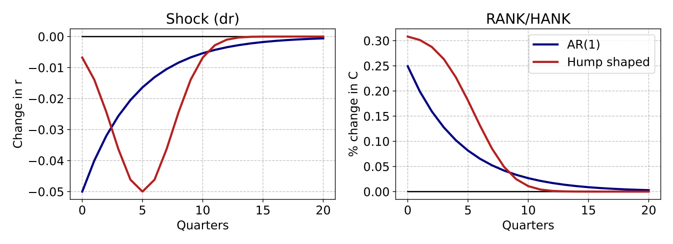
Micro Jumps, Macro Humps

- Auclert, Rognlie and Straub (2020) »Micro jumps, macro humps«
- Estimate parameters in quantitative HANK model to match estimated effects of causal monetary policy shock
- Main hurdle: Empirical response of C, Y is hump-shaped to monetary policy shock.
- Want a model that simultaneously match hump-shaped agg. response to r and iMPC moment



The problem

- Standard model does **not** give hump shaped for C to standard shock
- Does not matter if **shock** is hump shaped or not



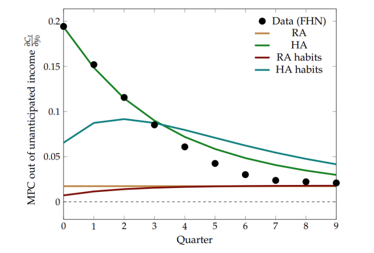
The solution: RANK

- Solution in RANK litterature: Habits in utility function:

$$\sum_{t=0}^{\infty} \beta^t u\left(C_t - \gamma C_{t-1}\right)$$

$$\Rightarrow u'\left(C_t - \gamma C_{t-1}\right) = \beta R_{t+1} u'\left(C_{t+1} - \gamma C_t\right)$$

- Generates persistence in C response to shocks because household don't want to deviate too much from last periods consumption level
- **However**: Does not work in HANK because it kills iMPCs:



Deviations from alternative expecations

- Solution: **Deviate** from **rational expecations** (RE)
- Assume households have imperfect expecations about **changes** in **aggregate variables** (Z, r)
  - Implies that steady state is unaffected
  - Still rational expecations w.r.t idiosyncratic income shocks
- Will only implement this to first-order (e.g. linear approximations)
  - Much more difficult if we want full non-linear solution

Income Jacobian

- Example: Response of aggregate consumption $\boldsymbol{C}$ to change in agg. income $\boldsymbol{Z}$

$$d\boldsymbol{C} = \boldsymbol{M} d\boldsymbol{Z}$$

- where $\boldsymbol{M}$ is jacobian with rational expectations:

$$\boldsymbol{M} = \begin{bmatrix} \frac{\partial C_0}{\partial Z_0} & \frac{\partial C_0}{\partial Z_1} & \frac{\partial C_0}{\partial Z_2} & \cdots \\ \frac{\partial C_1}{\partial Z_0} & \frac{\partial C_1}{\partial Z_1} & \frac{\partial C_1}{\partial Z_2} & \cdots \\ \frac{\partial C_2}{\partial Z_0} & \frac{\partial C_2}{\partial Z_1} & \frac{\partial C_2}{\partial Z_2} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

- Note that elements above diagonal are affected by expectations (i.e. they concern the **future**)
  - Elements on and below diagonal reflect changes in income **today** or in the **past** (known by HHs)

Expectations matrix

- Introduce expectations matrix $\boldsymbol{E}$:

$$\boldsymbol{E} = \begin{bmatrix} 1 & * & * & * & \cdots \\ 1 & 1 & * & * & \cdots \\ 1 & 1 & 1 & * & \cdots \\ 1 & 1 & 1 & 1 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

- Element t, s ($E_{t,s}$) captures average date-t exp. about shock to Z at date s.
  - $E_{t,s} dZ_s$ is then the expected value of dZ_s at date t
  - First column: Exp. of HHs at all dates w.r.t dZ_0
  - Second column: Exp. of HHs at all dates w.r.t dZ_1...
- How to get jacobian $\hat{\boldsymbol{M}}$ associated with $\boldsymbol{E}$?

Stylized Example I

- Expectations matrix:

$$\boldsymbol{E} = \begin{bmatrix} 1 & 0.4 & 0.3 & \cdots \\ 1 & 1 & 0.6 & \cdots \\ 1 & 1 & 1 & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

- At $t = 0$ expected path of $d\boldsymbol{Z}$ is $\{1 \cdot dZ_0, 0.4 \cdot dZ_1, 0.3 \cdot dZ_2\}$
- At $t = 1$ expected path of $d\boldsymbol{Z}$ is $\{1 \cdot dZ_0, 1 \cdot dZ_1, 0.6 \cdot dZ_2\}$
- What is response of $\boldsymbol{C}$?
- Period 0 with RE:

$$dC_0 = \frac{\partial C_0}{\partial Z_0} dZ_0 + \frac{\partial C_0}{\partial Z_1} dZ_1 + \frac{\partial C_0}{\partial Z_2} dZ_2 + \dots$$

- With alternative $\boldsymbol{E}$:

$$d\hat{C}_0 = \frac{\partial C_0}{\partial Z_0} dZ_0 + 0.4 \cdot \frac{\partial C_0}{\partial Z_1} dZ_1 + 0.3 \cdot \frac{\partial C_0}{\partial Z_2} dZ_2 + \dots$$

Stylized Example II

- $d\hat{C}_0$ simple to get. What about $d\hat{C}_1$?
- With RE we have:

$$dC_1 = \frac{\partial C_1}{\partial Z_0} dZ_0 + \frac{\partial C_1}{\partial Z_1} dZ_1 + \frac{\partial C_1}{\partial Z_2} dZ_2 + \dots$$

- With Alternative $\boldsymbol{E}$:

$$d\hat{C}_1 = \underbrace{\frac{\partial C_1}{\partial Z_0} dZ_0}_{\text{Past shock}} + \underbrace{0.4 \frac{\partial C_1}{\partial Z_1} dZ_1 + (1 - 0.4) \frac{\partial C_0}{\partial Z_0} dZ_1}_{\text{Shock "today"}} + \underbrace{0.3 \frac{\partial C_1}{\partial Z_2} dZ_2 + (0.6 - 0.3) \frac{\partial C_0}{\partial Z_1} dZ_2}_{\text{Future shock}}$$

- Intuition:
  - Past shock: Fully known, so standard effect
  - Present shock: Weighted average of forward looking RE part and »myopic« surprise
  - Future shock: Initial RE part from period 0 (weight: 0.3) and revision of expectations (weight: $0.6 - 0.3$)

General formula

- At first glance seems hard to implement
- ... but we have a general formula to get $\hat{\boldsymbol{M}}$ given $\boldsymbol{E}$
- $\hat{\boldsymbol{M}}$ matrix with expectations matrix $\boldsymbol{E}$:

$$\hat{M}_{t,s} = \sum_{\tau=0}^{\min\{t,s\}} \underbrace{\left(E_{\tau,s} - E_{\tau-1,s}\right) M_{t-\tau,s-\tau}}_{\text{date-}t\text{ effect of date-}\tau\text{ expectation revision of date-}s\text{ shock}}$$

- with $E_{-1,s} = 0$ by convention
- **Fast** and **easy** to implement

Examples

- Examples:

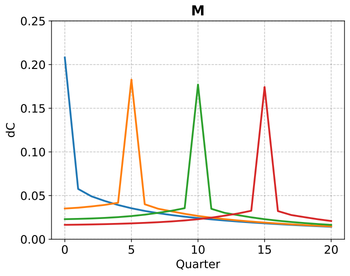
$$\boldsymbol{E}^{\text{RE}} = \begin{bmatrix} 1 & 1 & 1 & 1 & \cdots \\ 1 & 1 & 1 & 1 & \cdots \\ 1 & 1 & 1 & 1 & \cdots \\ 1 & 1 & 1 & 1 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}, \qquad \boldsymbol{E}^{\text{Myopic}} = \begin{bmatrix} 1 & 0 & 0 & 0 & \cdots \\ 1 & 1 & 0 & 0 & \cdots \\ 1 & 1 & 1 & 0 & \cdots \\ 1 & 1 & 1 & 1 & \cdots \\ \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

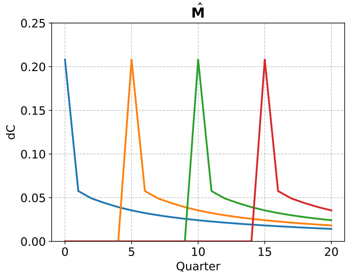
- Two extremes:
  - **Rational** expectations: Households are fully informed about the future path of Z from the moment the shock manifests
  - **Myopic** expectations: Households are not forward looking w.r.t aggregates. Every change in Z is a surprise.
- Implied jacobians:

$$\hat{\boldsymbol{M}}^{\text{RE}} = \boldsymbol{M} = \begin{bmatrix} \frac{\partial C_0}{\partial Z_0} & \frac{\partial C_0}{\partial Z_1} & \frac{\partial C_0}{\partial Z_2} & \cdots \\ \frac{\partial C_1}{\partial Z_0} & \frac{\partial C_1}{\partial Z_1} & \frac{\partial C_1}{\partial Z_2} & \cdots \\ \frac{\partial C_2}{\partial Z_0} & \frac{\partial C_2}{\partial Z_1} & \frac{\partial C_2}{\partial Z_2} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}, \qquad \hat{\boldsymbol{M}}^{\text{Myopic}} = \begin{bmatrix} \frac{\partial C_0}{\partial Z_0} & 0 & 0 & \cdots \\ \frac{\partial C_1}{\partial Z_0} & \frac{\partial C_0}{\partial Z_0} & 0 & \cdots \\ \frac{\partial C_2}{\partial Z_0} & \frac{\partial C_1}{\partial Z_0} & \frac{\partial C_0}{\partial Z_0} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

Jacobians

- Jacobian of C w.r.t Z





Solving GE with non-RE expecations

- Given some exp. matrix $\boldsymbol{E}$ we can construct alternative jacobians $\hat{\boldsymbol{M}}, \hat{\boldsymbol{M}}_r$
- Solve for GE using these jacobians instead of RE jacobians $\boldsymbol{M}, \boldsymbol{M}_r$ ($\boldsymbol{X}$=shock):

$$\boldsymbol{H}(\boldsymbol{U}, \boldsymbol{X}) = 0 \Rightarrow d\boldsymbol{U} = -\hat{\boldsymbol{H}}_U^{-1} \hat{\boldsymbol{H}}_X d\boldsymbol{X}$$

- In our example:

$$\begin{aligned} \boldsymbol{Y} - \boldsymbol{C}\left(\boldsymbol{r}, \frac{1}{\mu}\boldsymbol{Y}\right) &= 0 \\ \Rightarrow d\boldsymbol{Y} &= \left(\boldsymbol{I} - \frac{1}{\mu}\hat{\boldsymbol{M}}\right)^{-1} \hat{\boldsymbol{M}}_r d\boldsymbol{r} \end{aligned}$$

- where $-\hat{\boldsymbol{H}}_U^{-1} = \left(\boldsymbol{I} - \frac{1}{\mu}\hat{\boldsymbol{M}}\right)^{-1}$ and $\hat{\boldsymbol{H}}_X = -\hat{\boldsymbol{M}}_r$

Non-RE expecations in GEModelTools

- How to implement in GEModelTools?
  - Currently no built in way to handle
- Work around (see exercise):
  1. Compute all Jacobians for household block
     - `model._compute_jac_hh()`
     - If using RA/TA instead of HA must manually compute jac
  2. Construct Expectation matrix $\boldsymbol{E}$ and compute $\hat{\boldsymbol{M}}$ by modyfing RE jacobians in `model.jac_hh`
  3. Overwrite jacobians `model.jac_hh` with $\hat{\boldsymbol{M}}$ for each output/input to household block
  4. Compute all Jacobians w.r.t unknowns and shocks, but **not** for household block
     - `model.compute_jacs(skip_hh=True,skip_shocks=False)`
     - GEModelTools will automatically use whatever jacobian is in `model.jac_hh` to construct Jacobians $\boldsymbol{H}_U, \boldsymbol{H}_Z$
  5. Solve for IRFs:
     - `model.find_IRFs(shocks=[x])`

Back to Auclert, Rognlie, Straub (2020) - Sticky expectations

- Auclert, Rognlie, Straub (2020) use **sticky information/expectations** (Mankiw and Reis (2002))
- Only a fraction $1-\theta$ of HHs update their information set about the aggregate economy each period
  - Only learn full path of shock $d\boldsymbol{r}, d\boldsymbol{Z}$ if you update
  - 1. period: $1-\theta$ update and learn full path
  - 2. period: $\theta(1-\theta)$ update, so $1-\theta+\theta(1-\theta)=1-\theta^2$ have full info
- Expectations matrix:

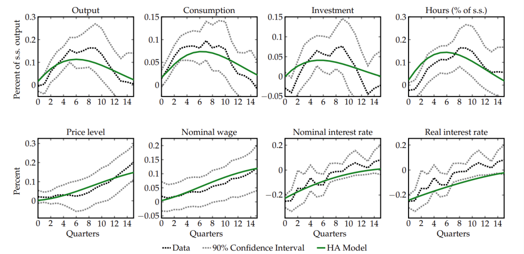
$$\boldsymbol{E}=\begin{pmatrix}1 & 1-\theta & 1-\theta & \dots \\ 1 & 1 & 1-\theta^2 & \dots \\ 1 & 1 & 1 & \dots \\ \vdots & \vdots & \vdots & \ddots\end{pmatrix}$$

Sticky expectations

- Properties:
  - Response of consumption at 0 to Z_1 is $(1-\theta)\frac{\partial C_0}{\partial Z_1}$
  - Response of consumption at 1 to $Z_1$is $(1-\theta)\frac{\partial C_1}{\partial Z_1}+\theta\frac{\partial C_0}{\partial Z_0}$ and so forth
- $\theta=0$ gives us RE, $\theta=1$ gives us myopic behavior.
- Since households perfectly observe income changes **today and in past** iMPCs are preserved
  - **Unlike** habit formation

Estimation

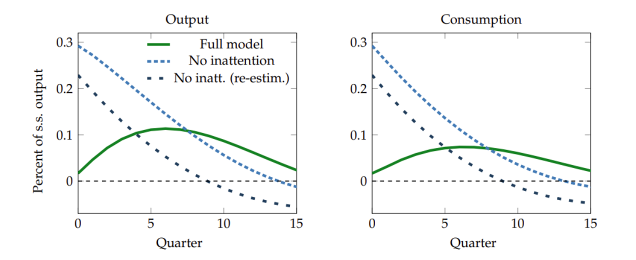
- Auclert, Rognlie, Straub (2020) fomulate full HANK model with:
  - Investment
  - Sticky wages + prices
  - Government
- Estimate parameters to match empirical evidence on causally identified monetary policy shock in the US (Romer & Romer shock)



- Estimate $\theta = 0.935 \Rightarrow$ **Large** deviation from RE

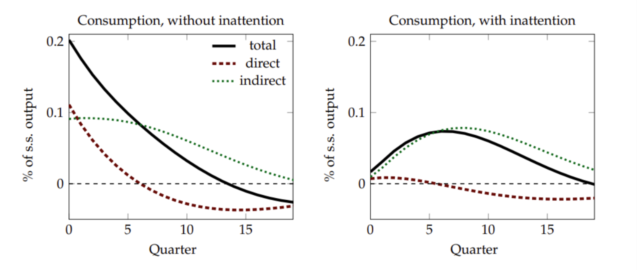
RE vs. Non-RE

- Why we need sticky expectations in order to match empirical response



Direct and indirect effects

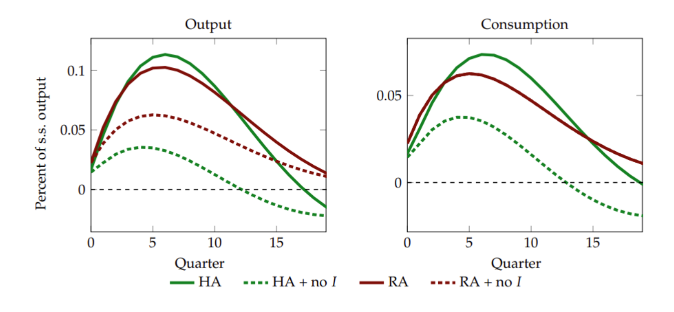
- Can decompose C into direct and indirect as before



- In the estimated model with sticky expectations indirect effect is by far the most important driver of consumption

Importance of Investment

- Importance of indirect effects in HANK partly comes from *investment*



Exercise

Exercise

Consider the HANK model described in section 2

1. Compare a monetary policy shock in HANK and RANK. Decompose the response in HANK into direct and indirect effects using the household Jacobians
2. Solve for a monetary policy shock in HANK and RANK with myopic expectations w.r.t $\boldsymbol{r}$, $\boldsymbol{Z}$,only $\boldsymbol{r}$ and only $\boldsymbol{Z}$
3. Solve for a monetary policy shock in HANK and RANK with sticky expectations w.r.t $\boldsymbol{r}$, $\boldsymbol{Z}$,only $\boldsymbol{r}$ and only $\boldsymbol{Z}$
4. Consider a model where household hold nominal government debt instead. Relax the borrowing constraint to -1, $\underline{a} = -1$ and solve for a monetary policy shock (assume rational expectations). Does the presence of household debt amplify or dampen the effects of monetary policy?

Summary

Summary and next week

- **Today:**
  - Monetary policy in HANK
  - Alternatives to rational expecations, and how to implement them using jacobians
- **Next week:** HANK + unemployment risk in GE (**JD**)
- **Homework:**
  1. Work on exercise