Micro Jumps, Macro Humps:

monetary policy and business cycles in an estimated HANK model

Adrien Auclert, Matt Rognlie and Ludwig Straub

Banque de France, December 2019

This paper matches the micro and macro of monetary policy

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- match **humps** in aggregates
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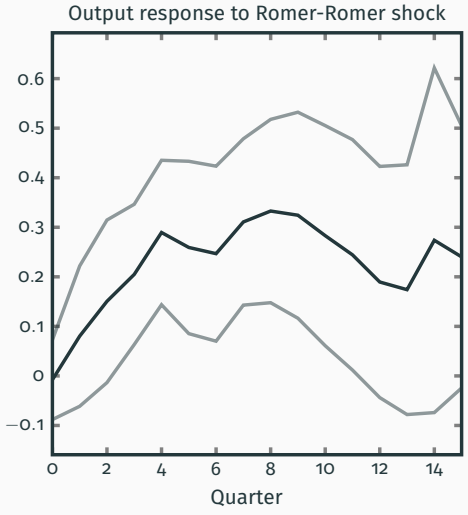
- use habits, adj. costs, inattention



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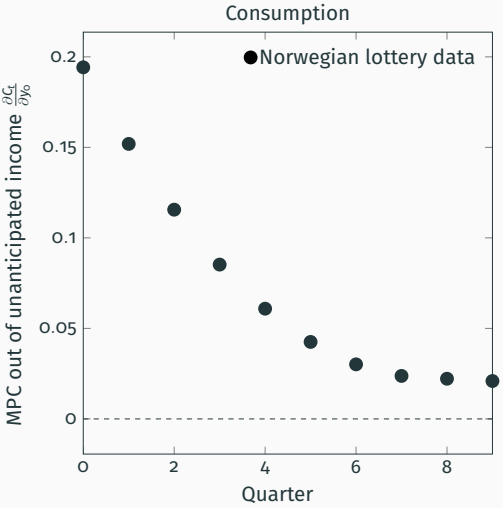

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This paper unifies the two:

- match *both* humps and jumps
- revisit
  - mon. transmission mechanism
  - sources of business cycles

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   - $I \uparrow \longrightarrow Y \uparrow \longrightarrow$ **amplified** by households' **MPCs**
   - **state dependence:** mon. pol. $\sim$ **85% less powerful** if I is constrained

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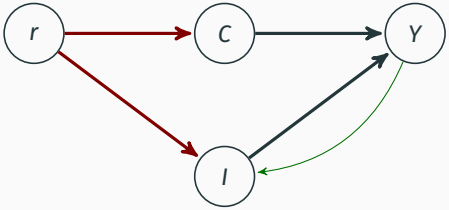
2. **Investment** is *key* for **business cycles** [over and above findings from existing studies]

Monetary transmission

Representative agent, no *I*

Representative agent



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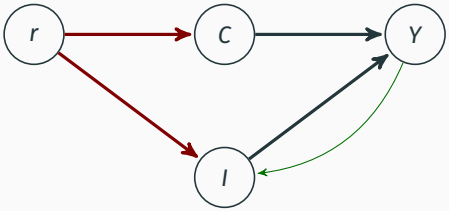

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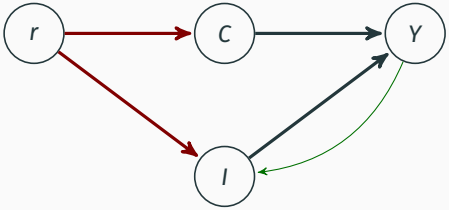

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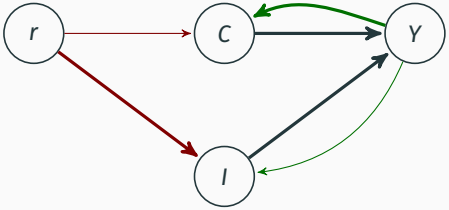

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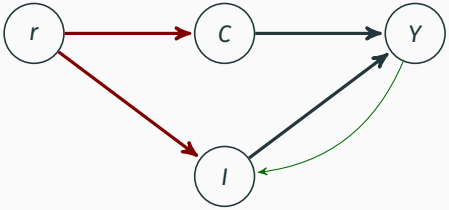

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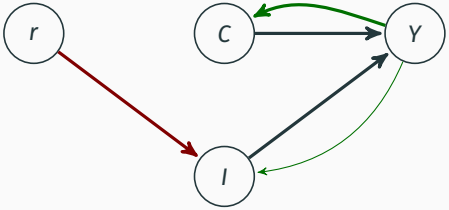

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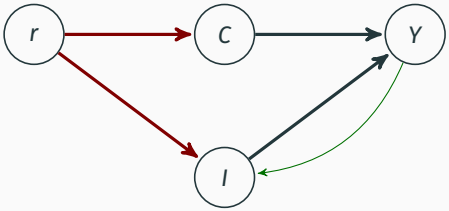

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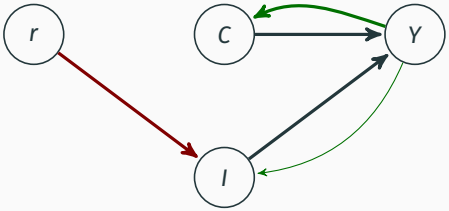

In HA: mon. pol. transmission operates through *I*

Any shocks that move *I*, comove with & are amplified by *C*

Our paper brings together **three literatures**

1. **HA / tractable HA models** (with nominal rigidities)
   - **mon. policy:** Gornemann-Kuester-Nakajima 2012, McKay-Nakamura-Steinsson 2016, Werning 2016, Ravn Sterk 2018, Kaplan-Moll-Violante 2018, Auclert 2019, Luetticke 2019, ...
   - **others:** McKay-Reis 2016, Guerrieri-Lorenzoni 2018, Auclert-Rognlie-Straub 2018, Acharya Dogra 2018, Bilbiie 2019, Hagedorn-Manovskii-Mitman 2019, ...
2. **Estimation of RA models**
   - **limited info:** Rotemberg-Woodford 1997, Christiano-Eichenbaum-Evans 2005, Altig-Christiano-Eichenbaum-Linde 2011, ...
   - **full info:** Ireland 2004, Smets-Wouters 2007, An-Schorfheide 2007, Justiniano-Primiceri-Tambalotti 2010, 2011, Fernández-Villaverde et al 2016
3. **Deviations from rational expectations and monetary policy**
   - **cognitive discounting** (Gabaix 2018), **lack of common knowledge** (Woodford 2003, Angeletos-Lian 2018), **rational inattention** (Sims 2002, Maćkowiak-Wiederholt 2009, 2015, Zorn 2018), ***k*-level thinking** (García-Schmidt-Woodford 2019, Farhi-Werning 2018)
   - **sticky information** (Gabaix-Laibson 2001, Mankiw-Reis 2002, 2006, Carroll et al 2018...)

Outline

1. How we match micro jumps & macro humps
2. Inattentive HA model
3. Estimation
4. Result 1: Investment is the transmission mechanism
5. Result 2: Investment drives business cycles
6. Conclusion

How we match micro jumps & macro humps

Heterogeneous-agent models can match (i)MPCs

Standard heterogeneous-agent model in s.s.:

$$
\begin{aligned}
V(a,s) &= \max_{c,a'} u(c) + \beta \mathbb{E}\left[V\left(a',s'\right)|s\right] \\
c + a' &\leq (1+r)a + ye(s) \\
a' &\geq 0
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$\rightarrow$ **intertemporal MPCs**
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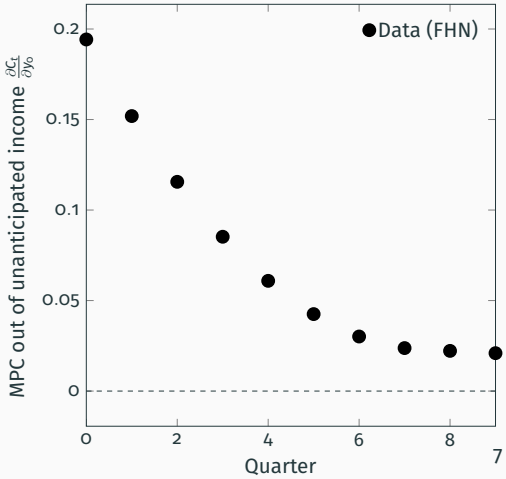

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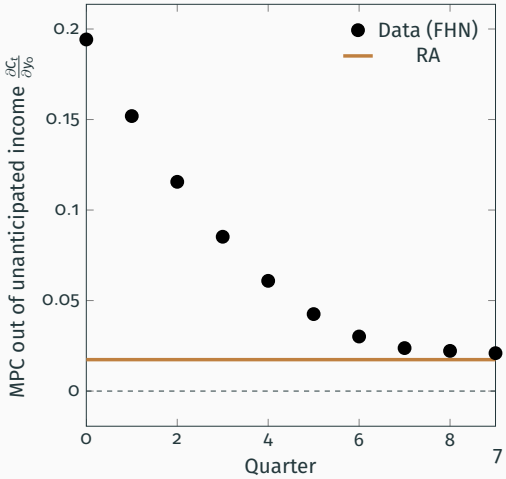

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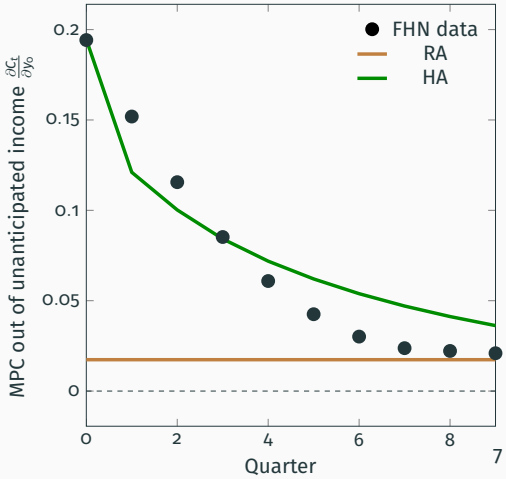

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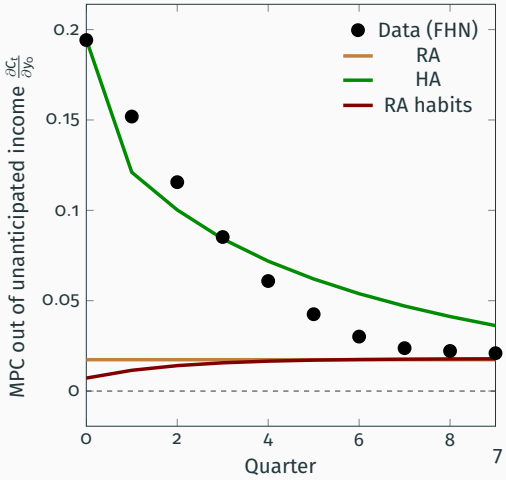

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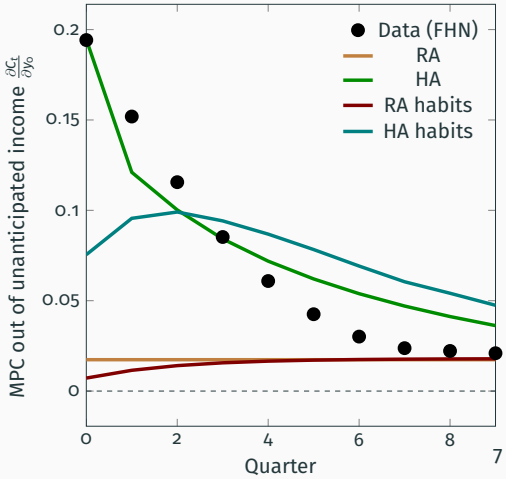

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- Introduce aggregate risk in r_t, y_t
- Our approach to humps: **sticky expectations**
  [Gabaix-Laibson 2001, Mankiw-Reis 2002, 2006, **Carroll-Crawley-Slacalek-Tokuoka-White 2018**]
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Inattentive HA model

Model overview

- Discrete time with aggregate shocks
- **Heterogeneous-agent** household side
  - two assets + **sticky expectations**
- Standard **New-Keynesian** supply side
  - investment adjustment costs + nominal rigidities + indexation
  - fiscal rule changing labor taxes, monetary policy follows Taylor rule

Households & mutual fund

- Total wealth held by **competitive & attentive "mutual fund"**, two liabilities:
  - liquid assets (deposits) a_t: short-term, pay rate $r_t^{\text{liq}} = r_t - \xi$
  - illiquid assets a_t^{illiq}: pay rate r_t, households follow withdrawal rule $d(a_t^{\text{illiq}})$

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- Households are inattentive also w.r.t. value of a_t^{illiq}. Thus:

$$V_t(a, s; k) = \max_{c, a'} u(c) + \beta \mathbb{E}_{t-k} \left[\theta V_{t+1}(a', s', k+1) + (1-\theta) V_{t+1}(a', s', 0) \mid s \right]$$

$$c + a' \leq (1 + r_t^{\text{liq}}) a + y_t e(s) + d\left(\mathbb{E}_{t-k} a_{it}^{\text{illiq}}\right), \qquad a' \geq 0$$

$$a_{it+1}^{\text{illiq}} \leq (1 + r_t) a_{it}^{\text{illiq}} - d\left(\mathbb{E}_{t-k} a_{it}^{\text{illiq}}\right)$$

- Allow for six household groups to capture heterogeneity in illiquid assets

Estimation

Two-step estimation procedure

- Split parameters into two categories:
  1. Steady-state relevant parameters [income process, share of liquid assets, ...]
     $\rightarrow$ calibrate to micro moments, e.g. income distribution, **MPCs**
  2. Impulse-response relevant parameters $\theta, \phi, \zeta^p, \zeta^w, \sigma^m, \rho^m$
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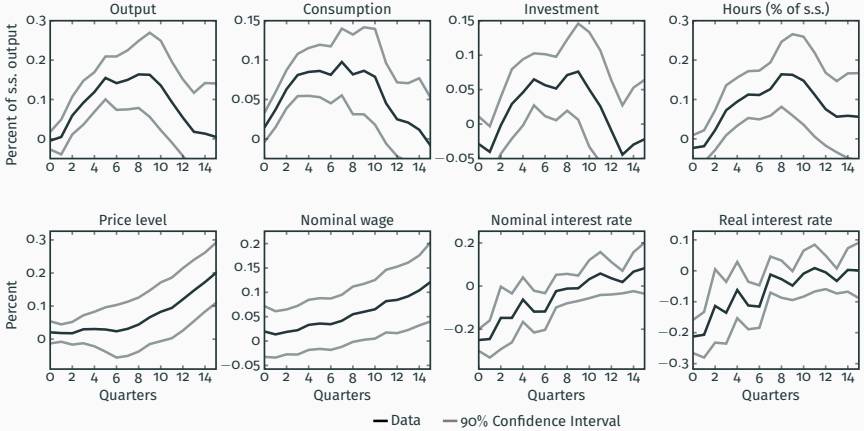
- Today: match **impulse responses to monetary policy shocks**
  - data on $\{Y_t, C_t, I_t, N_t, P_t, W_t, r_t\}$

Impulse response to monetary policy shock

▸ Details

- Monetary impulse response [Ramey 2016]
- Jordà method using Romer-Romer shocks in original sample (69m3–96m12)



How do we simulate HA + info friction?

- Complicated model! HA + sticky expectations ...
- Expand "**sequence-space Jacobian**" method [Auclert-Bardóczy-Rognlie-Straub 2019]

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  1. Use certainty equivalence $\rightarrow$ focus on small "MIT shocks"
  2. Break model into **blocks:** e.g. **household block** $\{Y_t, r_t\} \mapsto \{C_t\}$
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- Complicated model! HA + sticky expectations ...
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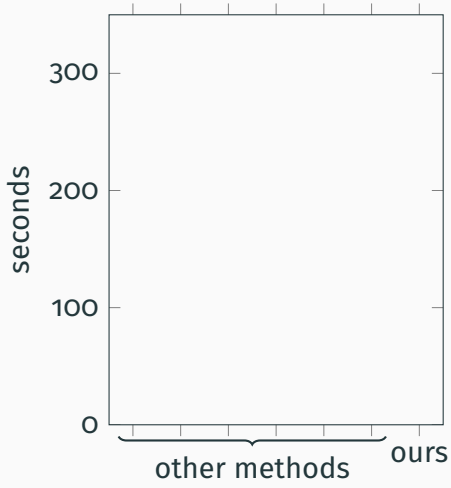
How fast is this?

[single IRF, not incl. steady state]



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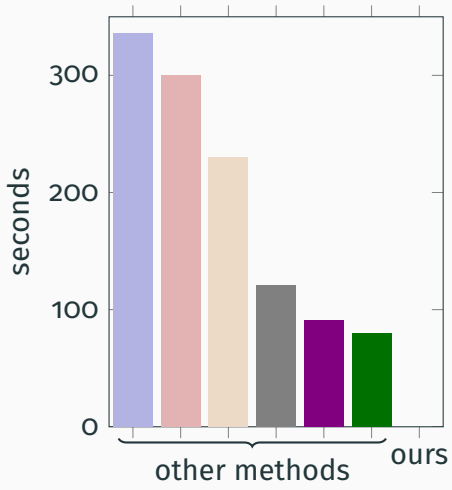

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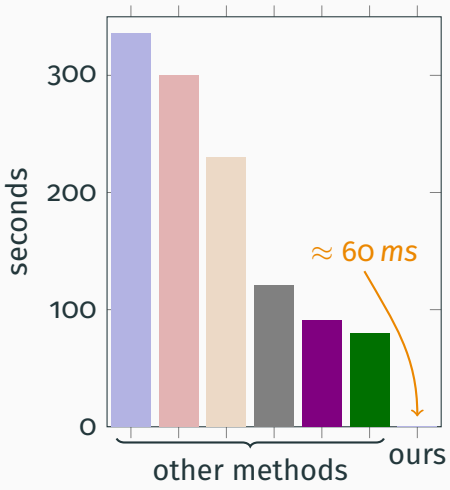
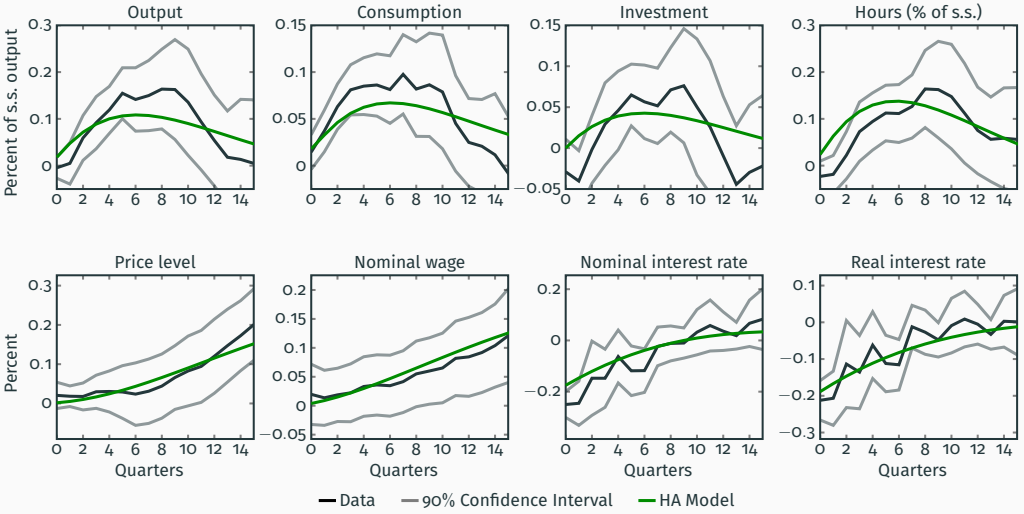


The estimated impulse responses

▸ Alternatives



Estimates point to significant inattention

Estimated parameters

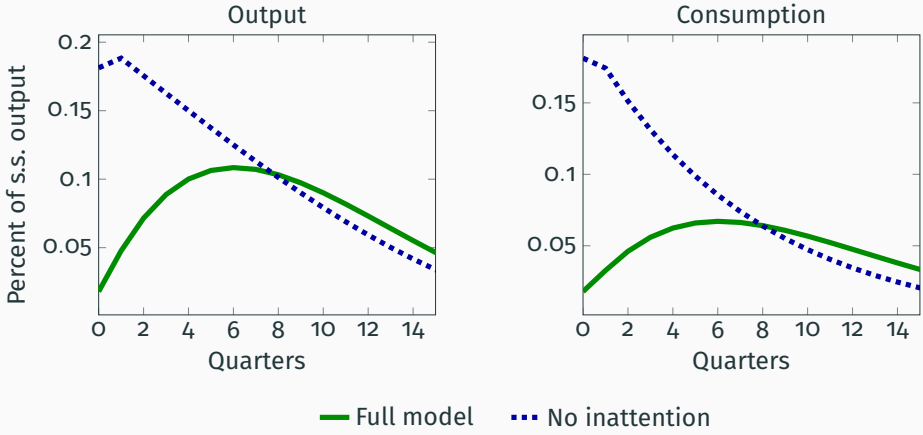
Parameter		Value	std. dev.
θ	Stickiness of household expectations	0.888	(0.016)
ϕ	Investment adjustment cost	7.487	(2.076)
ζ^p	Calvo price stickiness	0.933	(0.015)
ζ^w	Calvo wage stickiness	0.920	(0.018)
σ^m	Standard deviation of monetary shock	0.047	(0.005)
ρ^m	Persistence of monetary shock	0.903	(0.012)

- Comparable to Coibion Gorodnichenko (2012)
  - find 0.80, 0.86-0.89 for inflation expectations of households, prof. forecasters

How much does inattention matter?

▸ Full impulse

- Sticky expectations are crucial for the hump shape!



Inattention informs the **composition** of consumption

Decompose [Auclert 2019, Kaplan-Moll-Violante 2018, ...]

$$dC_t = \underbrace{\sum_s \frac{\partial \mathcal{C}_t}{\partial r_s} dr_s}_{\text{direct}} + \underbrace{\sum_s \frac{\partial \mathcal{C}_t}{\partial Y_s} dY_s + \dots}_{\text{indirect}}$$

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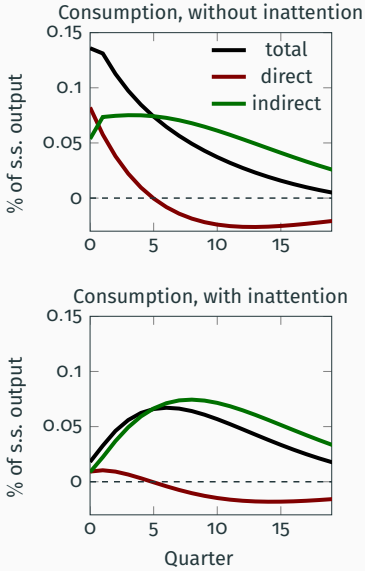

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Indirect effects largely driven by **MPCs**

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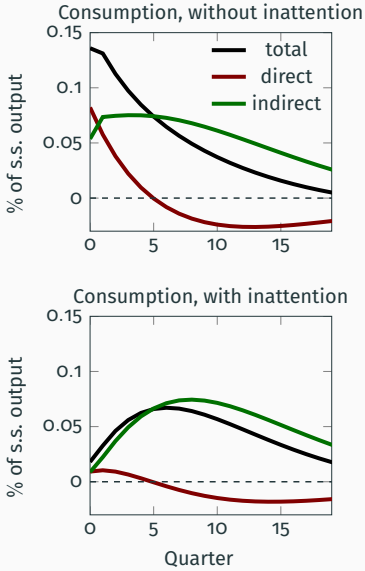
Direct effects strongly **dampened by inattention**

$\rightarrow$ intertemporal substitution $\simeq$ irrelevant for C!



Result 1: Investment is the transmission mechanism

How is monetary policy transmitted in this model?

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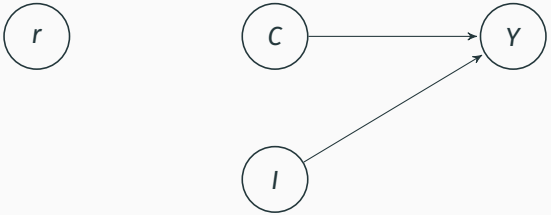

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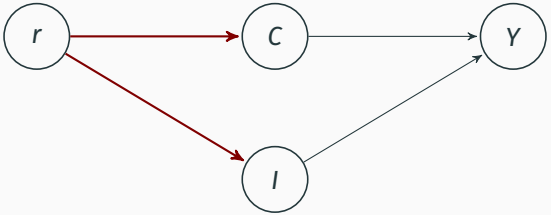

Direct channels

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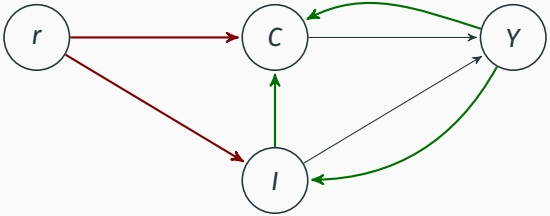
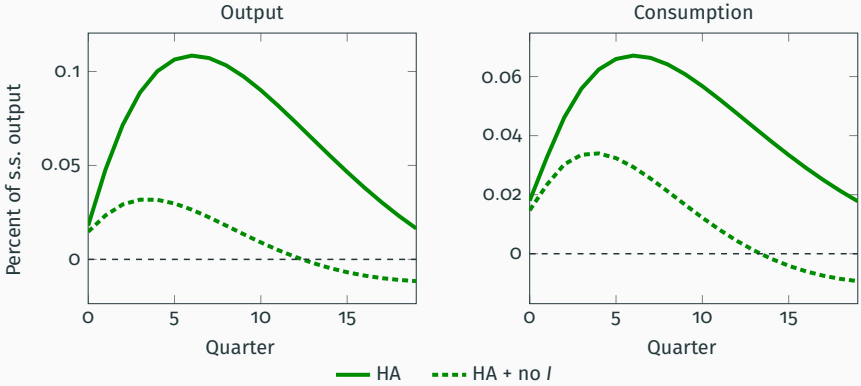


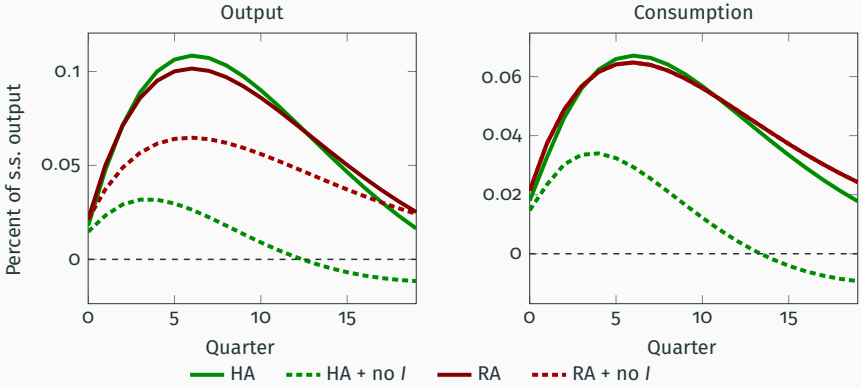
Direct channels & indirect channels

Switching off investment entirely...



...dampens HA output by 85% and consumption by 70% !

Switching off investment entirely...

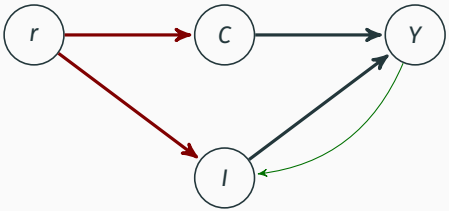


...but has no effect on RA consumption!

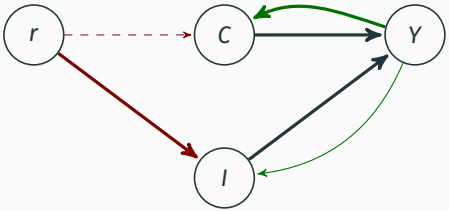
Investment *is* the transmission mechanism in HA

In RA, Y is mostly driven by direct response of C!

Representative agent



Heterogeneous agents



In HA Y is driven by investment!

Result 2: Investment drives business cycles

Bayesian estimation of our inattentive HA model

▸ Priors

- Enrich our model to include **7 standard shocks** [Smets Wouters 2007, JPT 2010, 2011, ...]
  - supply: TFP, W markup, P markup
  - demand: monetary policy, G_t, C_t, I_t
  - different: discount factor shock for C_t, risk premium shock for I_t

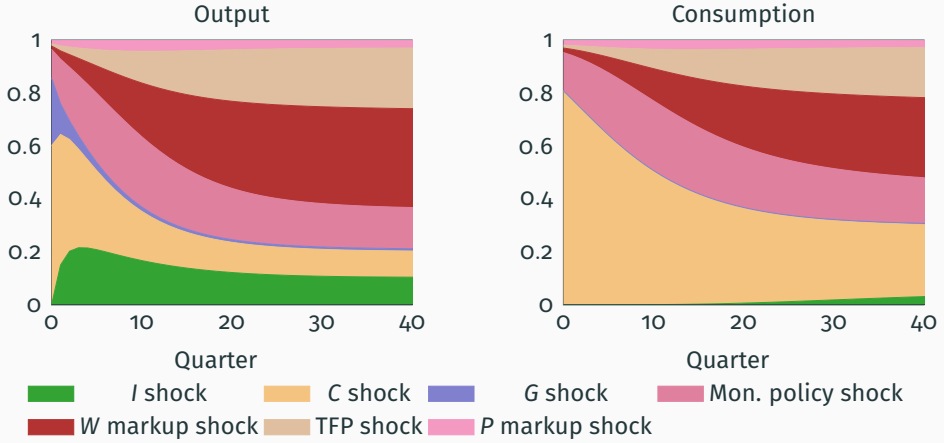
- Use **same model parameters** ...

... but **estimate all shock parameters** to 7 standard series

- To compare: apply same procedure to RA with habit

Consider baseline RA model

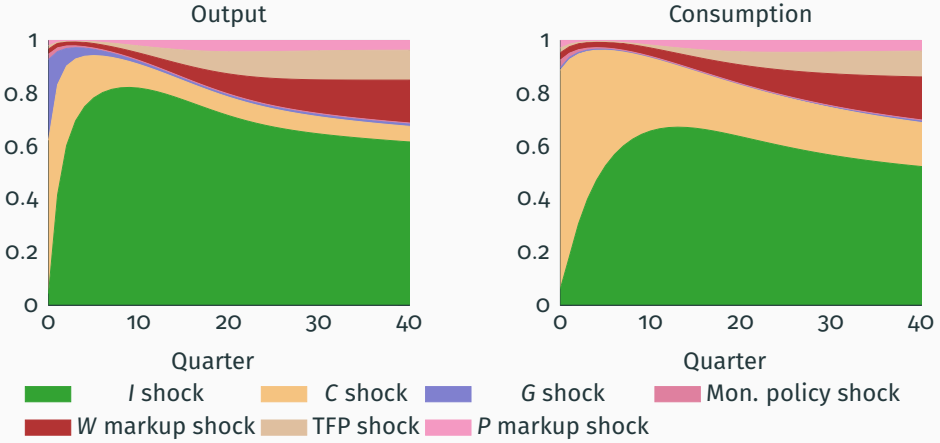
- Decompose forecast error variances $\text{Var}_t(Y_{t+h})$ at business cycle horizons:



In this estimated **RA**: it's about **markup and TFP shocks** [as in Smets Wouters 2007]

Endogenous $cov(C, I)$ in HA $\rightarrow$ investment shocks matter much more!

- Decompose forecast error variances $\text{Var}_t(Y_{t+h})$ at business cycle horizons:

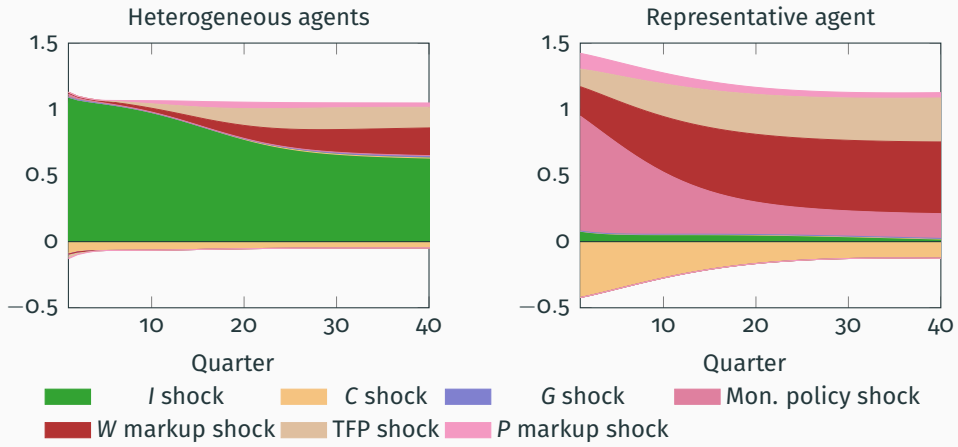


Replace **RA** with **HA**: **investment shocks** matter a lot more!

Why is this?

▸ Impulse to investment

- Salient feature of the data: **comovement** of $\text{Cov}_t(C_{t+h}, I_{t+h})$ [Barro-King 1984]



In **HA** investment shocks generate **endogenous** comovement between C and I

Conclusion

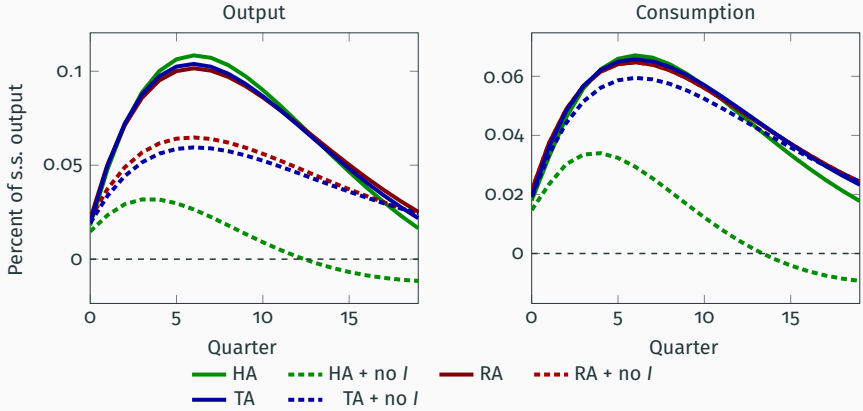
Conclusion

heterogeneity **(micro jumps)** $+$ **inattention** **(macro humps)** $\Rightarrow$ **investment** $\begin{cases} \text{drives monetary transmission} \\ \text{drives business cycles} \end{cases}$

Extra slides

Role of investment in estimated TA

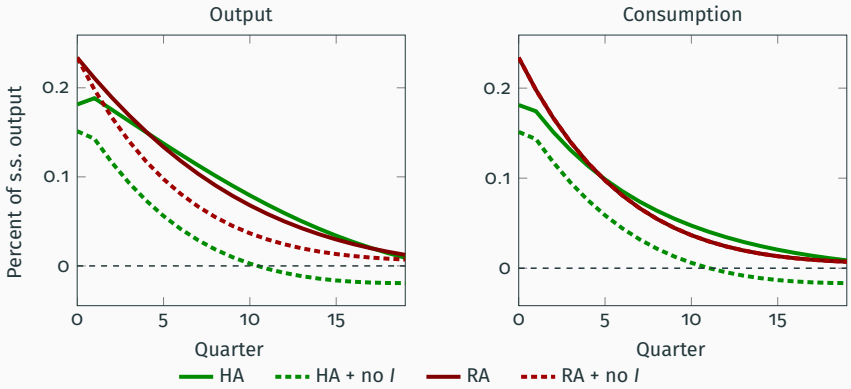
back



- **TA** model (share of hand to mouth = 20%) is relatively close to **RA**

Role of investment without inattention

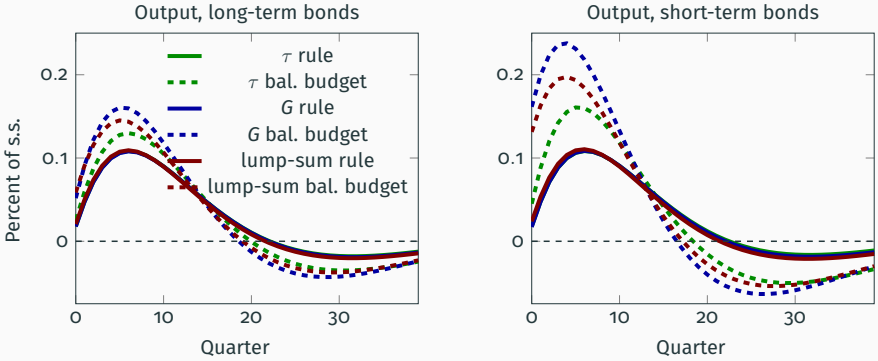
back



- Without inattention, **investment much less important**!

Why does fiscal policy not matter more?

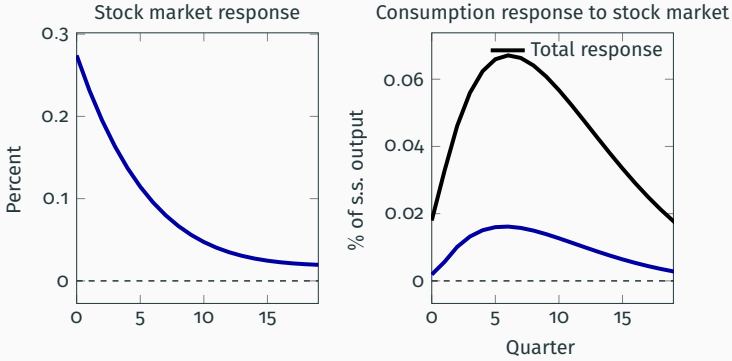
back



- With long-term bonds, much less of a windfall from lower r_t
  - precise fiscal rule less crucial than with short-term bonds

Role of stock market in monetary transmission

back



- Stock market goes up, sluggish transmission to C
  - shape & magnitude as in Chodorow-Reich Nenov Simsek (2019)