# Fiscal and Monetary Policy with Heterogeneous Agents

Ludwig Straub Harvard

ECB-IMF-IMFER Conference 2024

# A new tool in the toolbox

- Active literature on **Heterogeneous-Agent New-Keynesian** ("HANK") models

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Aren't two agents enough?

Can't I match my IRFs equally well with RANK?

# This talk: Intro to HANK via "sequence space"

1. Introduce a canonical "HANK" model in the sequence space
2. Fiscal policy: Persistent inflation
3. Monetary policy: Reliance on investment for transmission
4. Global spillovers: Large and persistent spillovers of U.S. fiscal stimulus

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Global Challenges and Channels for Fiscal and Monetary Policy

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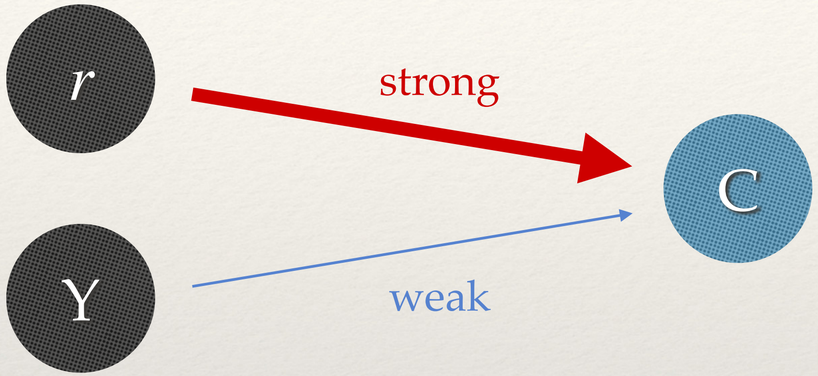
- Based on joint agenda with Adrien Auclert and Matt Rognlie

  + Rishabh Aggarwal, Bence Bardóczy, Hugo Monnery, Rodolfo Rigato, Martin Souchier…

# Core idea why HANK is so different

RANK




Consumption mostly determined by **interest rates**

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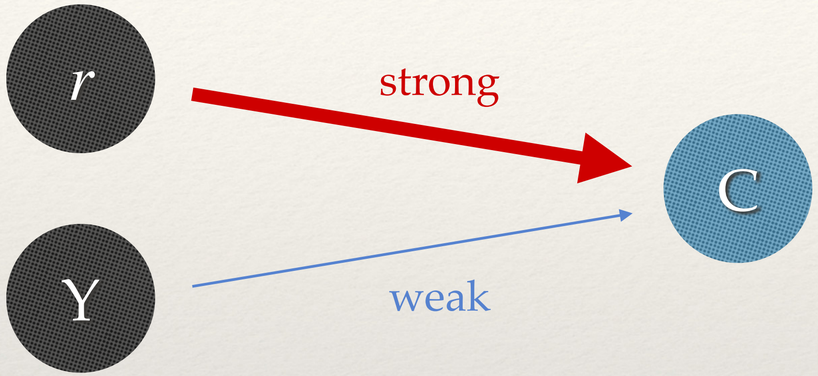


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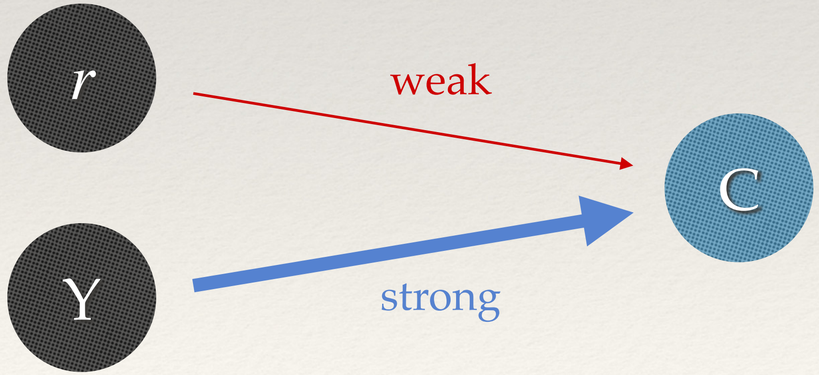


Consumption mostly determined by **income** *(incl. past income)*

# A canonical HANK model

# Making of a canonical HANK model

- The textbook representative-agent NK (RANK) model consists of:

  1. household side: representative agent
  2. fiscal policy: irrelevant due to Ricardian equivalence
  3. monetary policy: Taylor rule
  4. supply side: linear production, sticky prices set by firms

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  4. supply side: linear production, sticky ~~prices set by firms~~ wages set by unions
- Will go over all four ingredients in an economy with perfect foresight
  - without loss to first order (certainty equivalence)

# (1) Heterogeneous households

$$\max \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left( u(c_{it}) - v\left(N_t\right) \right)$$

hours set by unions (later)

$$c_{it} + a_{it} \leq (1 + r_{t-1}) a_{it-1} + e_{it} \left(1 - \tau_t\right) w_t N_t \qquad a_{it} \geq \underline{a}$$

idiosyncratic productivity shocks (Markov chain)

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Forward (distribution) iteration $\Psi_t(a, e)$ ← Aggregate consumption:

$$\mathscr{C}_t = \int c_t^*(a, e) d\Psi_t(a, e)$$

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$$\mathscr{C}_t\Big(\{r_s, Z_s\}\Big)$$

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$\mathscr{C}_t\left(\{r_s, Z_s\}\right)$ Aggregate consumption function in the sequence space

# (2, 3) Fiscal and monetary policy

- Government sets $\{G_s, T_s\}$ subject to

$$B_t = \left(1 + r_{t-1}\right) B_{t-1} + G_t - T_t \qquad T_t = \tau_t w_t N_t \qquad B_t \text{ bounded}$$

- Central bank sets nominal rate

$$i_t = r + \phi \pi_{t+1} + \epsilon_t \qquad \text{today: } \phi \searrow 1 \qquad \text{i.e. real rate} = r_t = r + \epsilon_t$$

# (4) Supply side

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  - useful starting point: labor rationed equally $n_{it} = N_t$ (see Ferriere-Navarro for a richer model)

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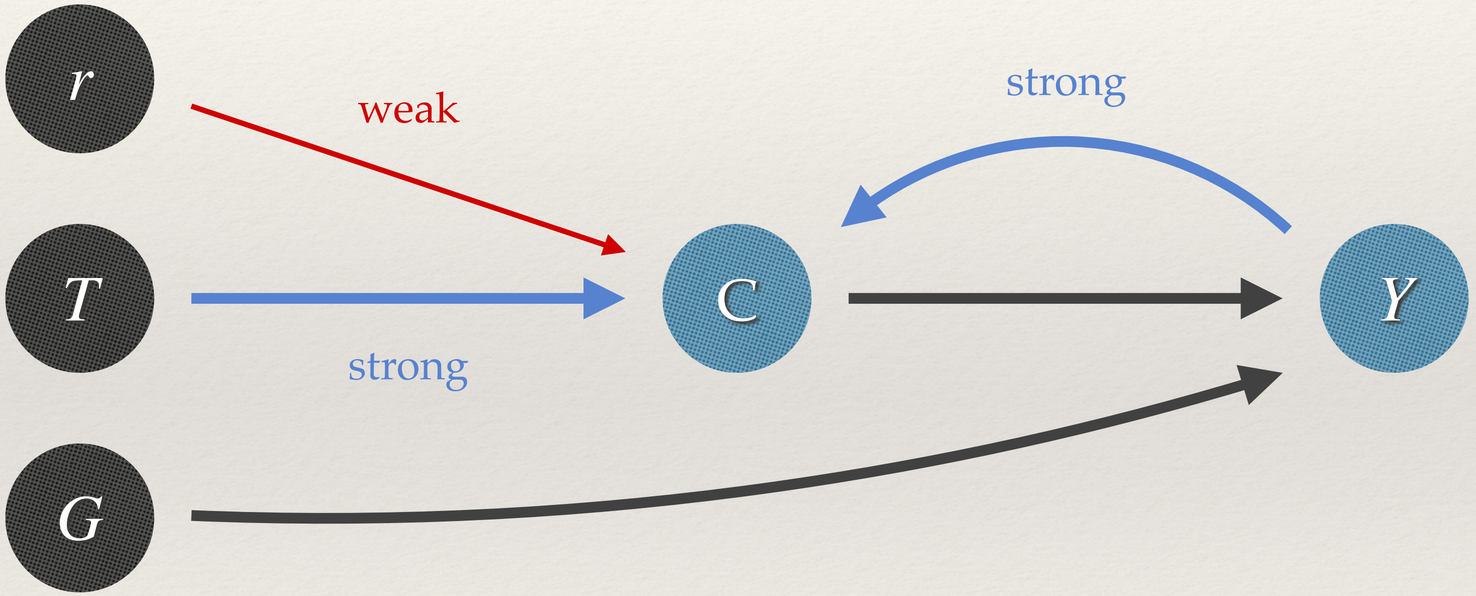
- Better than sticky prices + flexible wages ( → countercyclical profits…)

# Equilibrium as a graph



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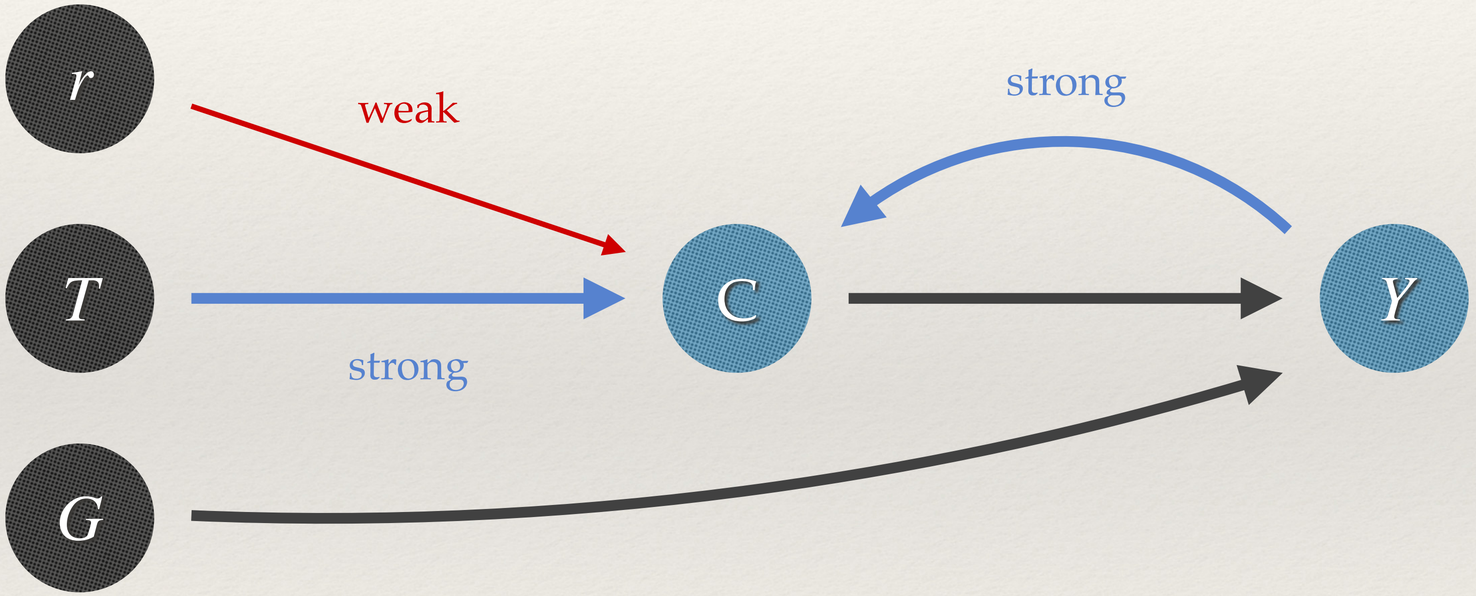


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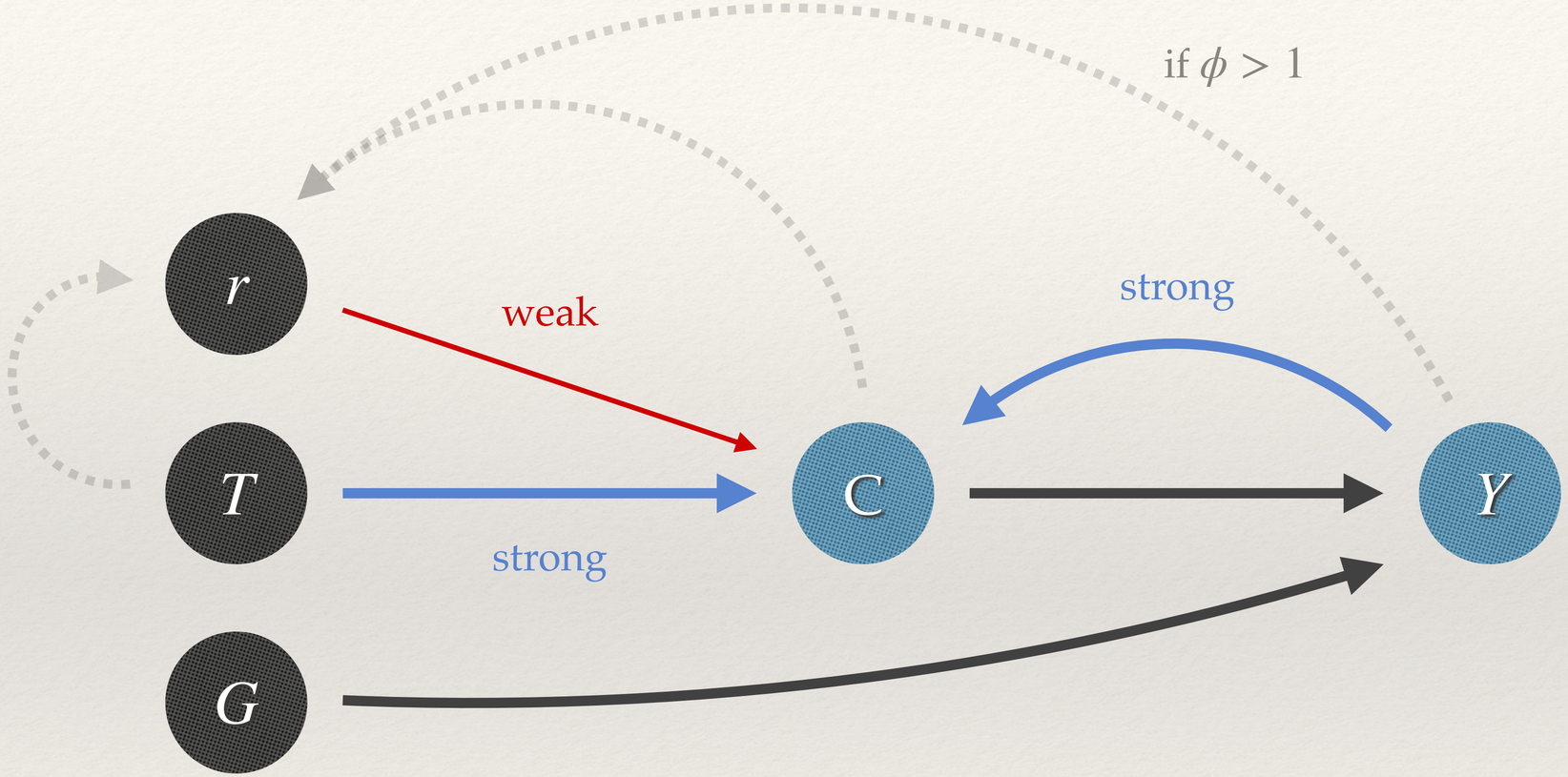


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# Fiscal policy in HANK

# Intertemporal Keynesian cross

- Imagine central bank keeps real interest rate constant: $r_t = r$.
- Fiscal policy shock $d\mathbf{G} = (dG_0, dG_1, \ldots)$, $d\mathbf{T} = (dT_0, dT_1, \ldots)$, same NPV.
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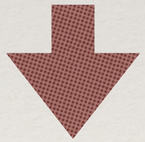

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Auclert Rognlie Straub "Intertemporal Keynesian Cross"

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**Intertemporal Keynesian cross**

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Auclert Rognlie Straub "Intertemporal Keynesian Cross"

# What is **M**?

- **M** is the matrix derivative (Jacobian) of the cons. function $\mathscr{C}_t\left(\{Y_s - T_s\}\right)$

$$\mathbf{M} = \begin{pmatrix} M_{00} & M_{01} & M_{02} & \cdots \\ M_{10} & M_{11} & M_{12} & \cdots \\ M_{20} & M_{21} & M_{22} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}$$

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# What is **M** for a representative agent?

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$$\mathbf{M} = \begin{pmatrix} 1-\beta & (1-\beta)\beta & (1-\beta)\beta^2 & \cdots \\ 1-\beta & (1-\beta)\beta & (1-\beta)\beta^2 & \cdots \\ 1-\beta & (1-\beta)\beta & (1-\beta)\beta^2 & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}$$

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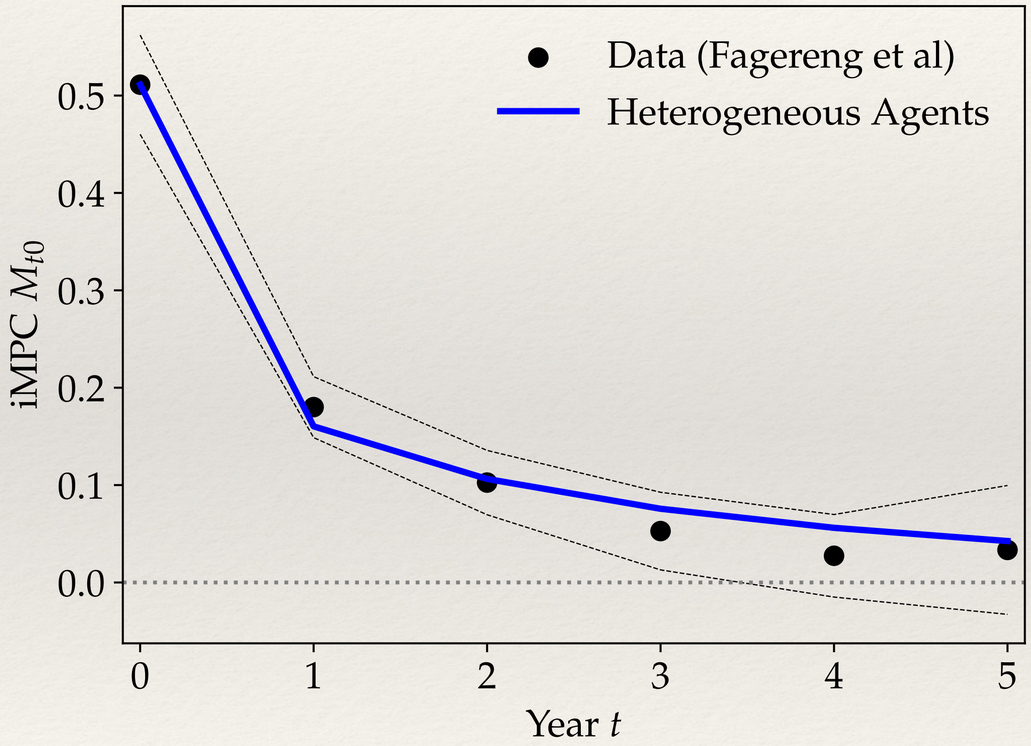
# M in models and the data

- Can compare first column with the data from Fagereng-Holm-Natvik:



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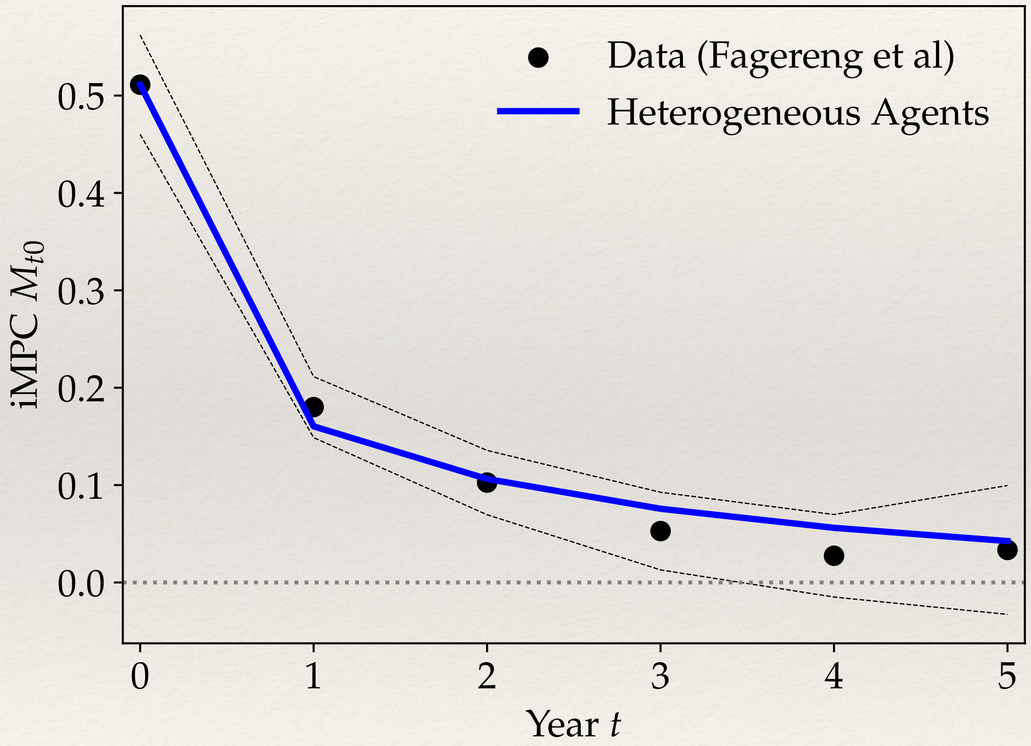


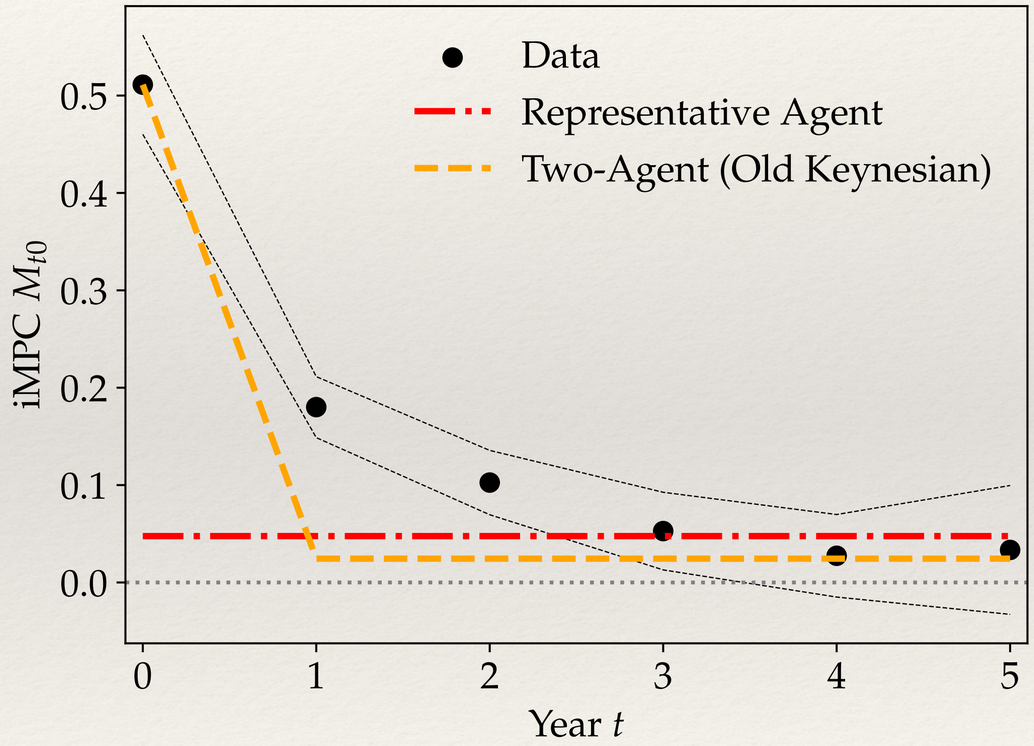

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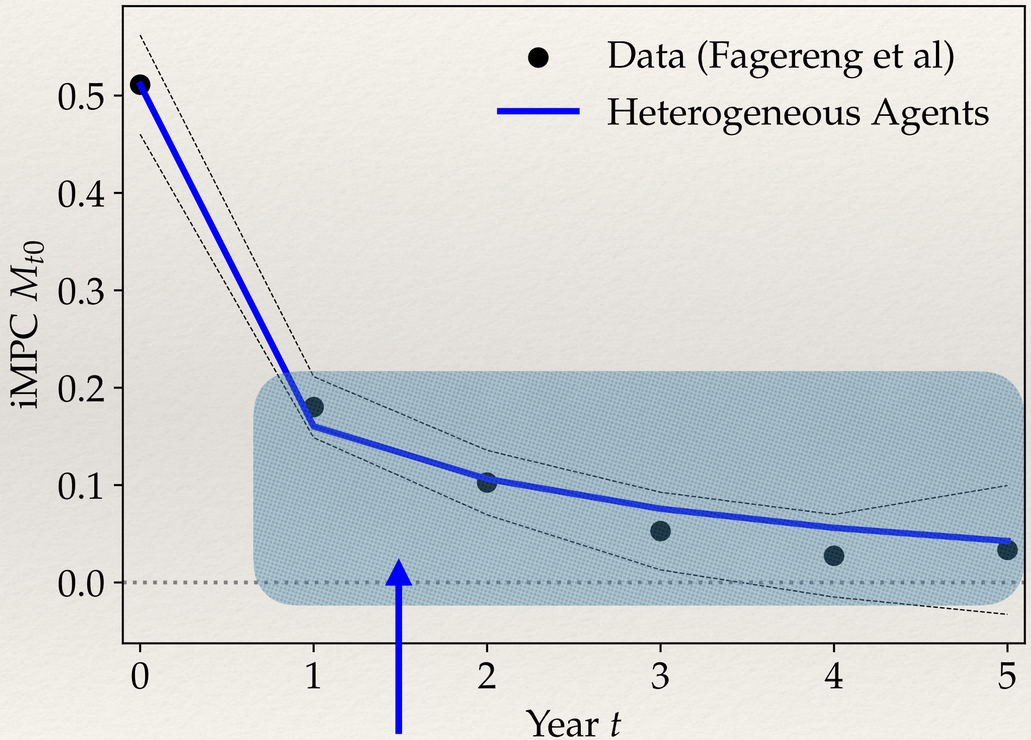


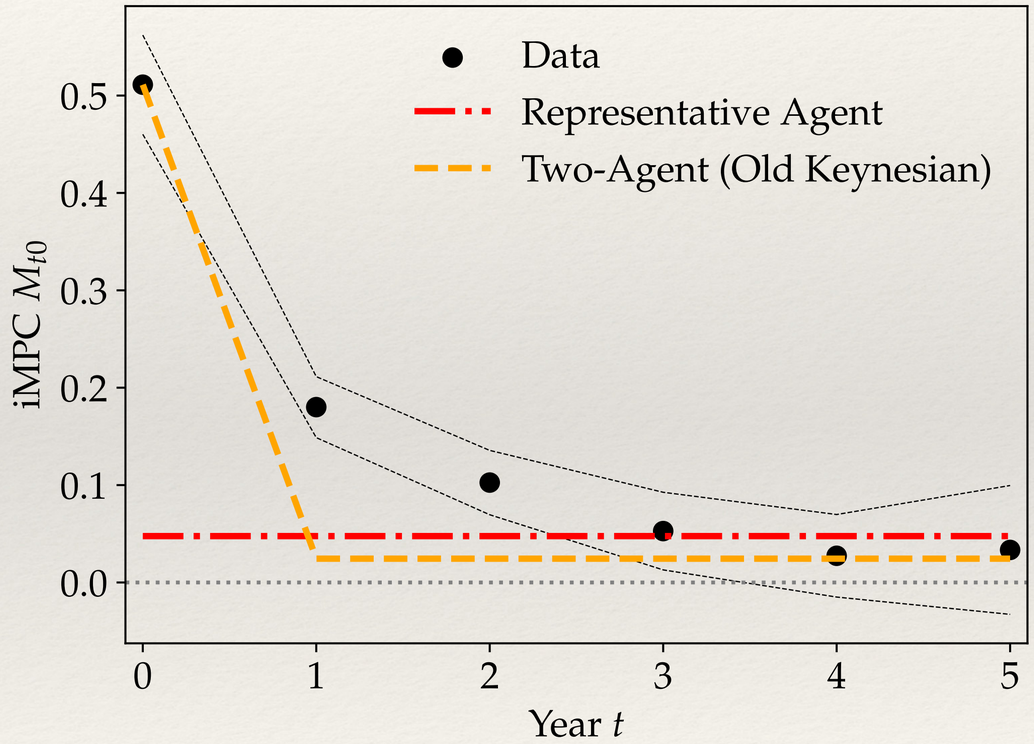


**HA**: Households spend down transfer relatively slowly

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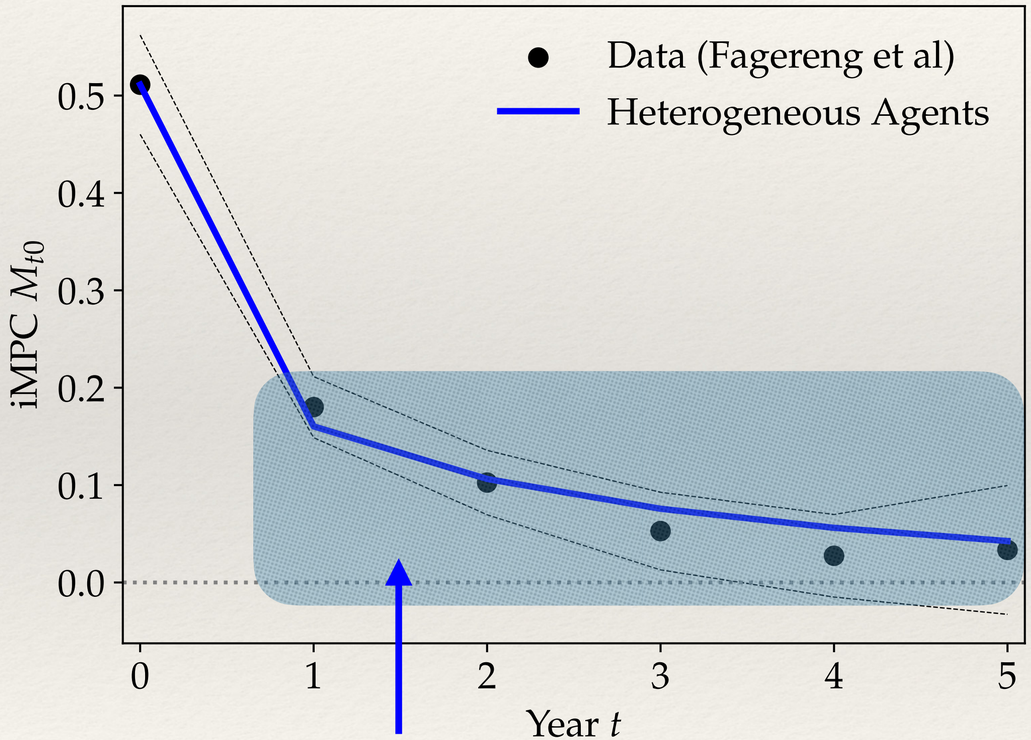


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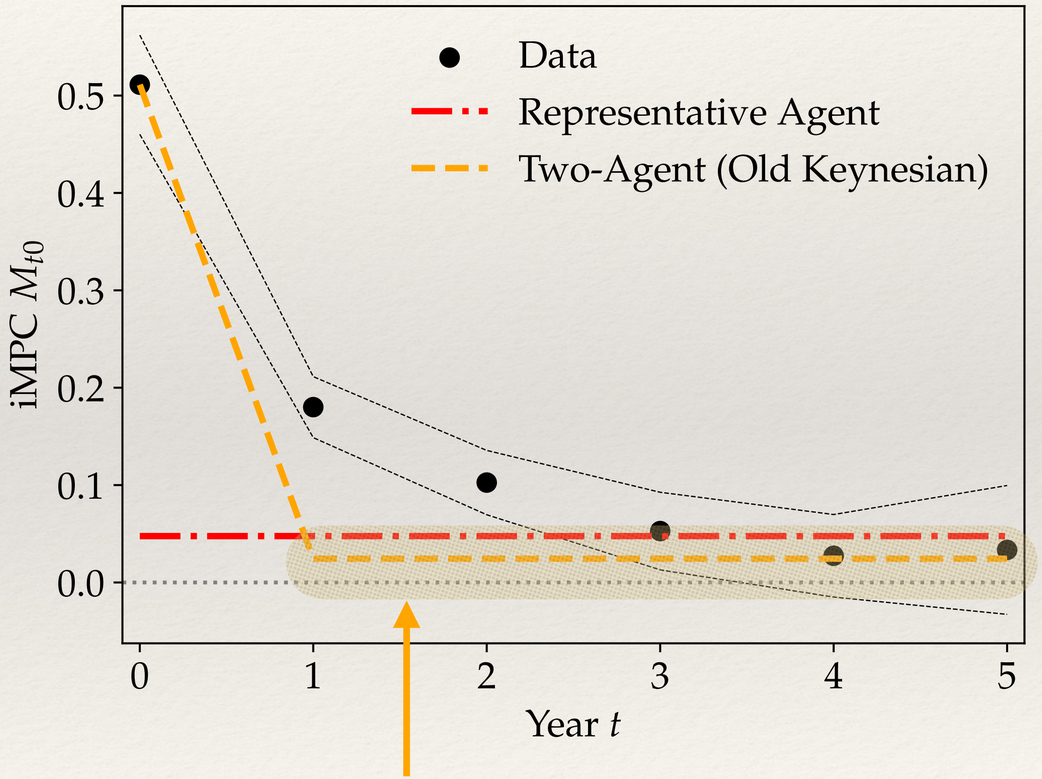
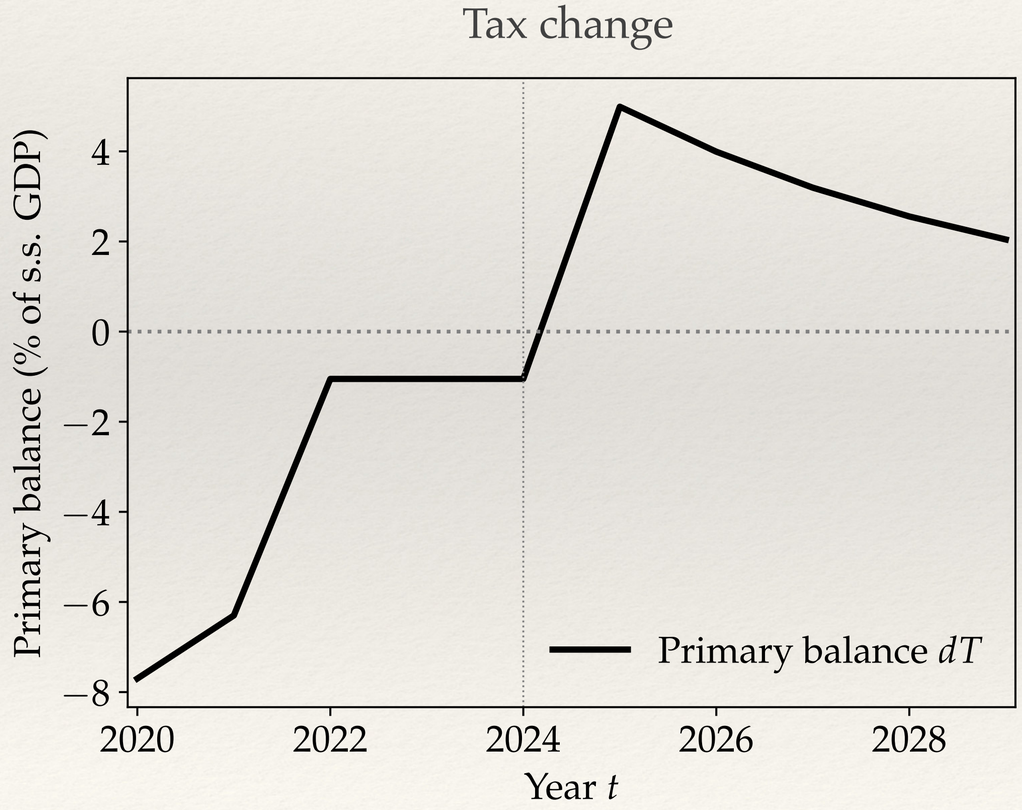



**TA**: Households spend either right away or little

Auclert Rognlie Straub "Intertemporal Keynesian Cross"

# The long shadow of Covid stimulus

- Feed in Covid stimulus and solve for consumption and inflation.




Constructed as 70% of observed primary balance beyond pre-Covid surplus of -2%

See also Bayer Born Luetticke Müller

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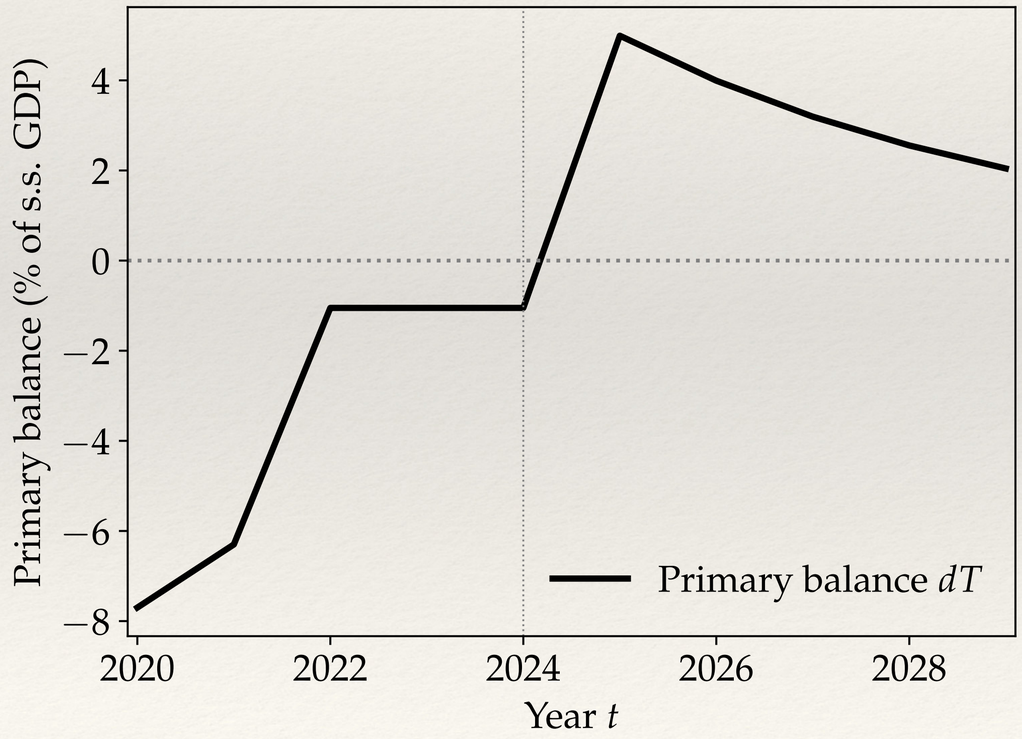
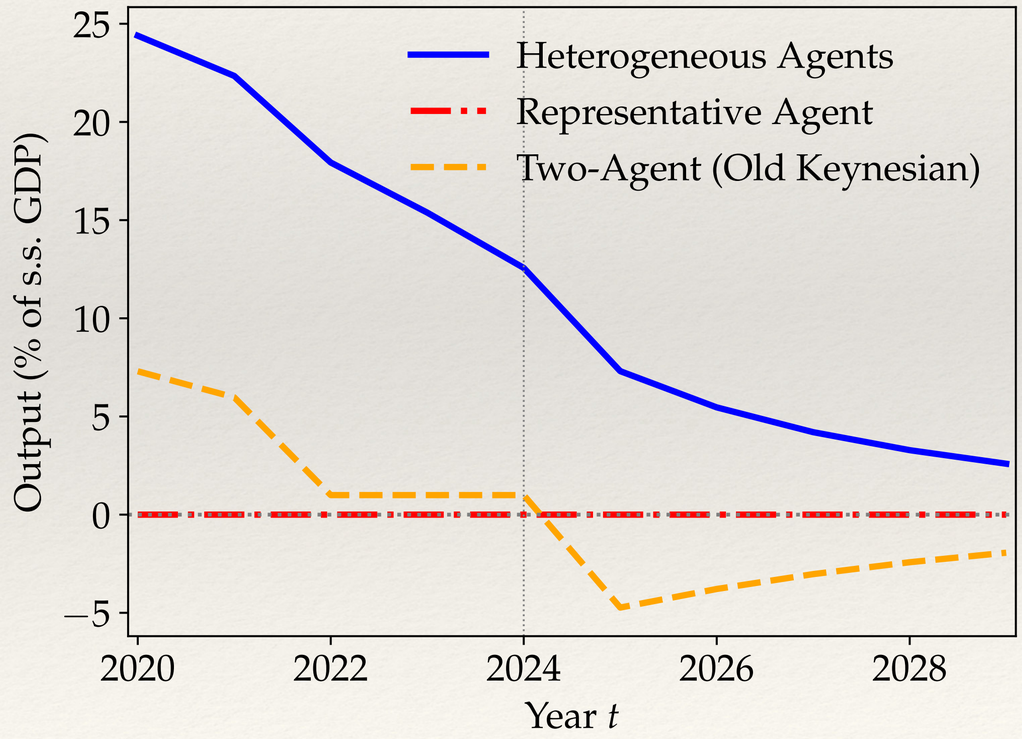
- Feed in Covid stimulus and solve for consumption and inflation.

Tax change




Consumption

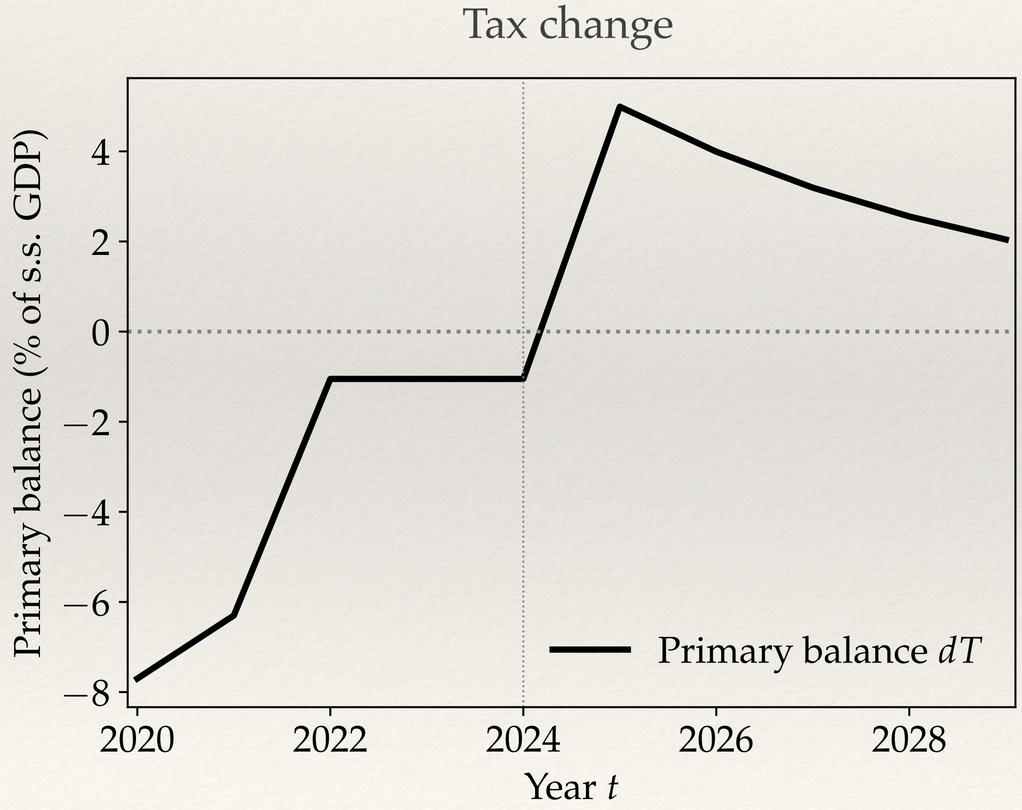



Constructed as 70% of observed primary balance beyond pre-Covid surplus of -2%

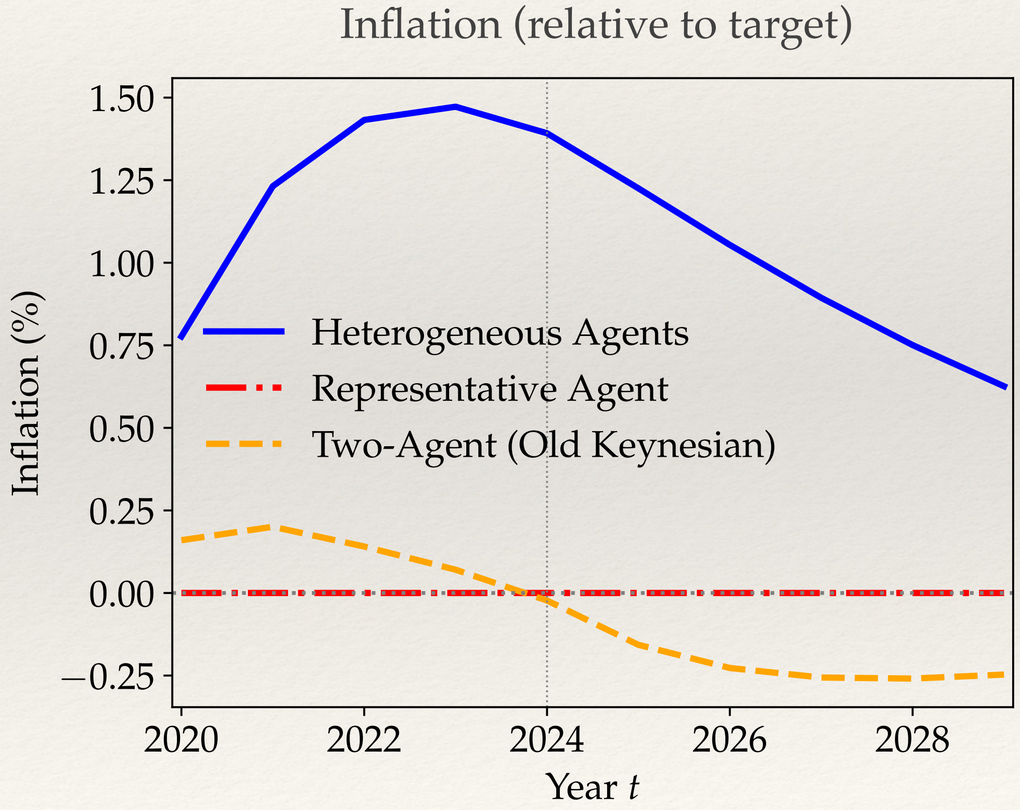
See also Bayer Born Luetticke Müller

# The long shadow of Covid stimulus

- Feed in Covid stimulus and solve for output and inflation.




Constructed as 70% of observed primary balance beyond pre-Covid level -2%

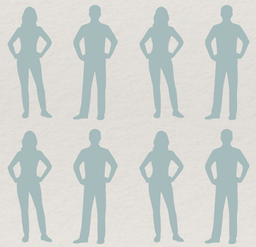


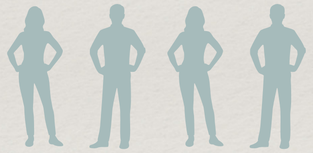

Standard hybrid NKPC with 50% weight on lagged inflation, $\kappa = 0.01$

# Why does heterogeneity lead to persistence?

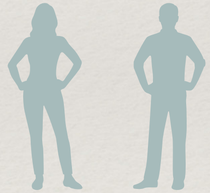
AGGREGATE DEMAND

POOR AND MIDDLE CLASS





UPPER MIDDLE CLASS



TOP 1%

Auclert Rognlie Straub “Trickling Up of Excess Savings”

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AGGREGATE DEMAND

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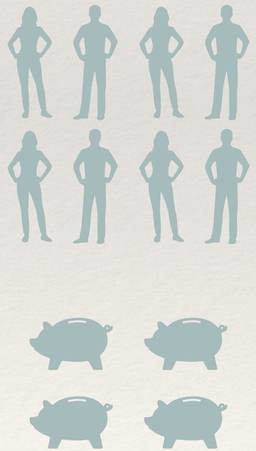

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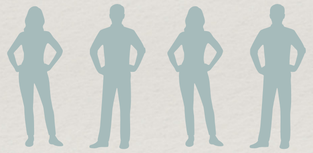

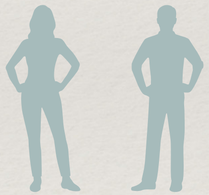

TOP 1%

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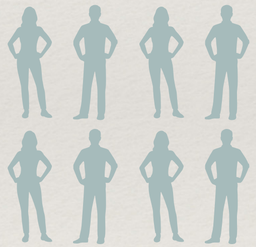
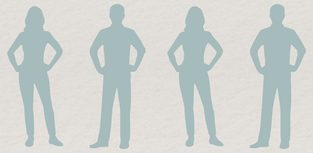
# Why does heterogeneity lead to persistence?

*Poor & middle class spend down the fastest*

AGGREGATE DEMAND

POOR AND MIDDLE CLASS





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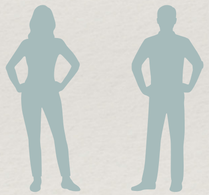

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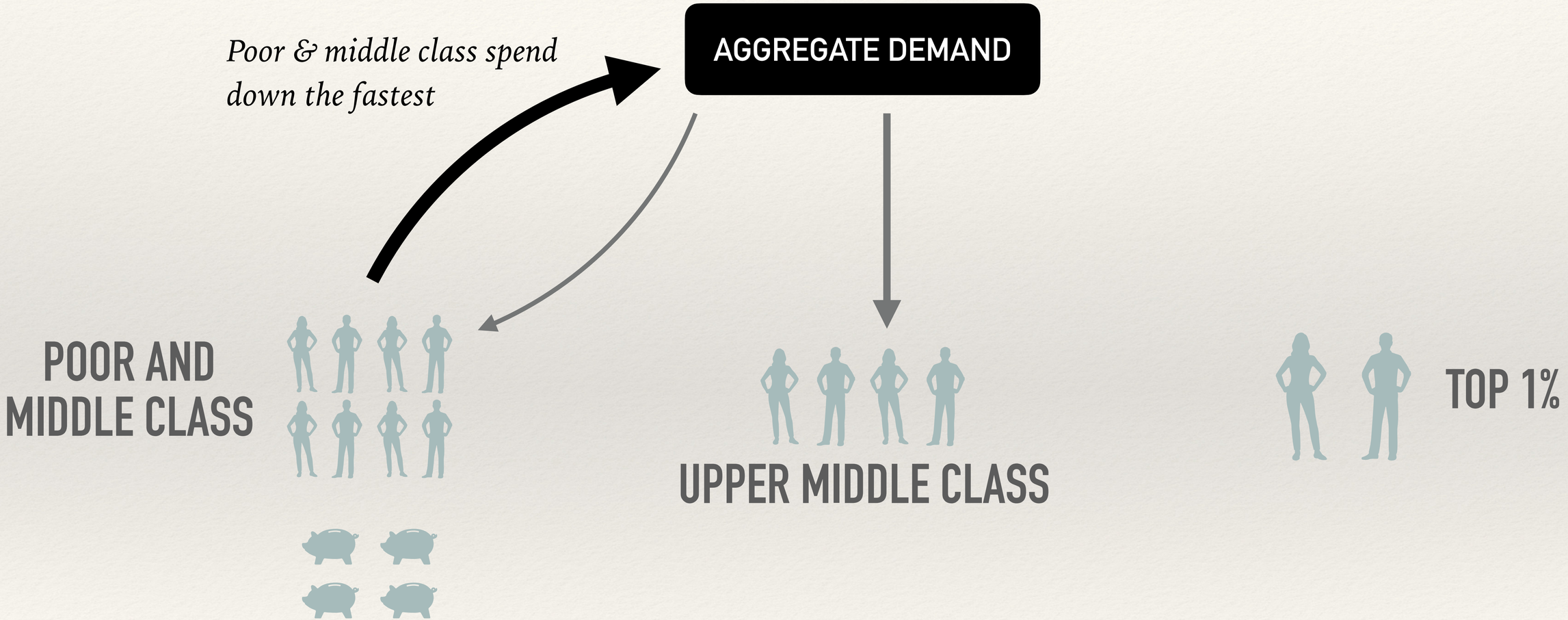


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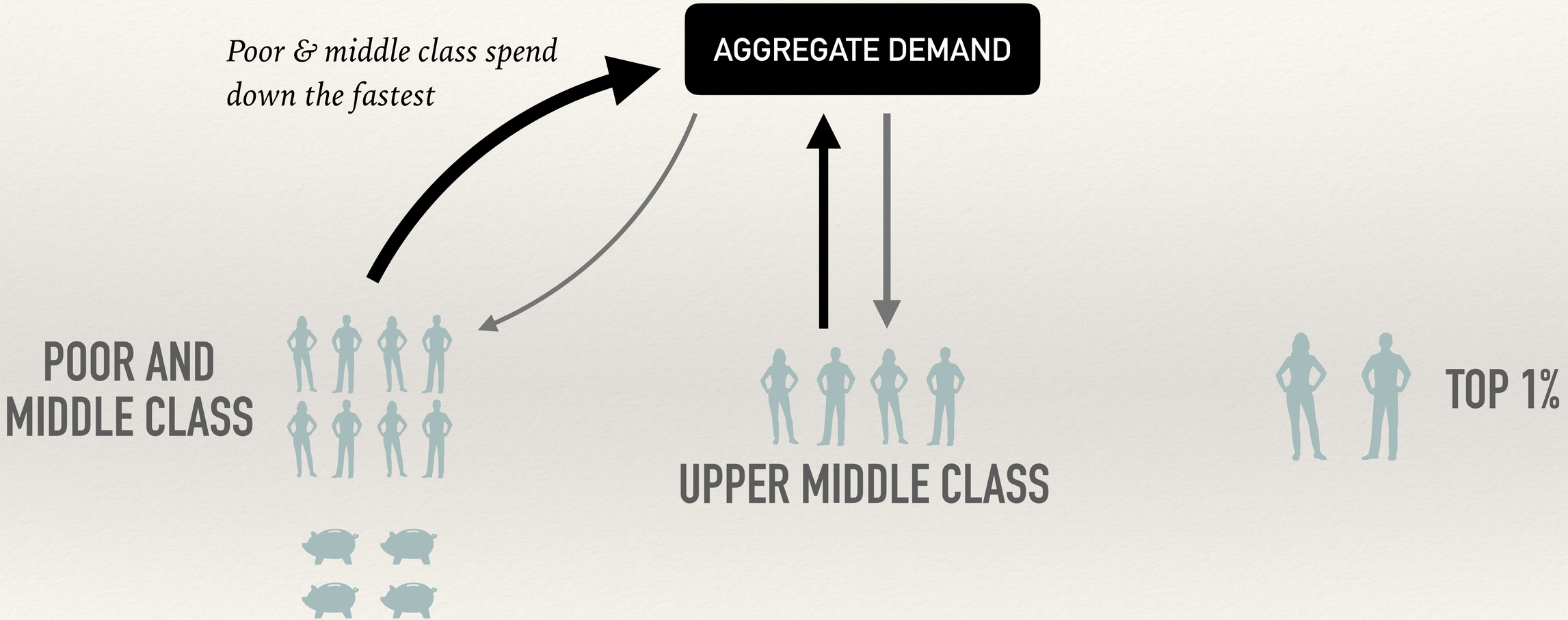


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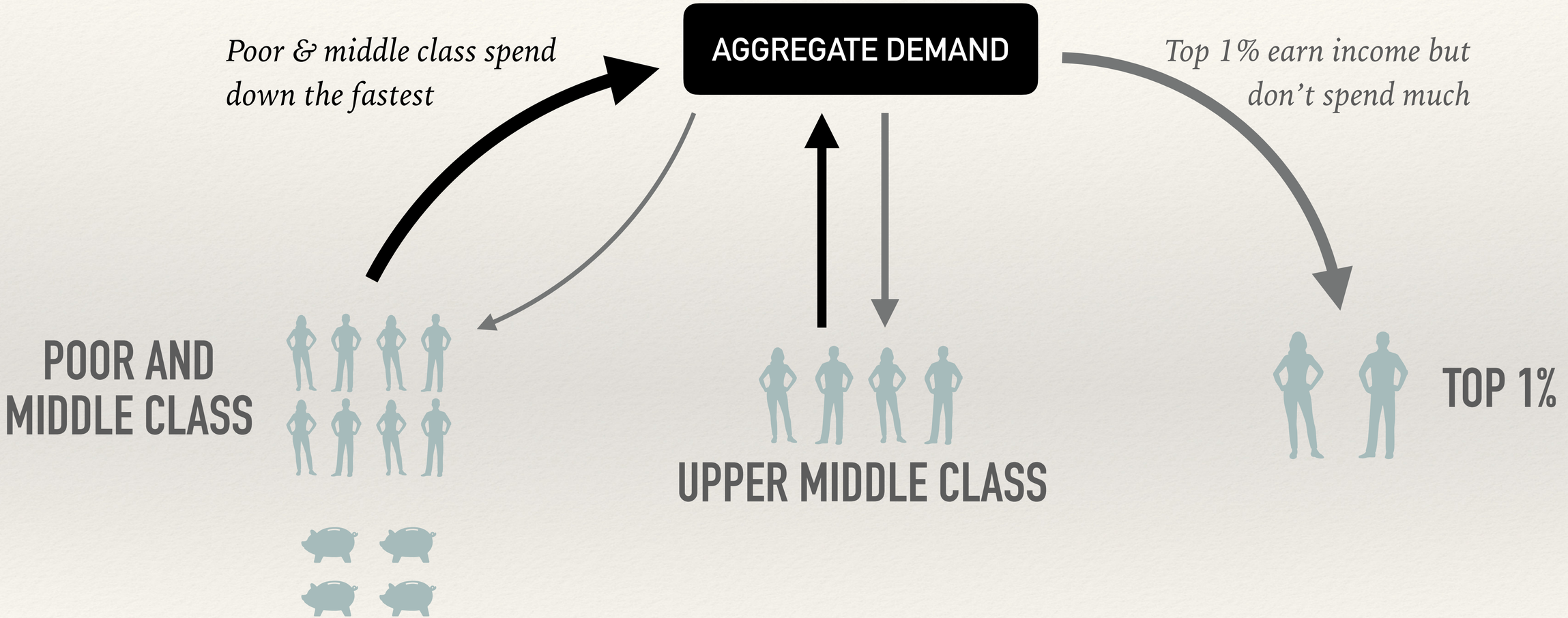


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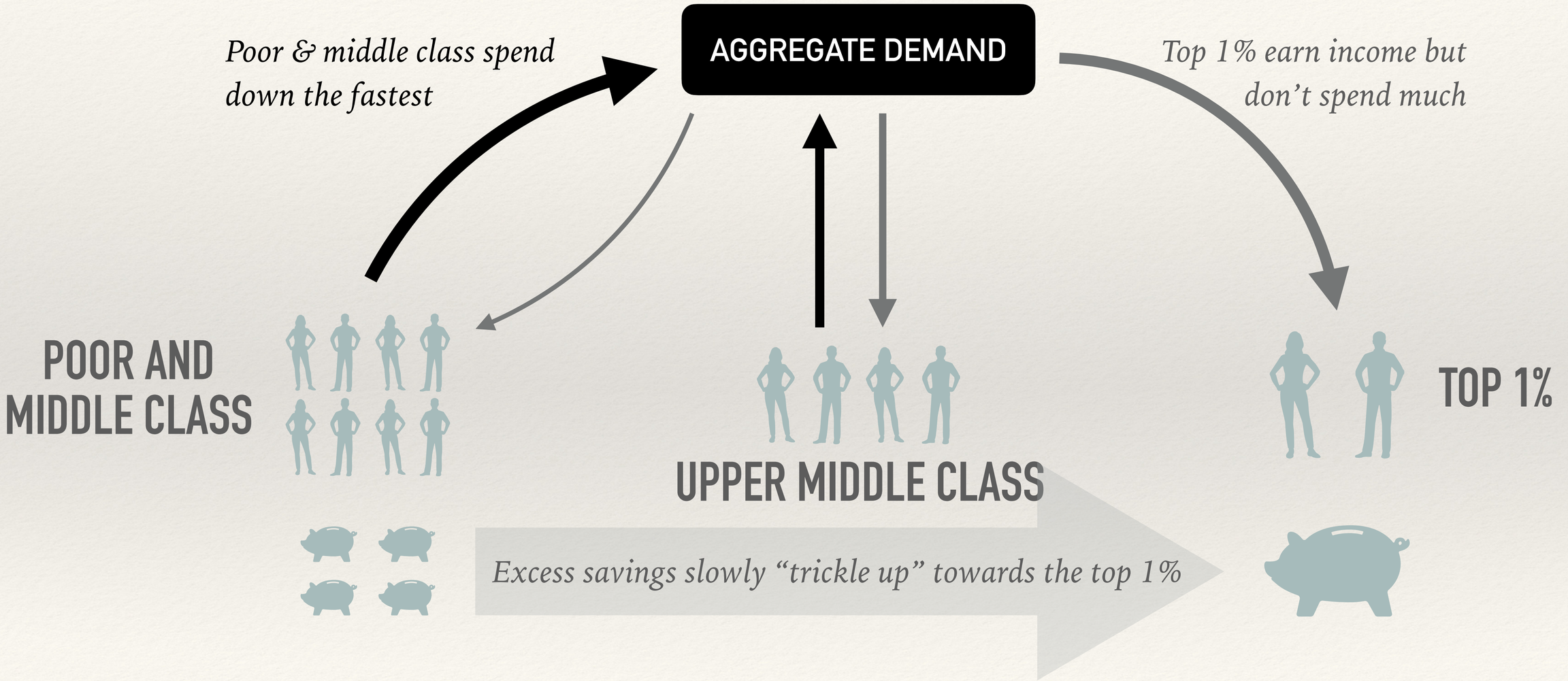


Auclert Rognlie Straub "Trickling Up of Excess Savings"

# Monetary policy

# Monetary policy

- Allow for central bank to shock the real interest rate $\{r_s\}$
- Assume gov. keeps debt repayment $(1 + r_{t-1})B_t$ constant and adjusts $T_t$

$$Y_t = G_t + \mathscr{C}_t\left(\{r_s, Y_s - T_s\}\right) \qquad T_t = (1 + r)B + G - \frac{(1 + r)B}{1 + r_t}$$

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$$d\mathbf{Y} = \mathbf{M}^r \frac{d\mathbf{r}}{1 + r} - \mathbf{M}B\frac{d\mathbf{r}}{1 + r} + \mathbf{M}d\mathbf{Y}$$

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Key channel with RA

direct effect of r

indirect effect via gov. budget

indirect effect via Y

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Key channels with HA
(Kaplan Moll Violante)

$$d\mathbf{Y} = \mathbf{M}^r \frac{d\mathbf{r}}{1+r} - \mathbf{M}B\frac{d\mathbf{r}}{1+r} + \mathbf{M}d\mathbf{Y}$$

Key channel with RA

direct effect of r

indirect effect via gov. budget

indirect effect via Y

# Aggregate effects of monetary policy

- Does HANK matter for aggregate effects of monetary policy?

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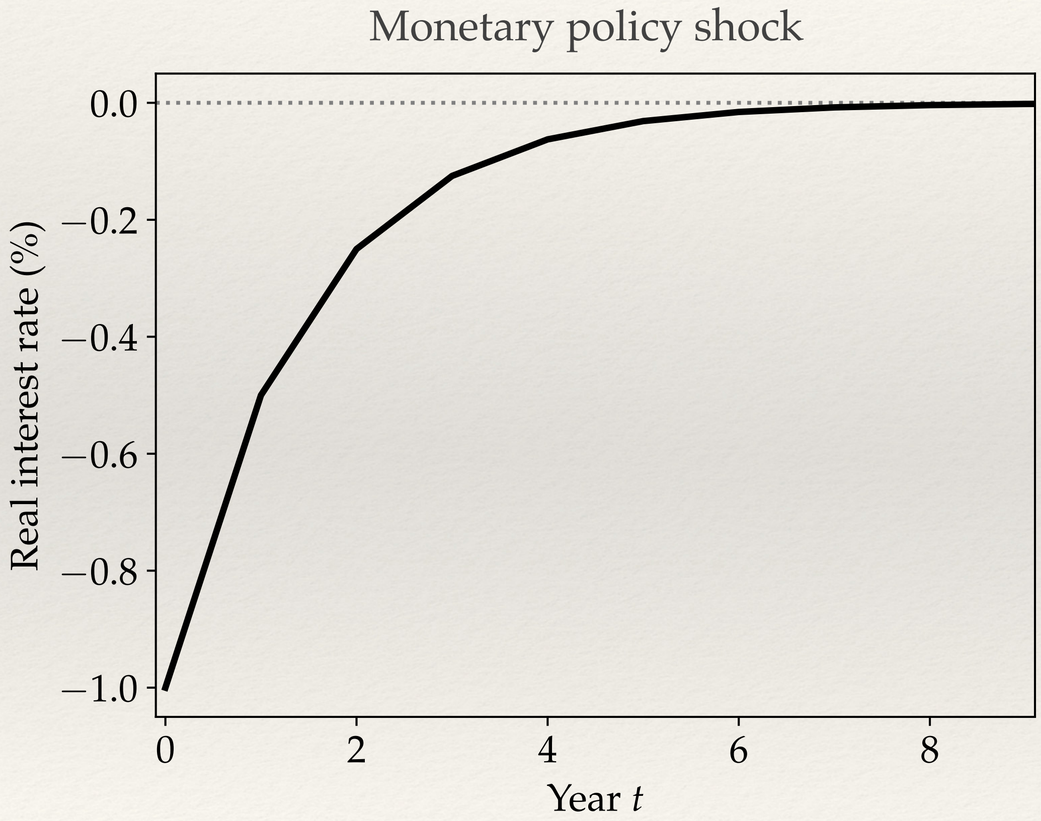
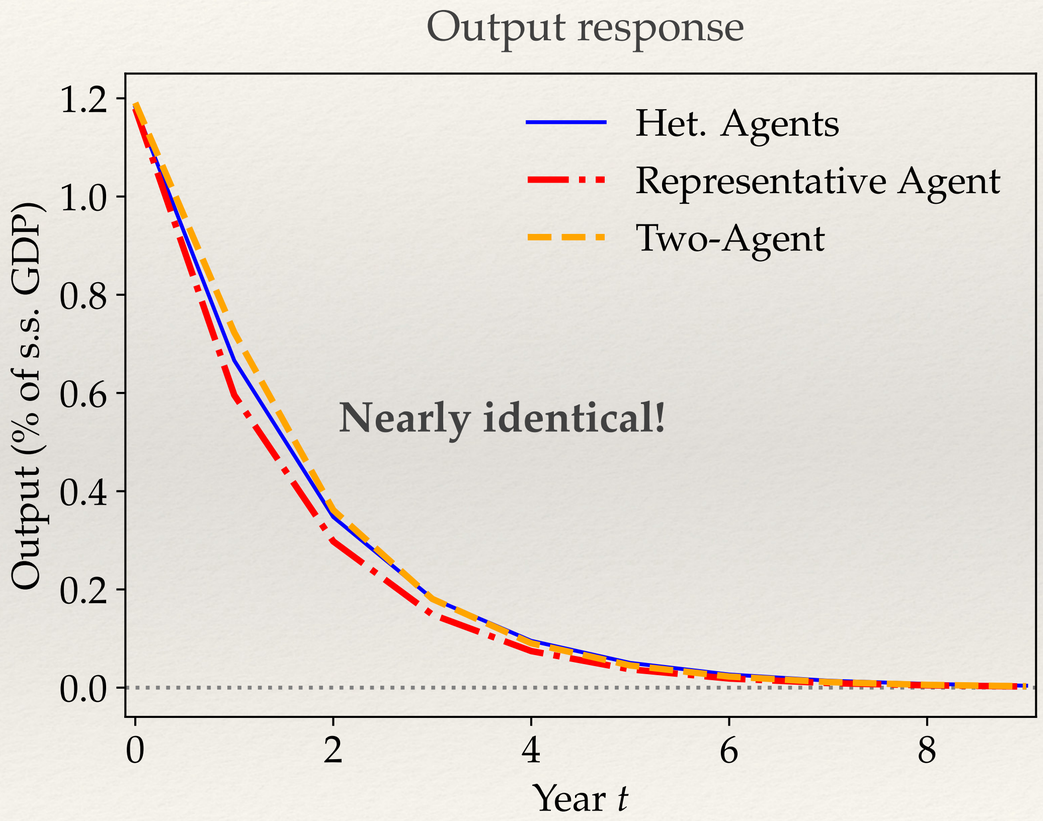
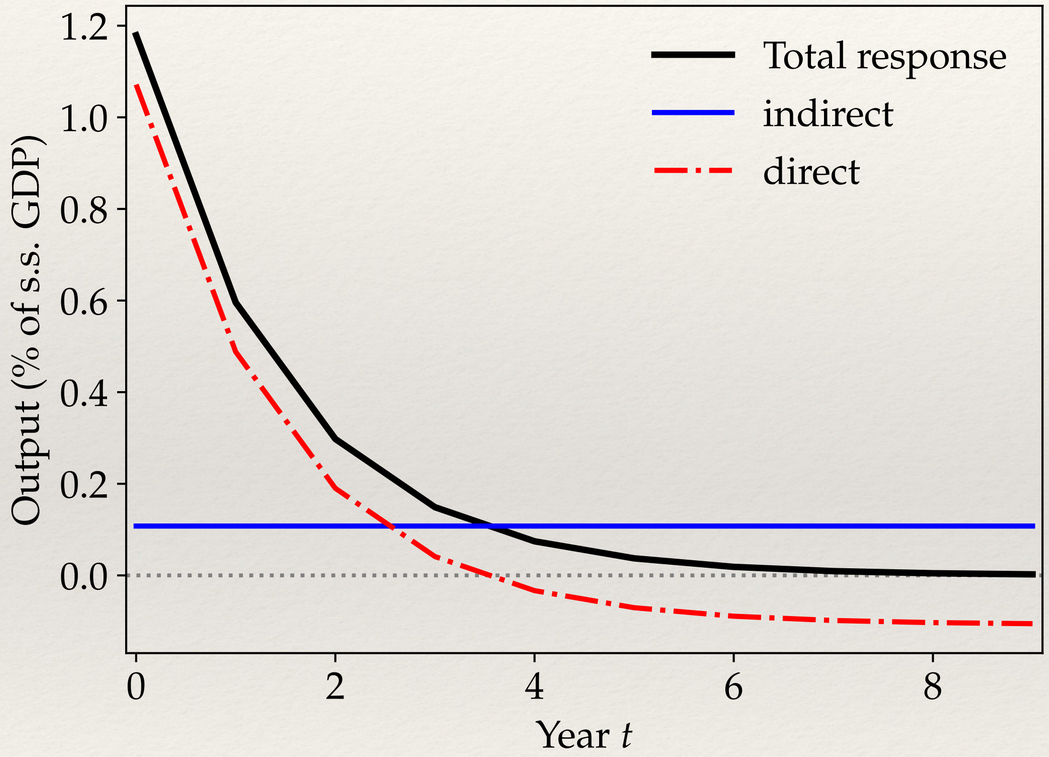


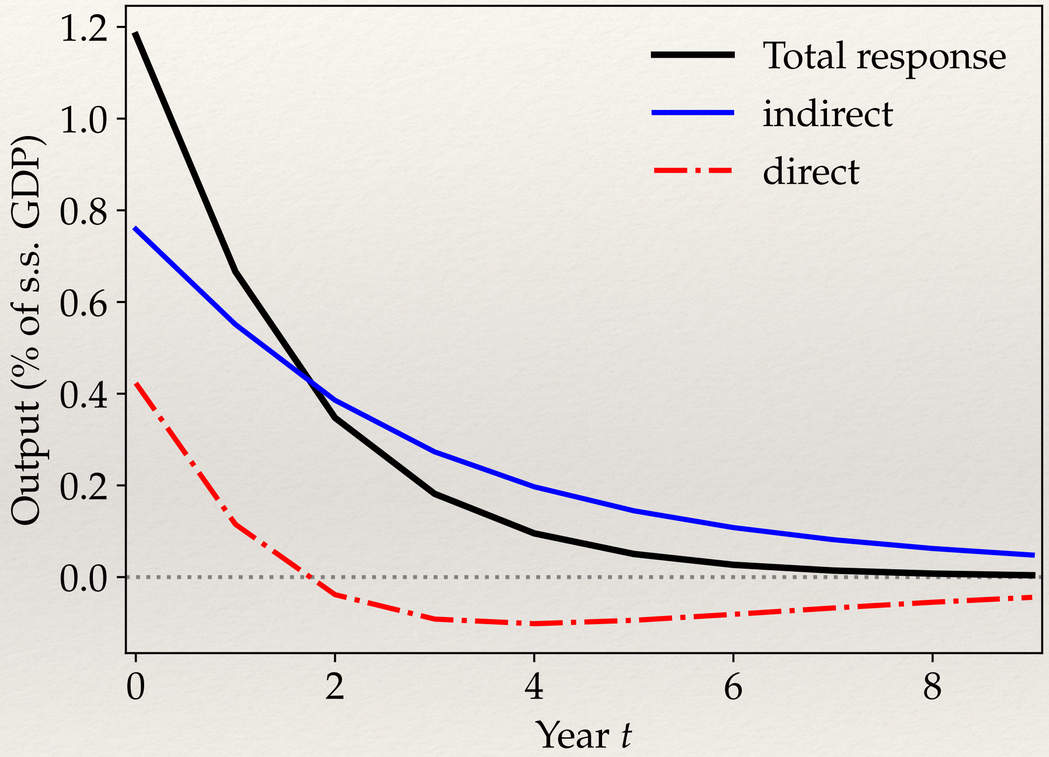



# Direct and indirect effects

Representative agent




Heterogeneous agents

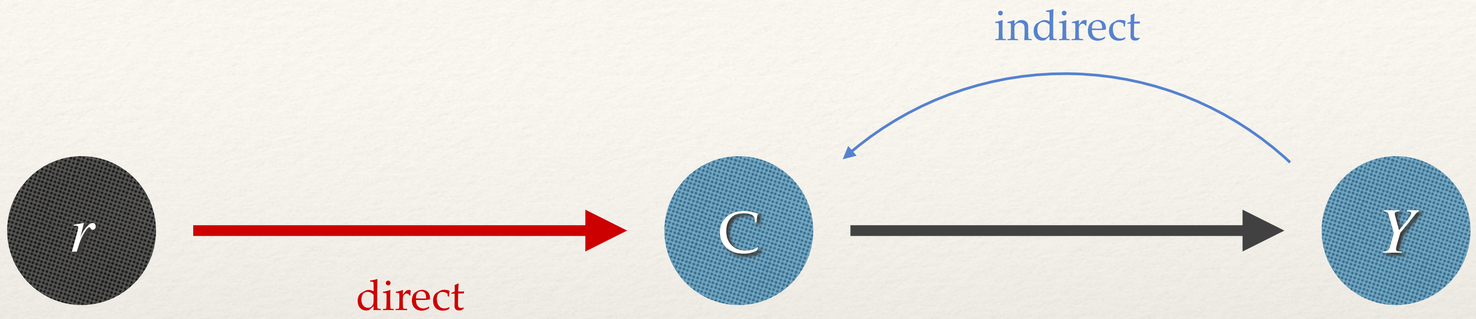



- HANK similar to RANK because stronger indirect offsets weaker direct effect!

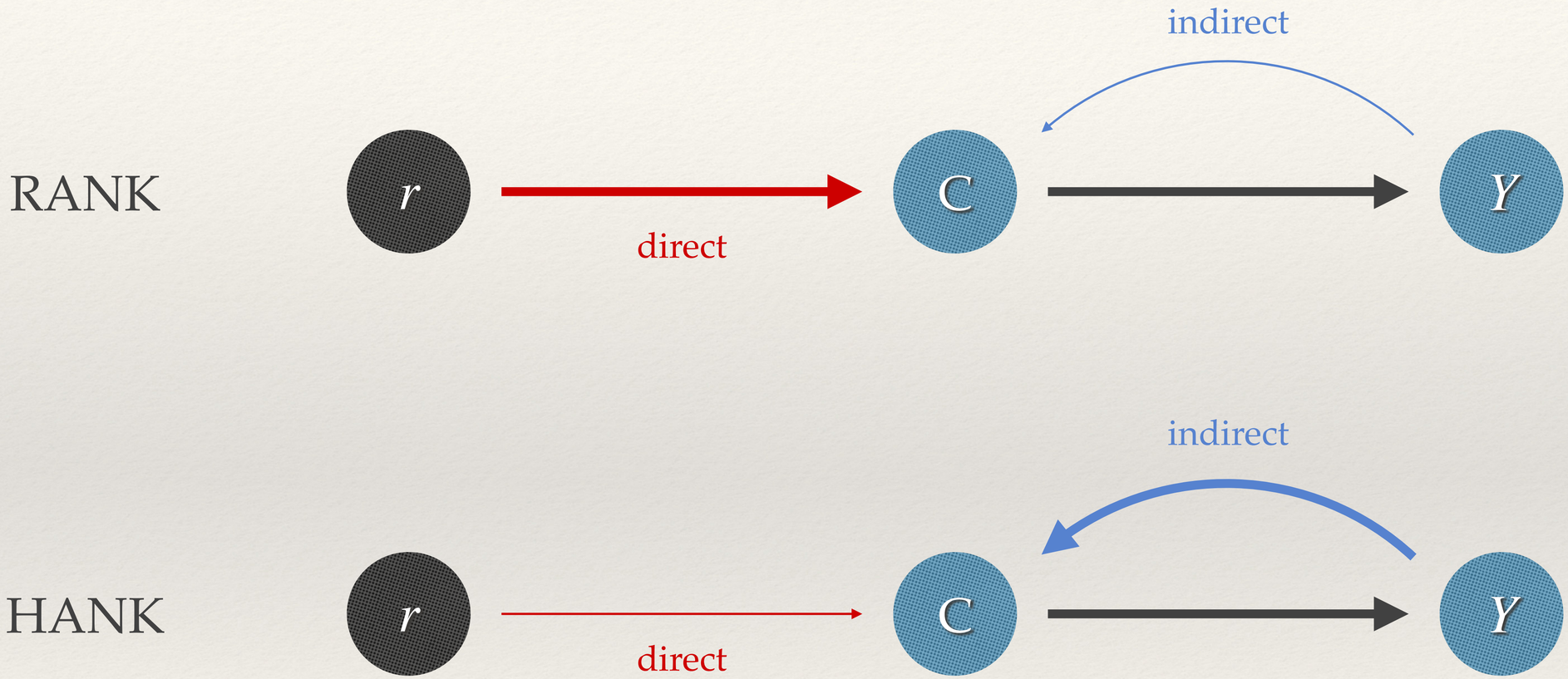
[Werning 2015]

# Monetary policy flowcharts

RANK



# Monetary policy flowcharts



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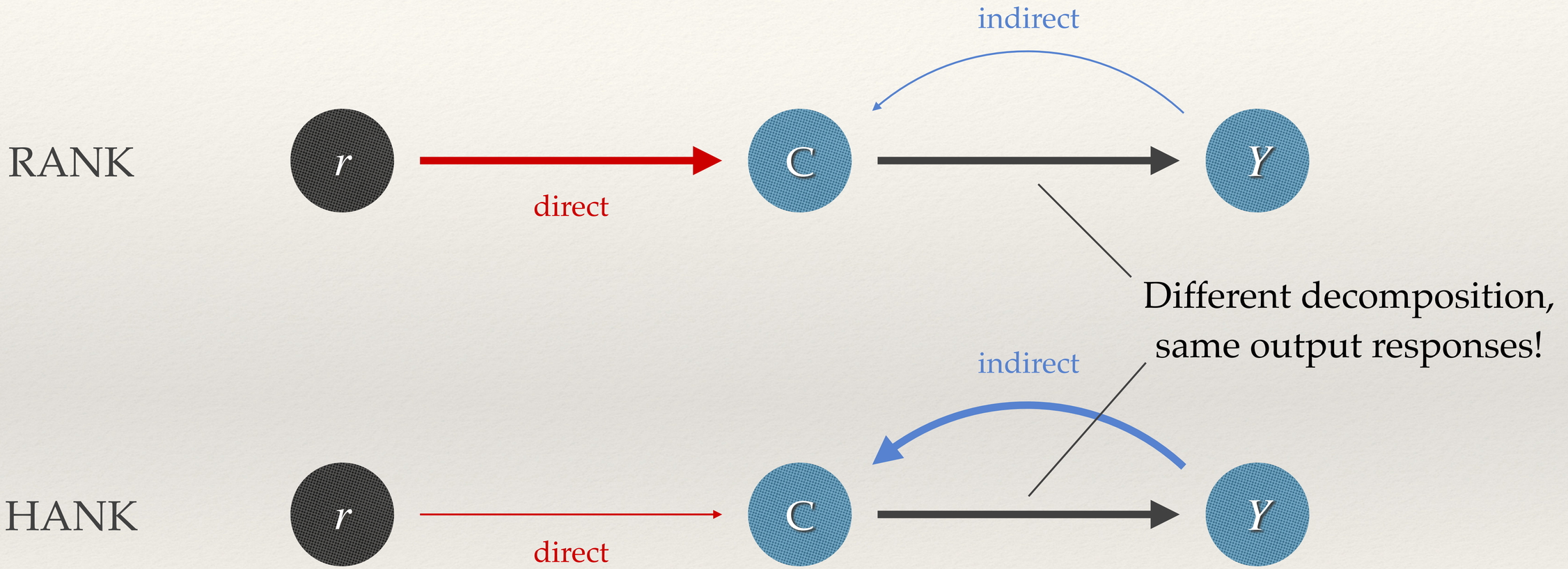
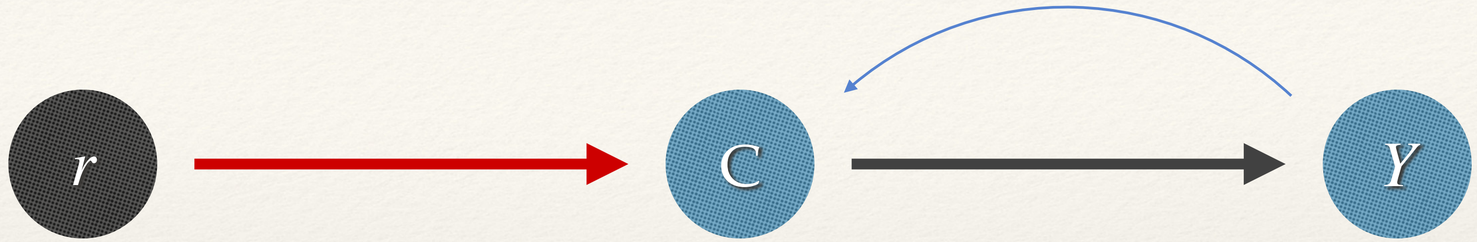
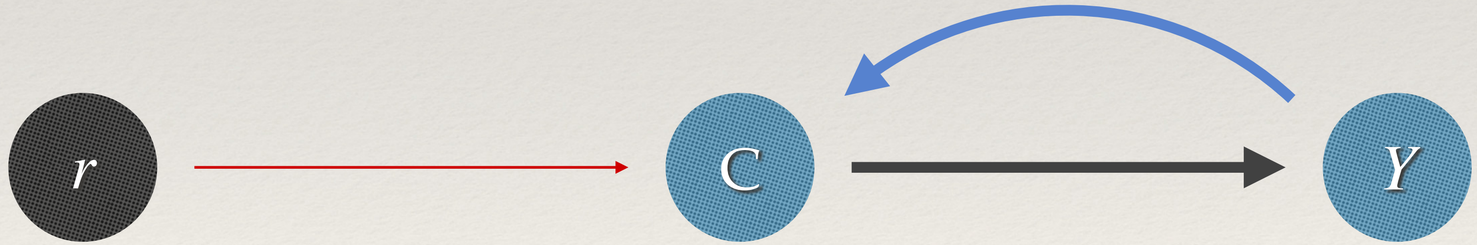


# What if there is investment?

RANK




HANK



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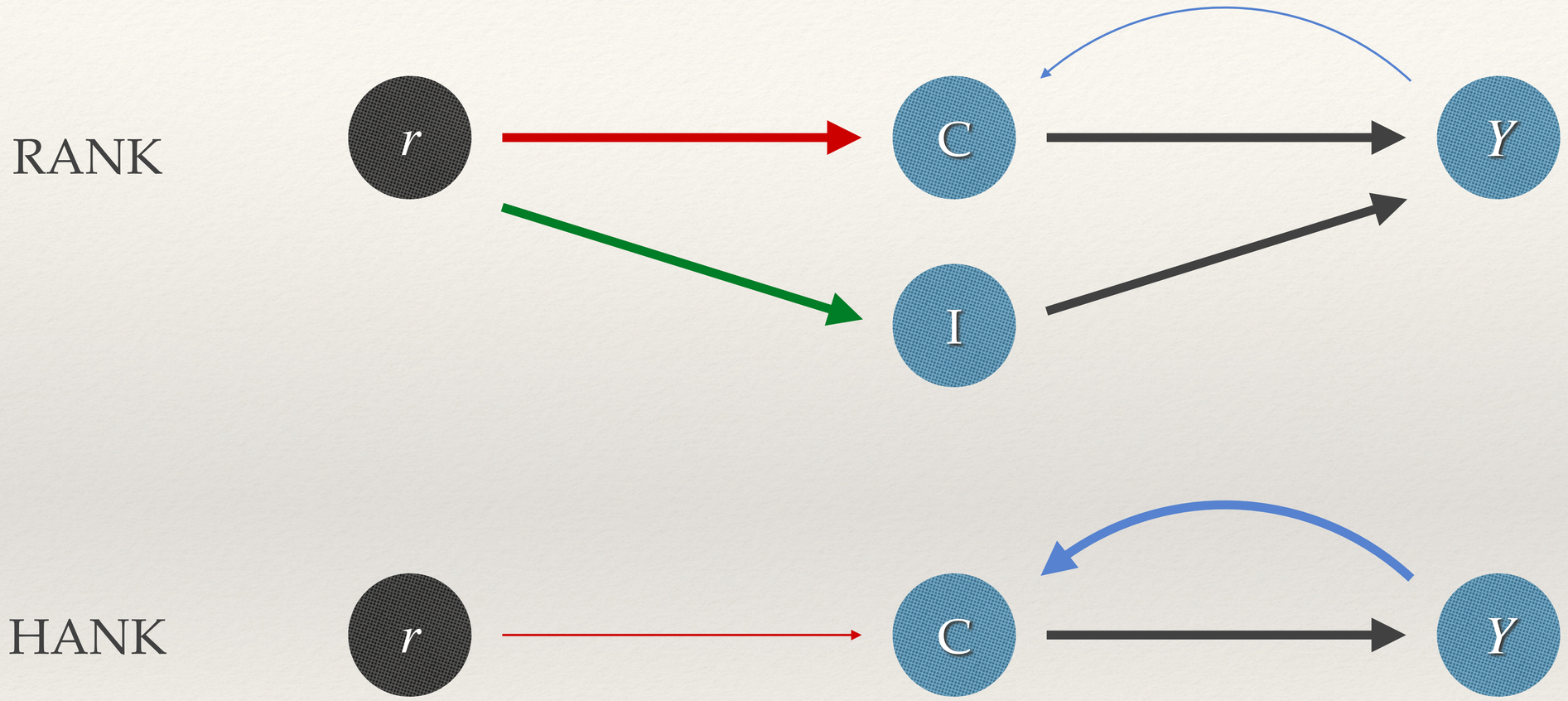

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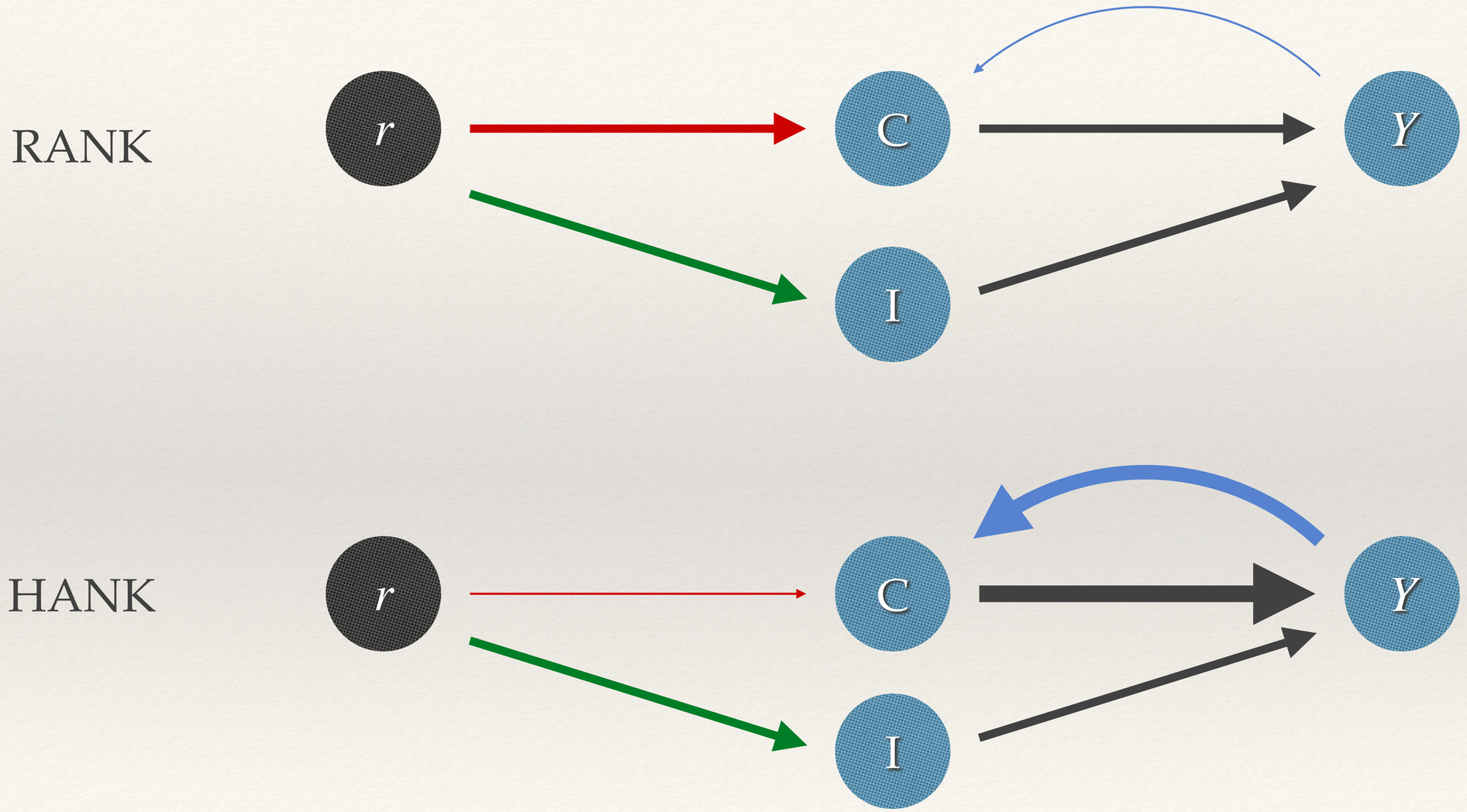

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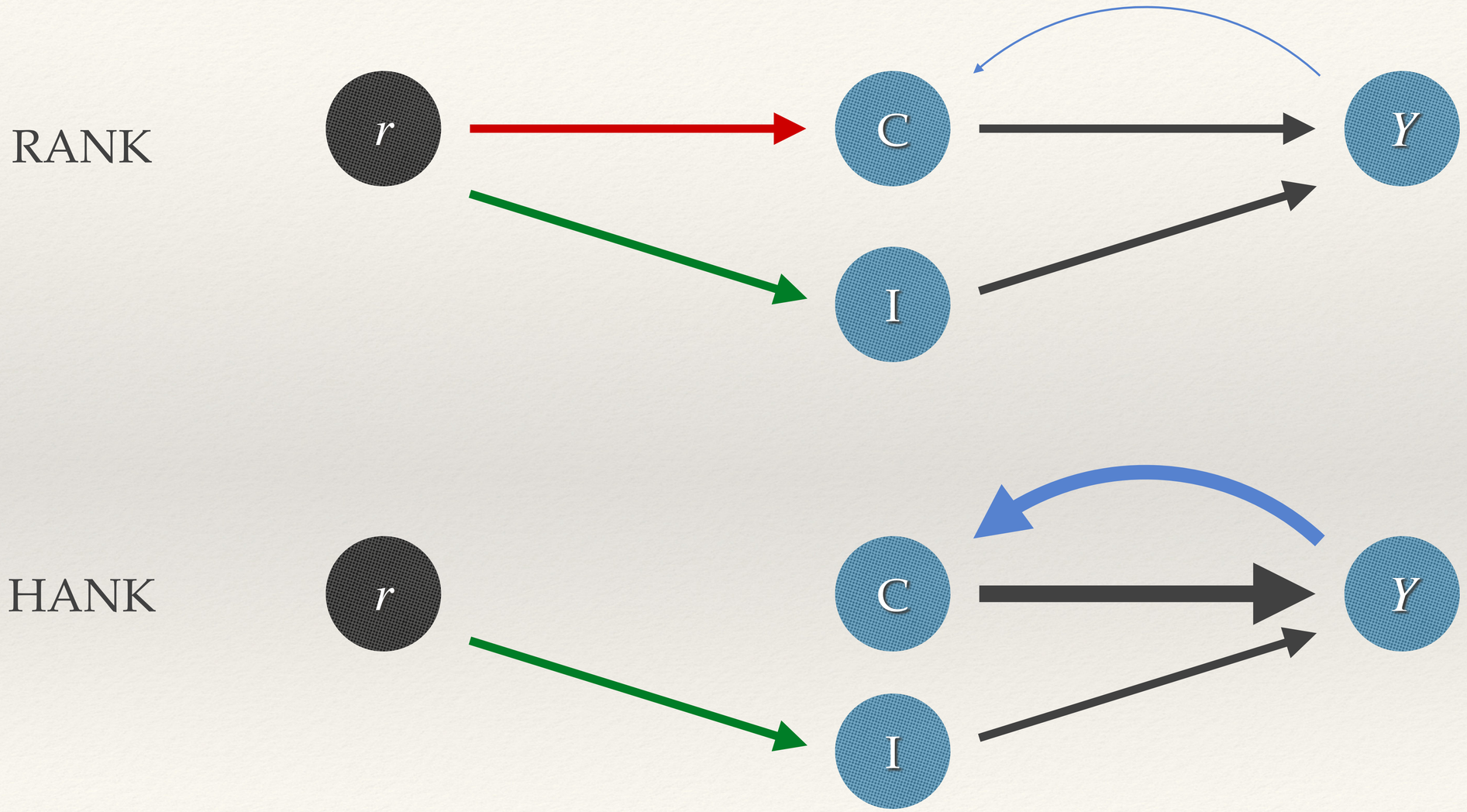

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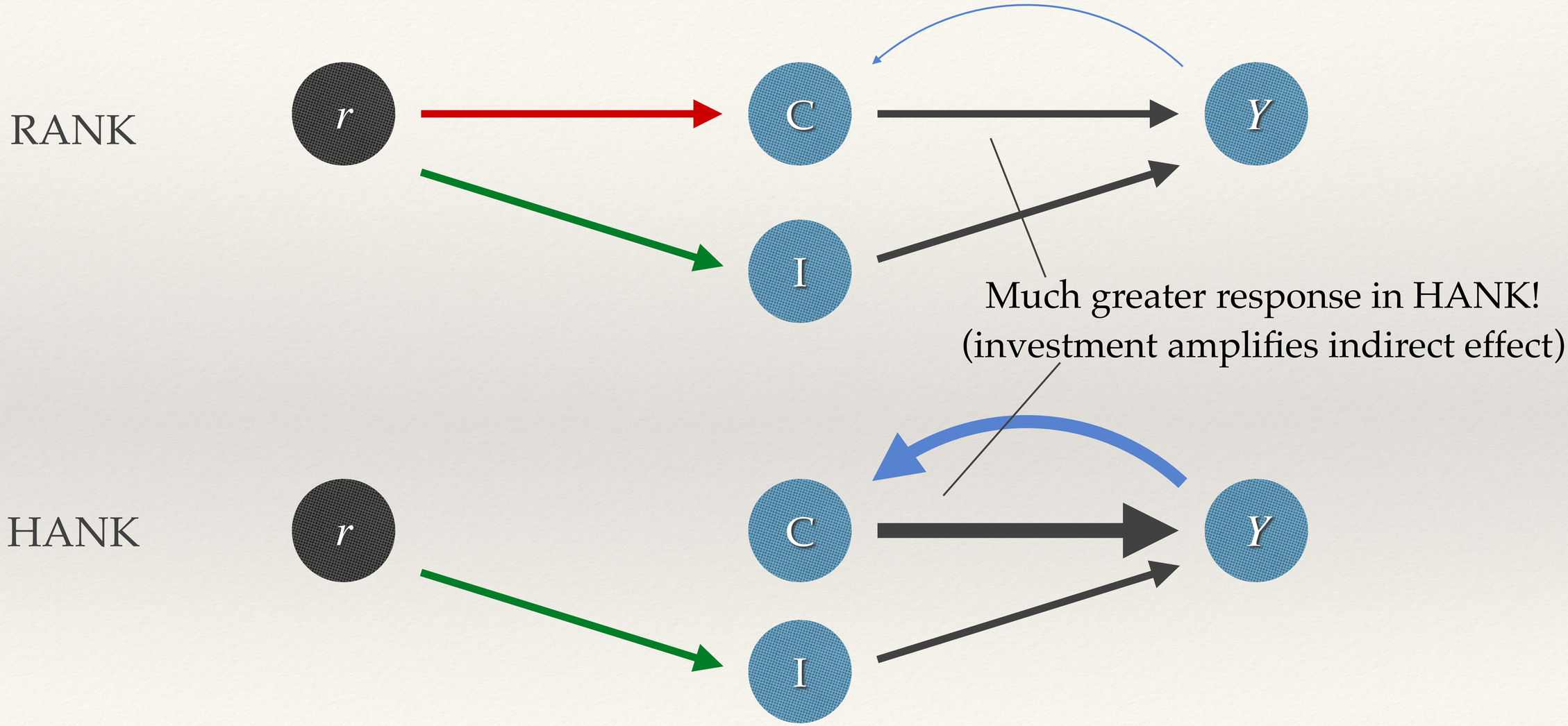
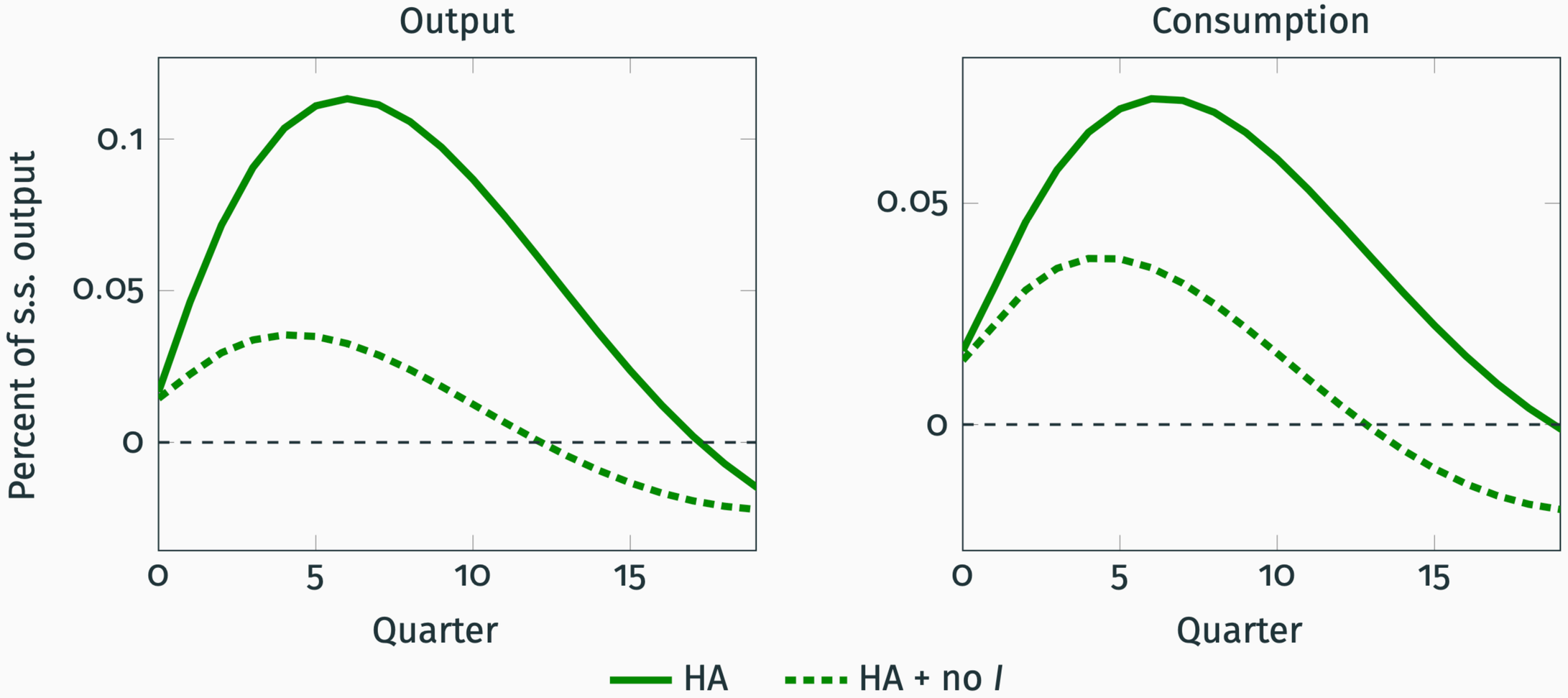


# Role of investment in monetary transmission




From Auclert Rognlie Straub "Micro Jumps and Macro Humps"

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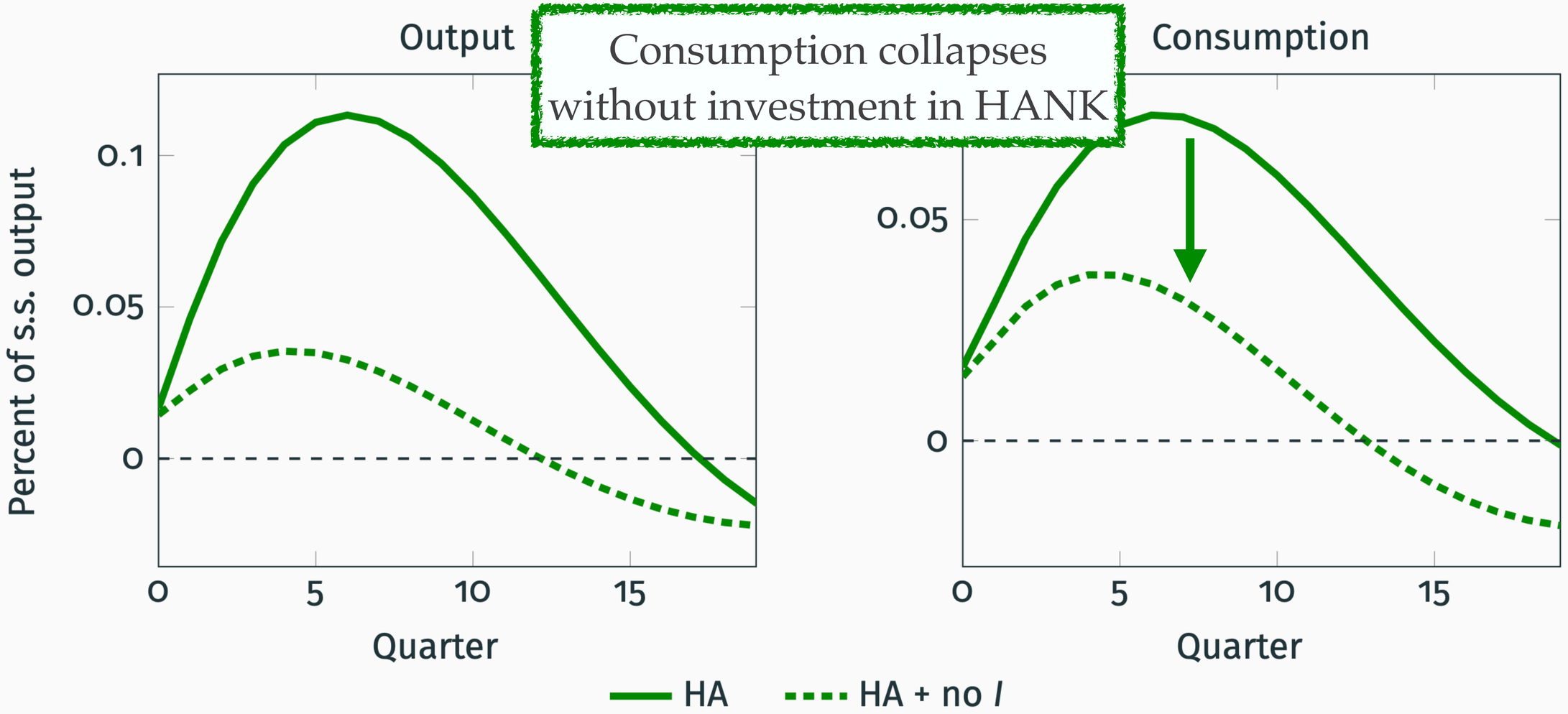


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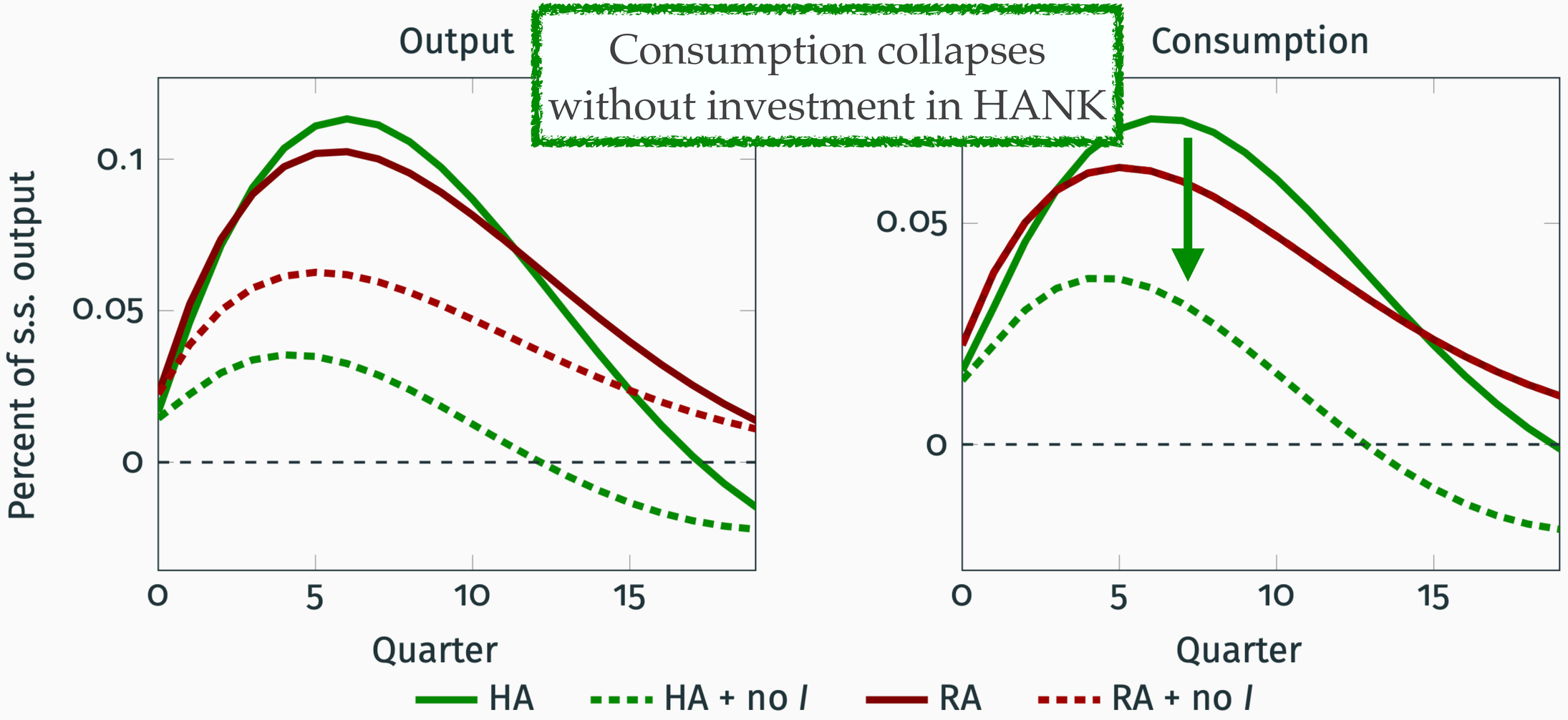


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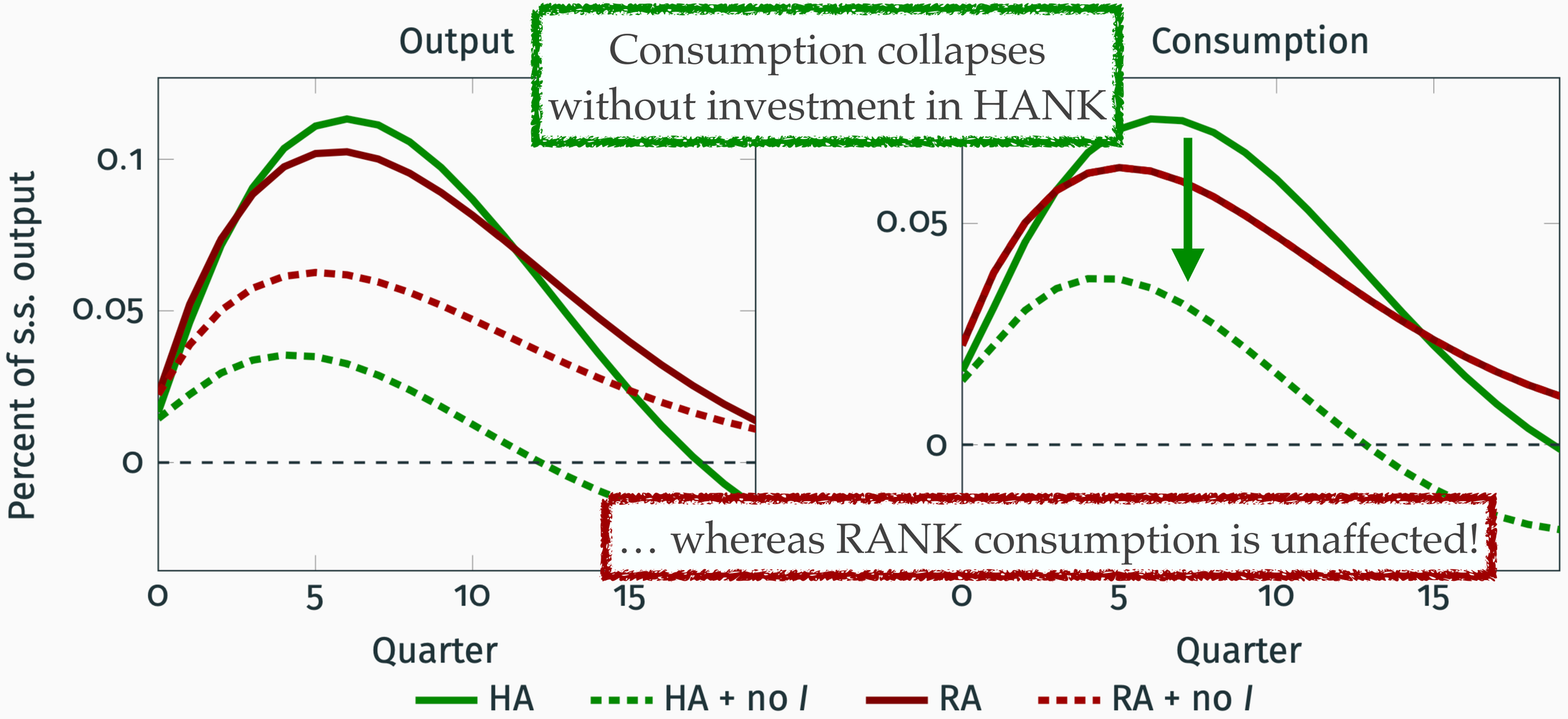


From Auclert Rognlie Straub "Micro Jumps and Macro Humps"

# Broader implications of investment in HANK

- Limited response to monetary policy tightening
  - if house prices & residential investment doesn't respond much!
- Investment stimulus (e.g. CHIPS, IRA) spills over into consumption!
  - Generates outsized positive effect on aggregate demand

# Global spillovers

# World economy

- Now consider a world economy with $N$ large economies
- Each home to heterogeneous households
  - average productivity differs but not nature of idiosyncratic risk
  - Same $\mathbf{M}$ in each country
- Armington trade network: fraction $a_{ij}$ of country $i$'s spending goes to country $j$
- Fiscal policy of country $i$: $G_{it}$, $T_{it}$ subject to $i$'s government budget constraint
- Monetary policy (today): "constant real rate" → Real exchange rate constant

# Fiscal shock in the U.S.

- Consider sequences of fiscal policy shocks $d\mathbf{G}_i, d\mathbf{T}_i$ for each $i$
- Output given by:

(related to Sunder-Plassmann et al 2024, Gourinchas et al 2022)

$$d\mathbf{Y}_j = d\mathbf{G}_j - \sum_{i=1}^{N} a_{ij}\mathbf{M}d\mathbf{T}_i + \sum_{i=1}^{N} a_{ij}\mathbf{M}d\mathbf{Y}_i$$

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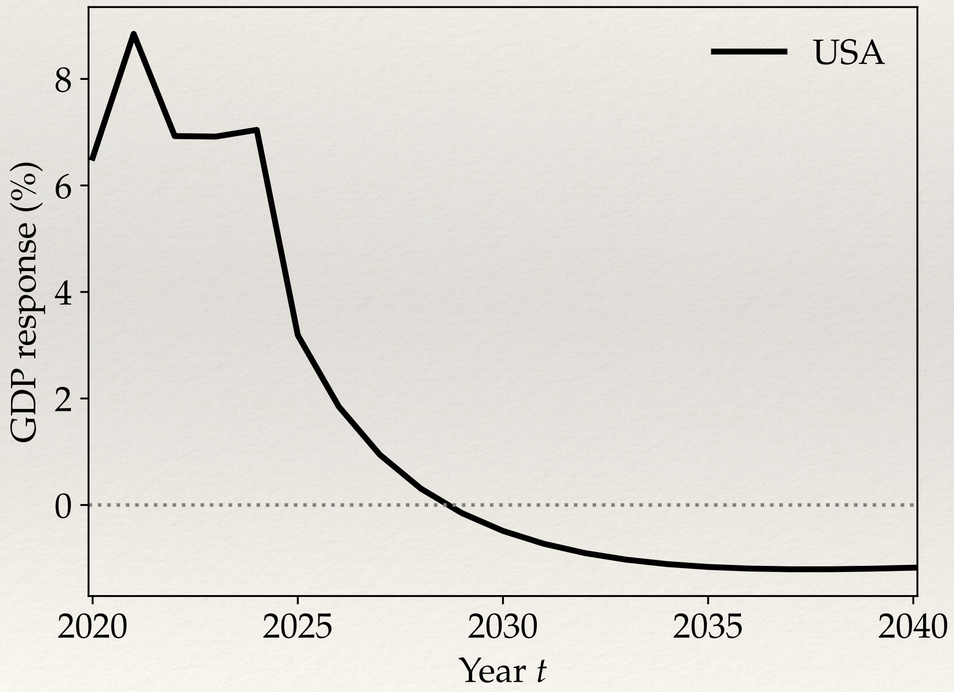
- Solution for 177 countries computationally highly non-trivial!
  - $\sim$ like inverting 54,000 x 54,000 matrix (3bn entries)
  - doable with Sequence-Space Jacobian 2.0 in 3 seconds

# Large output and inflation effects of U.S. stimulus

- Same fiscal shock to the U.S. as before

Output (% of trend GDP)




Standard hybrid NKPC with 50% weight on lagged inflation, $\kappa = 0.01$

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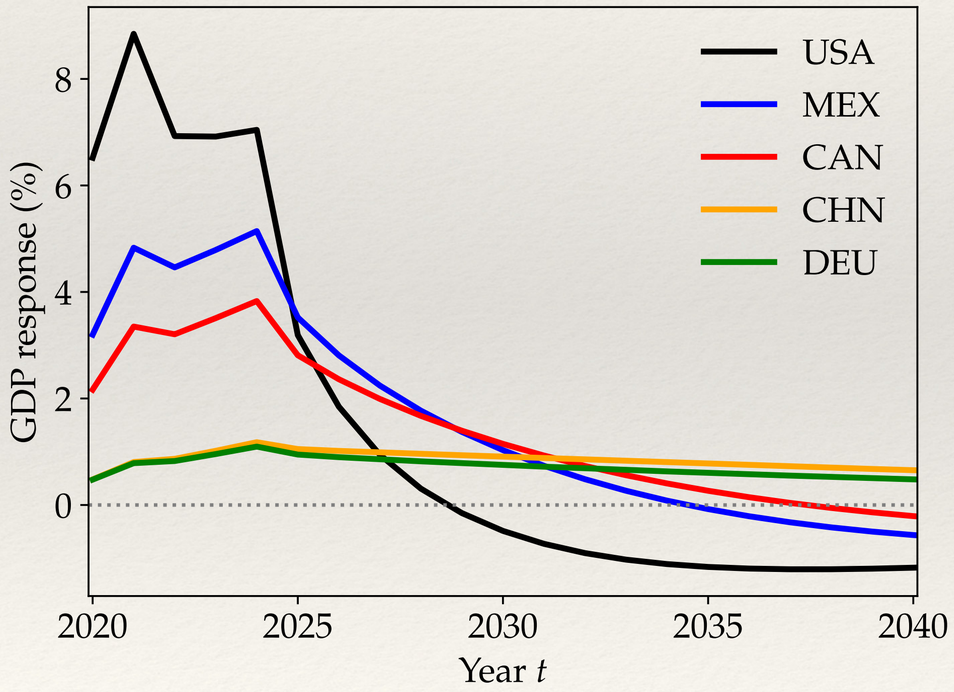


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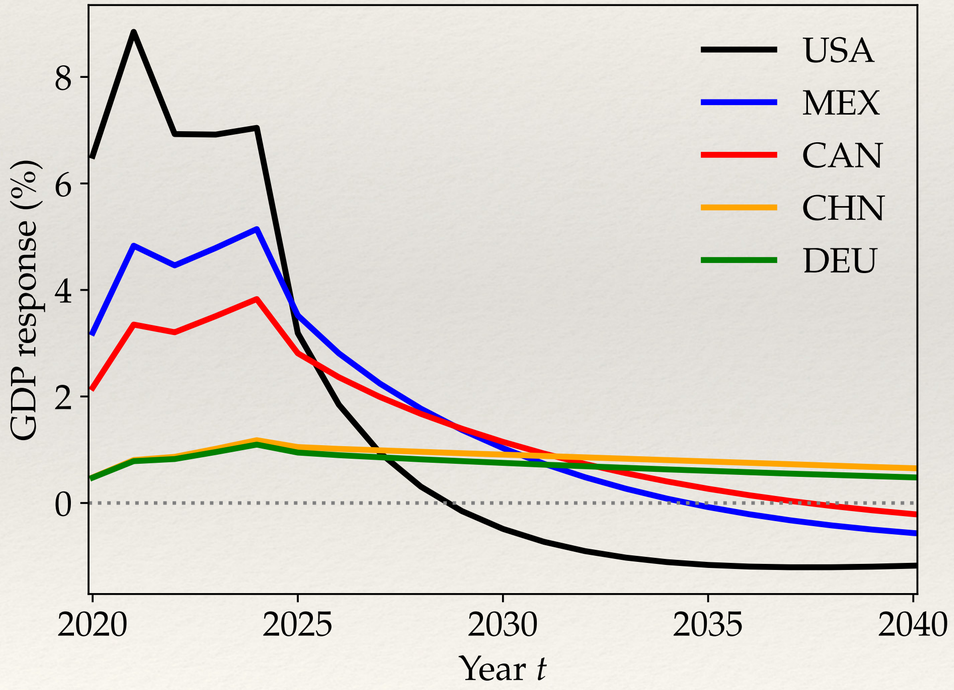
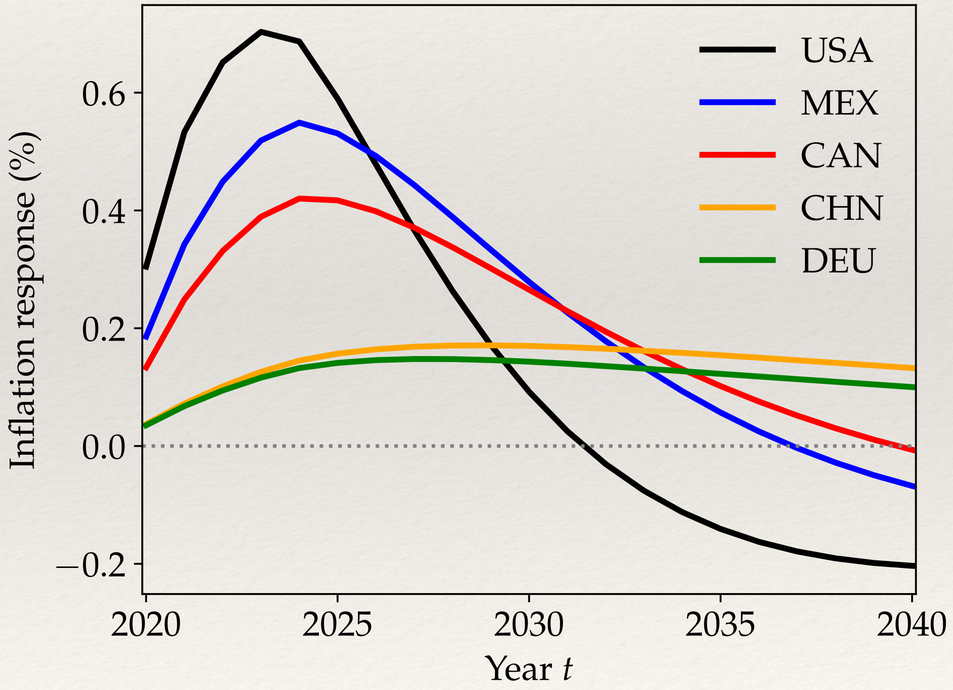



Domestic inflation (pp above target)

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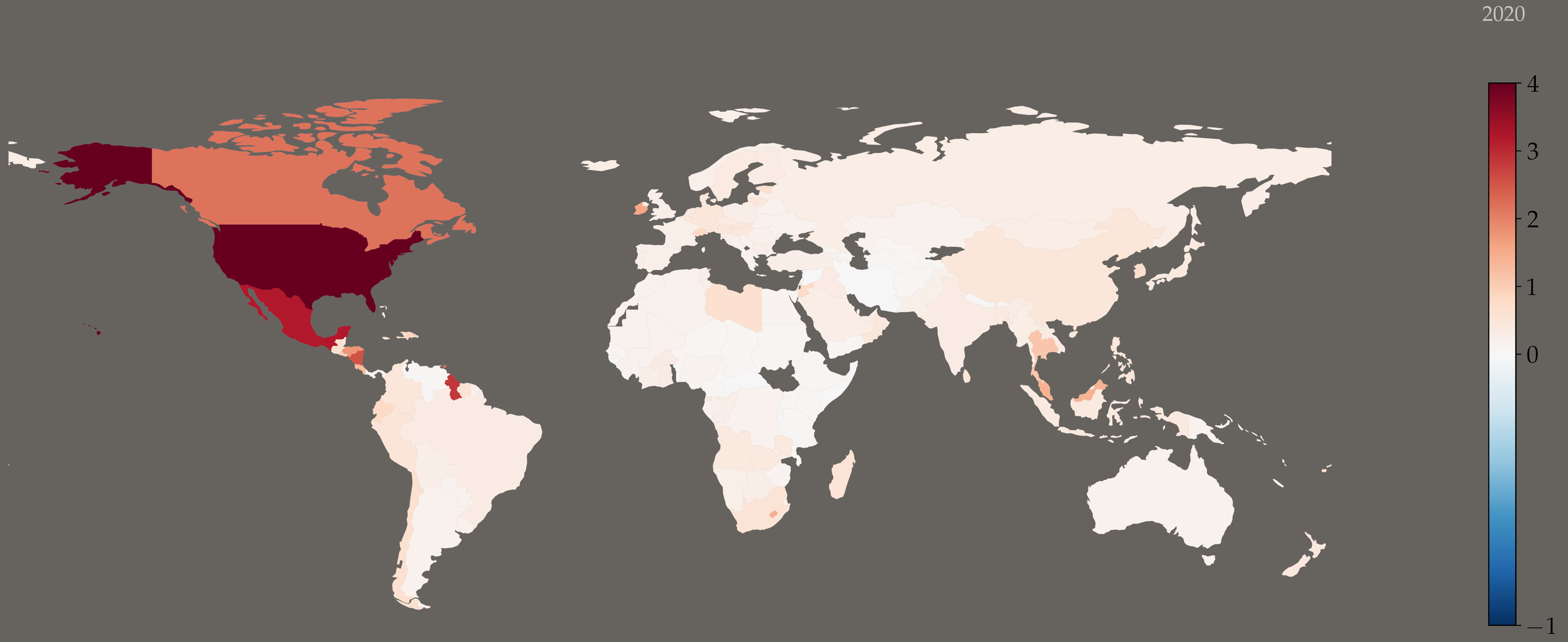
# Who is affected by U.S. stimulus?



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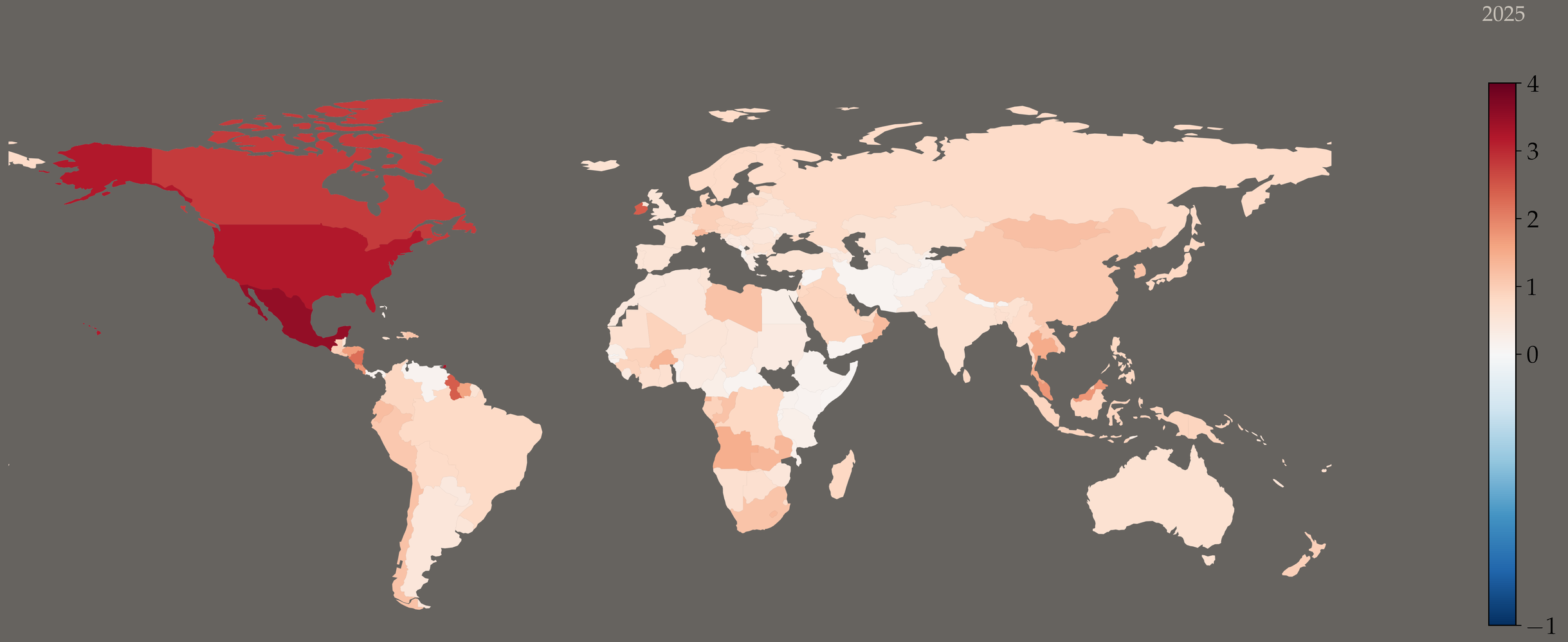

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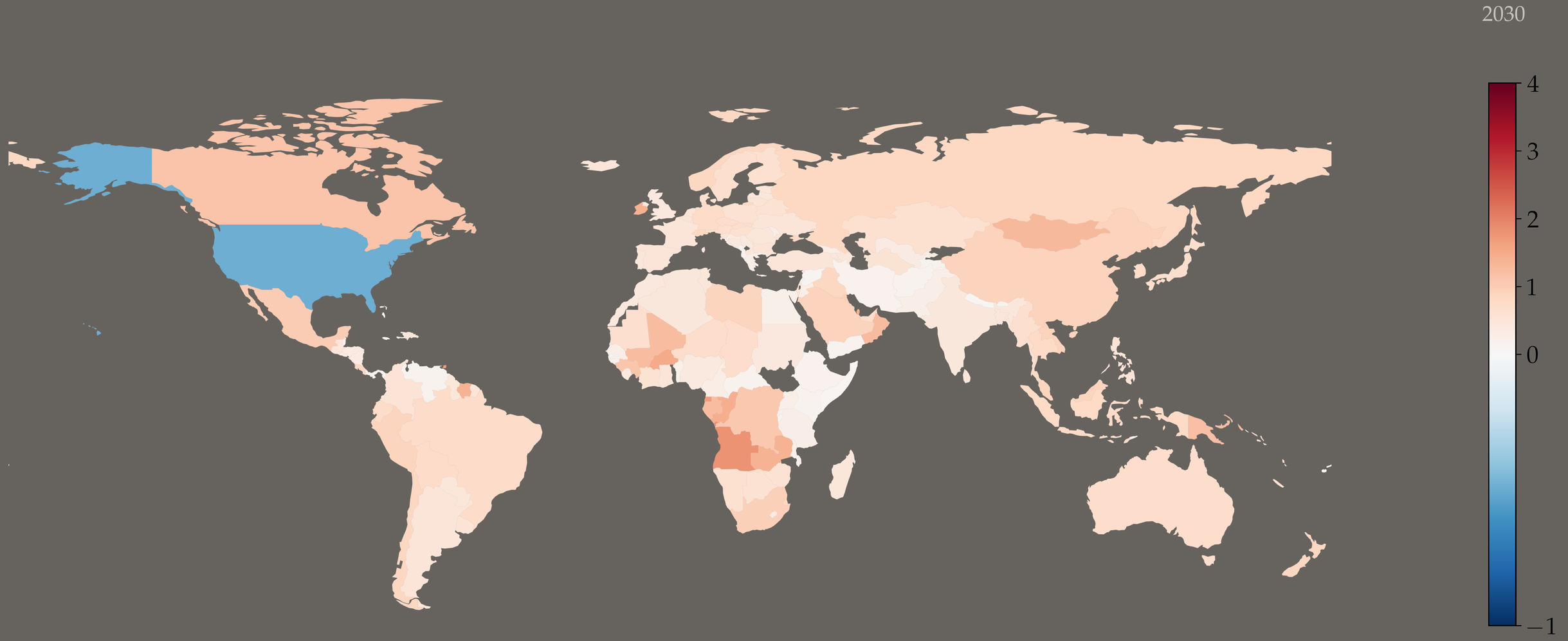
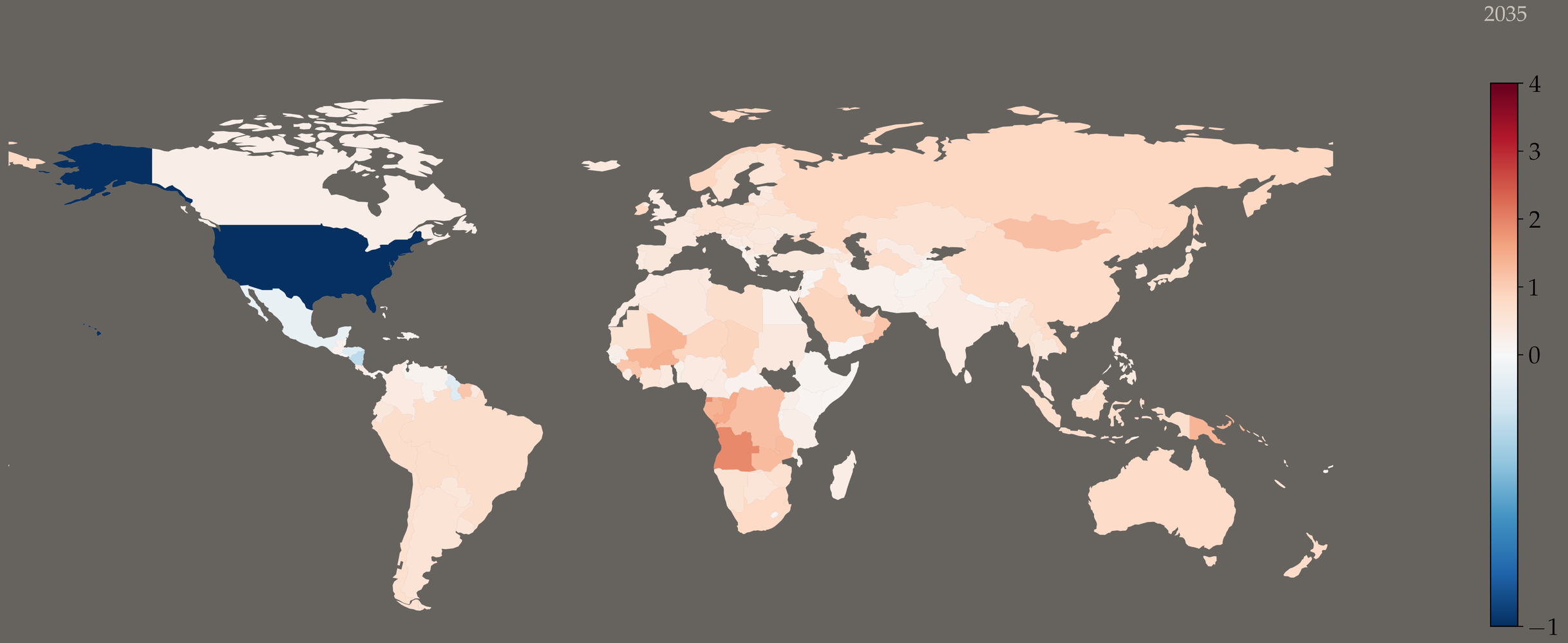


# Who is affected by U.S. stimulus?



# Conclusion

# Conclusion: Three takeaways

- **HANK** implies that consumption depends more on **income** than **interest rates**
- Natural to organize and analyze HANK models in the **sequence space**
- Three lessons:
  - deficit-financed fiscal stimulus is persistent
  - monetary policy only works if investment responds
  - global spillovers are large and slow to die out
- **Lots of work to do!**