Does Market Incompleteness Matter for Monetary Policy? Theory and Evidence

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Extended Abstract + Slides (at the end)

The aftermath of the Great Recession has brought inequality and heterogeneity across households into the forefront of macroeconomic research. Reseachers and policy makers have been motivated by the fact that virtually all policy changes differentially affect households. Whether based on income, wealth or employment status, most policies have non-trivial distributional consequences. But how important those distributional consequences are for aggregates remains an open question.

A growing literature has recently emerged to start to provide an answer to that question by incorporating price rigidities into heterogeneous agent incomplete markets models (HANK).[1] The HANK framework offers a new transmission mechanisms for monetary policy and allows

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[1] See Kaplan and Violante (2018) for a recent review of this emerging Heterogeneous Agents New Keynesian (HANK) literature. Early contributions which added nominal rigidities to a Bewley-Imrohoroglu-Huggett-Aiyagari model include Gornemann et al. (2012), Kaplan et al. (2018), Oh and Reis (2012) and Guerrieri and Lorenzoni (2017).

studying the two-way feedback between monetary and fiscal policy and income and wealth distributions. While parameterized versions of the HANK model *can* generate very different implications for the transmission of monetary policy from a complete markets model with sticky prices, it is unclear whether it *does* generate different implications and *how big* these differences are. In the seminal paper of Kaplan et al. (2018) incomplete and complete markets models deliver quite different effects of monetary policy, whereas Werning (2015) makes assumptions that ensure the equivalence of complete and incomplete markets. The discrepancies between those two papers (and many others) are driven by differences in model assumptions, which deliver differing conclusions. Those differences in assumptions can be hard to verify or quantify in the data.

The objective of this paper is to fill this gap and to quantify the role of market incompleteness in shaping the economy's response to monetary policy. Instead of trying to improve upon the direct measurement of specific model mechanisms, we develop a general methodology to quantify the differences between incomplete markets (IM) and complete markets (CM) models. This methodology relies directly on micro data and does not require knowledge of any specific modeling choices of the incomplete markets model beyond the fact that the household budget constraint has to hold.

Knowing all elements of the budget constraint allows us to calculate the changes to the budget due to a monetary policy shock if markets were complete. We then calculate household specific transfer sequences that replicate these changes, such that households can afford to adjust their consumption by the same amount that they would under complete markets. This ensures that the response of aggregate variables to a monetary policy shock coincide in the incomplete and complete markets if households receive these transfers. We can construct individual consumption responses from these individual transfer sequences using dynamic marginal propensities to consume (constructed from empirical and model evidence). Next, we aggregate the individual consumption responses to derive the aggregate implications. Combining these MPCs with transfers allows deriving the aggregate consumption difference which arises due to incomplete markets.

We then apply this methodology to US monetary policy using data from the Panel Survey of Income Dynamics (PSID). For each household we identify the components of its budget constraint in the data, which allows us to calculate the transfers identified by the theory. As prescribed by our methodology we combine the transfers with MPCs to derive the aggregate consumption responses. We find that monetary policy leads to an about 50% larger initial consumption response in the incomplete than in the complete markets model. The measured transfers show that the reason for this larger response is that a tigthtening of monetary policy distributes from high to low MPC households, implying a larger fall in aggregate consumption in comparison to a representative agent model —where distributional consequences of policy do not matter. It is important to point out that this result is just derived from measuring budget constraints in micro data without imposing further assumptions.

Berger et al. (2019) share our objective of measuring the implications of imperfect risk-sharing on aggregate dynamics but apply a different methodology. These authors build on and measure the wedges in a household consumption Euler equation which characterize the difference between complete and incomplete markets. In practice they group households along observable characteristics and focus on households with positive income shocks and low net worth. Our approach does not rely on the assumptions imposed in Berger et al. (2019) but instead we just use that a household has to satisfy its budget constraint and that we measure it properly.

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INTRODUCTION

- How important is heterogeneity and inequality in the amplification and propagation of aggregate shocks?
  - Renewed interest in this question since the Great Recession.
  - Research frontier in mon. econ: Heterogeneous Agent NK model.

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- Our objective: quantify the role of market incompleteness in shaping the response to monetary policy.
- How? Develop a general methodology to quantify the differences between incomplete markets (IM) and complete markets (CM) models.
- Apply methodology to monetary policy directly from micro data.

Theoretical Objective

- Understand the differences between CM and IM in the data.
- Therefore: Construct a transfer scheme $\Delta_{i,t}$ which renders the IM identical to CM (in terms of aggregates).
- Properties of $\Delta_{i,t}$ informative on how close IM and CM are.
- Can measure $\Delta_{i,t}$ in the data.
- Knife-edge case $\Delta_{i,t} \equiv 0$: $CM = IM$.
- Relate to Werning's paper below

Model

MODEL: HOUSEHOLDS

Continuum of ex-ante identical households with preferences:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \{u(c_t) - g(h_t)\}$$

where:

$$\begin{aligned} u(c) &= \log(c) \\ g(h) &= \psi \frac{h^{1+1/\varphi}}{1+1/\varphi} \end{aligned}$$

and $\beta \in (0,1)$ is the discount factor.

- Households' labor productivity $\{s_t\}_{t=0}^{\infty}$ is stochastic
- $s_t \in \mathscr{S} = \{s^1, \cdots, s^N\}$ with transition probability characterized by $p(s_{t+1}|s_t)$

Model: Recruiting Firms

A representative, competitive recruting firm aggregates a continuum of differentiated households labor services indexed by $j \in [0,1]$ and nominal wages per efficiency unit W_{jt}:

$$H_t = \left(\int_0^1 s_{jt} (h_{jt})^{\frac{\varepsilon_w - 1}{\varepsilon_w}} dj \right)^{\frac{\varepsilon_w}{\varepsilon_w - 1}}.$$

Given a level of aggregate labor demand H, demand for the labor services of household j is given by:

$$h_{jt} = h(W_{jt}; W_t, H_t) = \left(\frac{W_{jt}}{W_t} \right)^{-\varepsilon_w} H_t.$$

where W_t is the (equilibrium) nominal wage,

$$W_t = \left(\int_0^1 s_{jt} W_{jt}^{1-\varepsilon_w} dj \right)^{\frac{1}{1-\varepsilon_w}}.$$

Model: Wage Setting

- A union sets a nominal wage $W_{jt} = \hat{W}_t$ for an effective unit of labor to maximize profits.
- Quadratic wage adjustment as in Rotemberg (1982):

$$s_{jt}\frac{\theta_w}{2}\left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - 1\right)^2 H_t.$$

- Union's wage setting problem is to maximize

$$\begin{aligned}
& V_t^w\left(\hat{W}_{t-1}\right) \\
\equiv \quad & \max_{\hat{W}_t} \int \left(\frac{s_{jt}(1-\tau_t)\hat{W}_t}{P_t} h(\hat{W}_t; W_t, H_t) - \frac{g(h(\hat{W}_t; W_t, H_t))}{u'(C_t)}\right) dj \\
- \quad & \int s_{jt}\frac{\theta_w}{2}\left(\frac{\hat{W}_t}{\hat{W}_{t-1}} - 1\right)^2 H_t dj + \frac{1}{1+r_t} V_{t+1}^w\left(\hat{W}_t\right)
\end{aligned}$$

- Symmetry: $h_{jt} = H_t$ and $\hat{W}_t = W_t$. Real wage $w_t = \frac{W_t}{P_t}$.
  $C_t =$ aggregate consumption.

Model: Worker Households

Can write their problem recursively:

$$V(a,s;\Omega) = \max_{c\geq 0, h\geq 0, a'\geq 0} u(c,h) + \beta \sum_{s\in\mathscr{S}} p(s'|s)V(a',s';\Omega')$$

subject to

$$Pc + a' = (1+i)a + P(1-\tau)whs + \lambda\Gamma + \lambda^{MF} D^{DF}$$
$$\Omega' = \Upsilon(\Omega)$$

- $\Omega(a,s) \in \mathscr{M}$ is the distribution on the space $X = A \times S$.
- Υ equilibrium object determines evolution of Ω.

Model: Final Goods Production

A final good producer aggregates a continuum of intermediate goods indexed by $j \in [0,1]$ and with prices p_j:

$$Y_t = \left(\int_0^1 y_{jt}^{\frac{\varepsilon-1}{\varepsilon}} dj \right)^{\frac{\varepsilon}{\varepsilon-1}}.$$

Given a level of aggregate demand Y, cost minimization for the final goods producer implies that the demand for the intermediate good j is given by

$$y_{jt} = y(P_{jt}; P_t, Y_t) = \left(\frac{P_{jt}}{P_t} \right)^{-\varepsilon} Y_t,$$

where P_t is the (equilibrium) price of the final good and can be expressed as

$$P_t = \left(\int_0^1 P_{jt}^{1-\varepsilon} dj \right)^{\frac{1}{1-\varepsilon}}.$$

Model: Intermediate Goods Production

- Production technology takes capital and labor:

$$Y_{jt} = \begin{cases} Z_t K_{jt}^{\alpha} H_{jt}^{1-\alpha} - Z_t F & \text{if} \geq 0 \\ 0 & \text{otherwise} \end{cases},$$

  where Z_t is aggregate productivity and Φ is fixed cost of production.

- Marginal costs given by

$$mc_t = \left(\frac{1}{\alpha}\right)^{\alpha} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \frac{(r_t^k)^{\alpha}(w_t)^{1-\alpha}}{Z_t}$$

- Price adjustment costs a la Rotemberg (1982):

$$\frac{\theta}{2}\left(\frac{P_{jt}}{P_{jt-1}} - 1\right)^2 Y_t.$$

Model: Mutual Fund

- Collects HH savings A_{t+1}/P_{t+1}, pays real return r^a_t, invests in bonds B_{t+1} and capital K_{t+1}.
- Capital subject to adjustment costs $\Phi(K_{t+1}, K_t)$
- In equilibrium:

$$
\begin{aligned}
r_{t+1} &= r^a_{t+1} \\
1 + r^k_{t+1} - \delta &= (1 + r^a_{t+1})(1 + \Phi_1(K_{t+1}, K_t)) + \Phi_2(K_{t+2}, K_{t+1}) \\
A_{t+1}/P_{t+1} &= K_{t+1} + B_{t+1}/P_{t+1} + \Phi(K_{t+1}, K_t).
\end{aligned}
$$

- The total profits of the fund are

$$D^{MF}_{t+1} = (1 + r^k_{t+1} - \delta)K_{t+1} + (1 + r_{t+1})B_{t+1}/P_{t+1} - (1 + r^a_{t+1})(A_{t+1}/P_{t+1}),$$

- Households receive:

$$(1 + r^a_{t+1}) = 1 + r^i_{t+1}.$$

- Dividends distributed according to λ^{MF}_{it}

Model: Government

Government taxes labor income and provides nominal transfers:

$$\tilde{T}(wsh) = -\Gamma + \tau Pwsh.$$

- Government fully taxes firm profits $P_t d_t$
- Government issues nominal bonds B^g
- Exogenous unvalued expenditures G_t
- Government budget constraint given by:

$$B^g_{t+1} = (1+i_t)B^g_t + G_t - P_t d_t - \int \tilde{T}_t(w_t s_t h_t) d\Omega.$$

EQUILIBRIUM

Definition: A monetary competitive equilibrium is a sequence of prices P_t, tax rates τ_t, nominal transfers T_t, nominal government spending G_t, bonds B_t^g, a value functions v_t, policy functions a_t and c_t, h_t, H_t, pricing functions r_t and w_t, and law of motion Υ, such that:

1. v_t satisfies the Bellman equation with corresponding policy functions a_t, c_t, h_T given price sequences r_t, w_t.
2. Prices are set optimally by firms.
3. Wages are set optimally by middlemen.
4. For all $\Omega \in \mathscr{M}$: Markets clear
5. Aggregate law of motion Υ generated by a' and p.

Focus on steady state equilibria where all real variables are constant, and constant rate of inflation.

Monetary Policy in Complete Markets

The complete markets economy arises as a special case when there is no idiosyncratic risk:

$$
\begin{aligned}
Y_t^{CM} = Z_t (K_t^{CM})^{\alpha} (H_t^{CM})^{1-\alpha} &= C_t^{CM} + g_t + Z_t F + K_{t+1}^{CM} - (1-\delta) K_t^{CM} + \Phi(K_{t+1}^{CM}, K_t^{CM}) \\
u_c(C_t^{CM}) = (C_t^{CM})^{-\sigma} &= \beta \frac{1 + i_{t+1}}{1 + \pi_{t+1}^{CM,a}} u_c(C_{t+1}^{CM}) = \beta (1 + r_{t+1}^{CM,a})(C_{t+1}^{CM})^{-\sigma} \\
(1-\varepsilon) + \varepsilon mc_t^{CM} &= \theta \left(\pi_t^{CM} - \overline{\Pi} \right) \pi_t^{CM} - \frac{1}{1 + r_t^{CM}} \theta \left(\pi_{t+1}^{CM} - \overline{\Pi} \right) \pi_{t+1} \frac{Y_{t+1}^{CM}}{Y_t^{CM}} \\
mc_t^{CM} &= \left(\frac{1}{\alpha} \right)^{\alpha} \left(\frac{1}{1-\alpha} \right)^{1-\alpha} \frac{(r_t^{CM,k})^{\alpha} (w_t^{CM})^{1-\alpha}}{Z_t} \\
\frac{K_t^{CM}}{H_t^{CM}} &= \frac{\alpha w_t^{CM}}{(1-\alpha) r_t^{CM,k}} \\
\vdots \qquad & \qquad \vdots
\end{aligned}
$$

MEASUREMENT: DIFFERENCES IM $\leftrightarrow$ CM

- Complete Markets:
  - Steady state in CM: $C_{ss}^{CM}, K_{ss}^{CM}, H_{ss}^{CM}, Y_{ss}^{CM}, w_{ss}^{CM}$.
  - Monetary Policy shock: $i_0 = i^*, i_1, i_2, \dots, i_t, \dots i^*$
  - Consumption/Capital/Hours/Output/Wages Responses:

$$\begin{aligned}
\text{Consumption, Capital:} \qquad & \gamma_t^C = \frac{C_t^{CM}}{C_{ss}^{CM}}, \quad \gamma_t^K = \frac{K_t^{CM}}{K_{ss}^{CM}} \\
\text{Hours, Output:} \qquad & \gamma_t^H = \frac{H_t^{CM}}{H_{ss}^{CM}}, \quad \gamma_t^Y = \frac{Y_t^{CM}}{Y_{ss}^{CM}} \\
\text{Wages:} \qquad & \gamma_t^w = \frac{w_t^{CM}}{w_{ss}^{CM}},
\end{aligned}$$

- Incomplete Markets:
  - Distributional Impact of MP $\rightarrow$ Different Responses
  - Compute transfers $\Delta_{i,t}$ to undo $\rightarrow$ Same aggregate response

IM Transfers

Household dynamic program in response to MP shock:

$$V_t(a_{i,t}, s_{i,t}) = \max_{c_{i,t}^{IM}, a_{i,t+1}^{IM} \geq 0} u(c_{i,t}^{IM}, h_{i,t}) + \beta \mathbb{E}_{s_{t+1}} V_{t+1}(a_{i,t+1}, s_{i,t+1})$$

$$\text{subj. to} \quad c_{i,t}^{IM} + a_{i,t+1}^{IM} = \frac{(1+i_t^{IM})}{(1+\pi_t^{IM})} a_{i,t} + (1-\tau) w_t^{IM} h_{i,t}^{IM} s_{i,t} + \lambda_{it} \Gamma_t^{IM} + \lambda_{it}^{MF} D_t^{IM,MF} + \Delta_{i,t}$$

Note: $\Delta_{i,t} = \Delta(a_{i,0}; s_{i,0}, \ldots, s_{i,t})$ does not depend on any choices.

Construct $\Delta_{i,t}$ such that

$$\begin{aligned}
c_{i,t}^{IM} &= \frac{C_t^{CM}}{C_{ss}^{CM}} c_{i,t}^{IM,ss} \\
h_{i,t}^{IM} &= \frac{H_t^{CM}}{H_{ss}^{CM}} h_{i,t}^{IM,ss} \\
\frac{a_{i,t+1}^{IM}}{P_t^{IM}} &= \frac{A_{t+1}^{CM}}{A_{ss}^{CM}} \frac{a_{i,t+1}^{IM,ss}}{P_t^{IM,ss}}
\end{aligned}$$

IM Transfers

Use Werning idea:

Assume $a \equiv 0$. Equally proportional income changes, $\forall i, j$:

$$
\begin{aligned}
& \frac{w_t^{IM} h_{i,t}^{IM} s_{i,t} + \lambda_{it} \Gamma_t^{IM} + \lambda_{it}^{MF} D_t^{IM,MF}}{w_{ss}^{IM} h_{i,ss}^{IM} s_{i,t} + \lambda_{it} \Gamma_{ss}^{IM} + \lambda_{it}^{MF} D_{ss}^{IM,MF}} \\
= \quad & \frac{w_t^{IM} h_{j,t}^{IM} s_{j,t} + \lambda_{jt} \Gamma_t^{IM} + \lambda_{jt}^{MF} D_t^{IM,MF}}{w_{ss}^{IM} h_{j,ss}^{IM} s_{j,t} + \lambda_{jt} \Gamma_{ss}^{IM} + \lambda_{jt}^{MF} D_{ss}^{IM,MF}}
\end{aligned}
$$

IM Transfers

Use Werning idea:

Assume $a \equiv 0$. Equally proportional income changes, $\forall i, j$:

$$\frac{w_t^{IM} h_{i,t}^{IM} s_{i,t} + \lambda_{it}\Gamma_t^{IM} + \lambda_{it}^{MF} D_t^{IM,MF} + \Delta_{it}}{w_{ss}^{IM} h_{i,ss}^{IM} s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF} D_{ss}^{IM,MF}} = \frac{w_t^{IM} h_{j,t}^{IM} s_{j,t} + \lambda_{jt}\Gamma_t^{IM} + \lambda_{jt}^{MF} D_t^{IM,MF} + \Delta_{jt}}{w_{ss}^{IM} h_{j,ss}^{IM} s_{j,t} + \lambda_{jt}\Gamma_{ss}^{IM} + \lambda_{jt}^{MF} D_{ss}^{IM,MF}}$$

Typically assumption does not hold. We construct Δ_{it}, Δ_{jt}.

Preserves heterogeneity: Δ_{it} not related to Arrow securities.

IM TRANSFERS

Use Werning idea:

Assume $a \equiv 0$. Equally proportional income changes, $\forall i, j$:

$$\frac{w_t^{IM} h_{i,t}^{IM} s_{i,t} + \lambda_{it} \Gamma_t^{IM} + \lambda_{it}^{MF} D_t^{IM,MF} + \Delta_{it}}{w_{ss}^{IM} h_{i,ss}^{IM} s_{i,t} + \lambda_{it} \Gamma_{ss}^{IM} + \lambda_{it}^{MF} D_{ss}^{IM,MF}}$$

$$= \quad \frac{w_t^{IM} h_{j,t}^{IM} s_{j,t} + \lambda_{jt} \Gamma_t^{IM} + \lambda_{jt}^{MF} D_t^{IM,MF} + \Delta_{jt}}{w_{ss}^{IM} h_{j,ss}^{IM} s_{j,t} + \lambda_{jt} \Gamma_{ss}^{IM} + \lambda_{jt}^{MF} D_{ss}^{IM,MF}}$$

Typically assumption does not hold. We construct Δ_{it}, Δ_{jt}.

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Extend to models with capital accumulation and $a \neq 0$.

Construct transfers

- 1. Take away income change

$$\Delta_{i,t} = (w_{ss}^{IM}(1-\tau)h_{i,t}^{IM,ss}s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF}D_{ss}^{IM,MF})$$
$$-(w_{t}^{IM}(1-\tau)h_{i,t}^{IM}s_{i,t} + \lambda_{it}\Gamma_{t}^{IM} + \lambda_{it}^{MF}D_{t}^{IM,MF})$$

CONSTRUCT TRANSFERS

- 1. Take away income change

$$\begin{aligned}\Delta_{i,t} = &(w_{ss}^{IM}(1-\tau)h_{i,t}^{IM,ss}s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF}D_{ss}^{IM,MF}) \\ &-(w_t^{IM}(1-\tau)h_{i,t}^{IM}s_{i,t} + \lambda_{it}\Gamma_t^{IM} + \lambda_{it}^{MF}D_t^{IM,MF})\end{aligned}$$

- 2. Add resources for consumption

$$\Delta_{i,t} + c_{i,t}^{IM} - c_{i,t}^{IM,ss}$$

Construct transfers

- 1. Take away income change

$$\Delta_{i,t} = (w_{ss}^{IM}(1-\tau)h_{i,t}^{IM,ss}s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF}D_{ss}^{IM,MF})$$
$$-(w_{t}^{IM}(1-\tau)h_{i,t}^{IM}s_{i,t} + \lambda_{it}\Gamma_{t}^{IM} + \lambda_{it}^{MF}D_{t}^{IM,MF})$$

- 2. Add resources for consumption

$$\Delta_{i,t} + c_{i,t}^{IM} - c_{i,t}^{IM,ss} \qquad = 0 \text{ in Werning}$$

Construct transfers

- 1. Take away income change

$$\Delta_{i,t} = (w_{ss}^{IM}(1-\tau)h_{i,t}^{IM,ss}s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF}D_{ss}^{IM,MF}) \\ -(w_t^{IM}(1-\tau)h_{i,t}^{IM}s_{i,t} + \lambda_{it}\Gamma_t^{IM} + \lambda_{it}^{MF}D_t^{IM,MF})$$

- 2. Add resources for consumption

$$\Delta_{i,t} + c_{i,t}^{IM} - c_{i,t}^{IM,ss}$$

- 3. Take away asset income changes

$$\Delta_{i,t} + \frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}}[(1+(1-\tau_k)i_{ss}^{a,IM})\frac{P_{t-1}^{IM,ss}}{P_t^{IM,ss}} - (1+(1-\tau_k)i_t^{a,IM})\frac{P_{t-1}^{IM}}{P_t^{IM}}]$$

Construct transfers

- 1. Take away income change

$$\Delta_{i,t} = (w_{ss}^{IM}(1-\tau)h_{i,t}^{IM,ss}s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF}D_{ss}^{IM,MF}) \\ -(w_{t}^{IM}(1-\tau)h_{i,t}^{IM}s_{i,t} + \lambda_{it}\Gamma_{t}^{IM} + \lambda_{it}^{MF}D_{t}^{IM,MF})$$

- 2. Add resources for consumption

$$\Delta_{i,t} + c_{i,t}^{IM} - c_{i,t}^{IM,ss}$$

- 3. Take away asset income changes

$$\Delta_{i,t} + \frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}}[(1+(1-\tau_k)i_{ss}^{a,IM})\frac{P_{t-1}^{IM,ss}}{P_{t}^{IM,ss}} - (1+(1-\tau_k)i_{t}^{a,IM})\frac{P_{t-1}^{IM}}{P_{t}^{IM}}]$$

- 4. Take away income due to higher assets

$$\Delta_{i,t} + (\frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}} - \frac{a_{i,t}^{IM}}{P_{t-1}^{IM}})\frac{P_{t-1}^{IM}}{P_{t}^{IM}}(1+(1-\tau_k)i_{t}^{a,IM})$$

CONSTRUCT TRANSFERS

- 1. Take away income change

$$\Delta_{i,t} = (w_{ss}^{IM}(1-\tau)h_{i,t}^{IM,ss}s_{i,t} + \lambda_{it}\Gamma_{ss}^{IM} + \lambda_{it}^{MF}D_{ss}^{IM,MF}) \\ -(w_t^{IM}(1-\tau)h_{i,t}^{IM}s_{i,t} + \lambda_{it}\Gamma_t^{IM} + \lambda_{it}^{MF}D_t^{IM,MF})$$

- 2. Add resources for consumption

$$\Delta_{i,t} + c_{i,t}^{IM} - c_{i,t}^{IM,ss}$$

- 3. Take away asset income changes

$$\Delta_{i,t} + \frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}}[(1+(1-\tau_k)i_{ss}^{a,IM})\frac{P_{t-1}^{IM,ss}}{P_t^{IM,ss}} - (1+(1-\tau_k)i_t^{a,IM})\frac{P_{t-1}^{IM}}{P_t^{IM}}]$$

- 4. Take away income due to higher assets

$$\Delta_{i,t} + (\frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}} - \frac{a_{i,t}^{IM}}{P_{t-1}^{IM}})\frac{P_{t-1}^{IM}}{P_t^{IM}}(1+(1-\tau_k)i_t^{a,IM})$$

- 5. Add resources for asset accumulation

$$\Delta_{i,t} + \frac{a_{i,t+1}^{IM}}{P_t^{IM}} - \frac{a_{i,t+1}^{IM,ss}}{P_t^{IM,ss}}$$

CONSTRUCT TRANSFERS

Taking into account that in the desired equilibrium:

$$\begin{aligned}
w_t^{IM} - w_{ss}^{IM} &= (\frac{w_t^{CM}}{w_{ss}^{CM}} - 1) w_{ss}^{IM} = (\gamma_t^w - 1) w_{ss}^{IM} \\
h_{i,t}^{IM} - h_{i,t}^{IM,ss} &= (\frac{H_t^{CM}}{H_{ss}^{CM}} - 1) h_{i,t}^{IM,ss} = (\gamma_t^H - 1) h_{i,t}^{IM,ss} \\
c_{i,t}^{IM} - c_{i,t}^{IM,ss} &= (\frac{C_t^{CM}}{C_{ss}^{CM}} - 1) c_{i,t}^{IM,ss} = (\gamma_t^C - 1) h_{i,t}^{IM,ss} \\
\ldots & \qquad \ldots
\end{aligned}$$

We get:

$$\begin{aligned}
\Delta_{i,t} &= (\gamma_t^C - 1) c_{i,t}^{IM,ss} - \left(\gamma_t^H \gamma_t^w - 1\right) w_{i,t}^{IM,ss} (1 - \tau_{ss}) s_{it} h_{i,t}^{IM,ss} \\
&- \lambda_{i,t} (\gamma_t^\Gamma - 1) \Gamma_{ss}^{IM} - \lambda_{i,t}^{MF} (\gamma_t^{MF} - 1) D_{ss}^{IM,MF} \\
&+ \frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}} [(1 + (1 - \tau_k) i_{ss}^{a,IM}) \frac{P_{t-1}^{IM,ss}}{P_t^{IM,ss}} - (1 + (1 - \tau_k) i_t^{a,IM}) \frac{P_{t-1}^{IM}}{P_t^{IM}}] \\
&- \frac{a_{i,t}^{IM,ss}}{P_{t-1}^{IM,ss}} (\gamma_t^A - 1) \frac{P_{t-1}^{IM}}{P_t^{IM}} (1 + (1 - \tau_k) i_t^{a,IM}) + \frac{a_{i,t+1}^{IM,ss}}{P_t^{IM,ss}} (\gamma_{t+1}^A - 1).
\end{aligned}$$

PROPERTIES OF Δ_{it}

- Adjust β^{CM} : Same IM and CM steady-state real interest rates:

$$\frac{1}{\beta^{CM}} = 1 + r_{ss}^{CM}(1 - \tau_k) = 1 + r_{ss}^{IM}(1 - \tau_k)$$

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- Δ_{it} depends on cross-sectional stationary distributions of $c, a, swh, \ldots \Longleftarrow$ DATA

EQUIVALENCE BETWEEN IM AND CM

THEOREM

Consider the CM economy $\{C_t^{CM}, K_t^{CM} H_t^{CM}, w_t^{CM}, \pi_t^{CM}, 1+i_t\}$. *The IM economy with transfers* $\Delta_{i,t}$ *as above and the same policies has the same aggregate consumption, capital, hours, wages and inflation rates as the complete markets case. Furthermore, individual consumption, hours, and savings satisfy*

$$\begin{aligned} c_{i,t}^{IM} &= \gamma_t^C c_{i,t}^{IM,ss}, \\ h_{i,t}^{IM} &= \gamma_t^H h_{i,t}^{IM,ss}, \\ \frac{a_{i,t+1}^{IM}}{P_t^{IM}} &= \gamma_{t+1}^A \frac{a_{i,t+1}^{IM,ss}}{P_t^{IM,ss}}, \end{aligned}$$

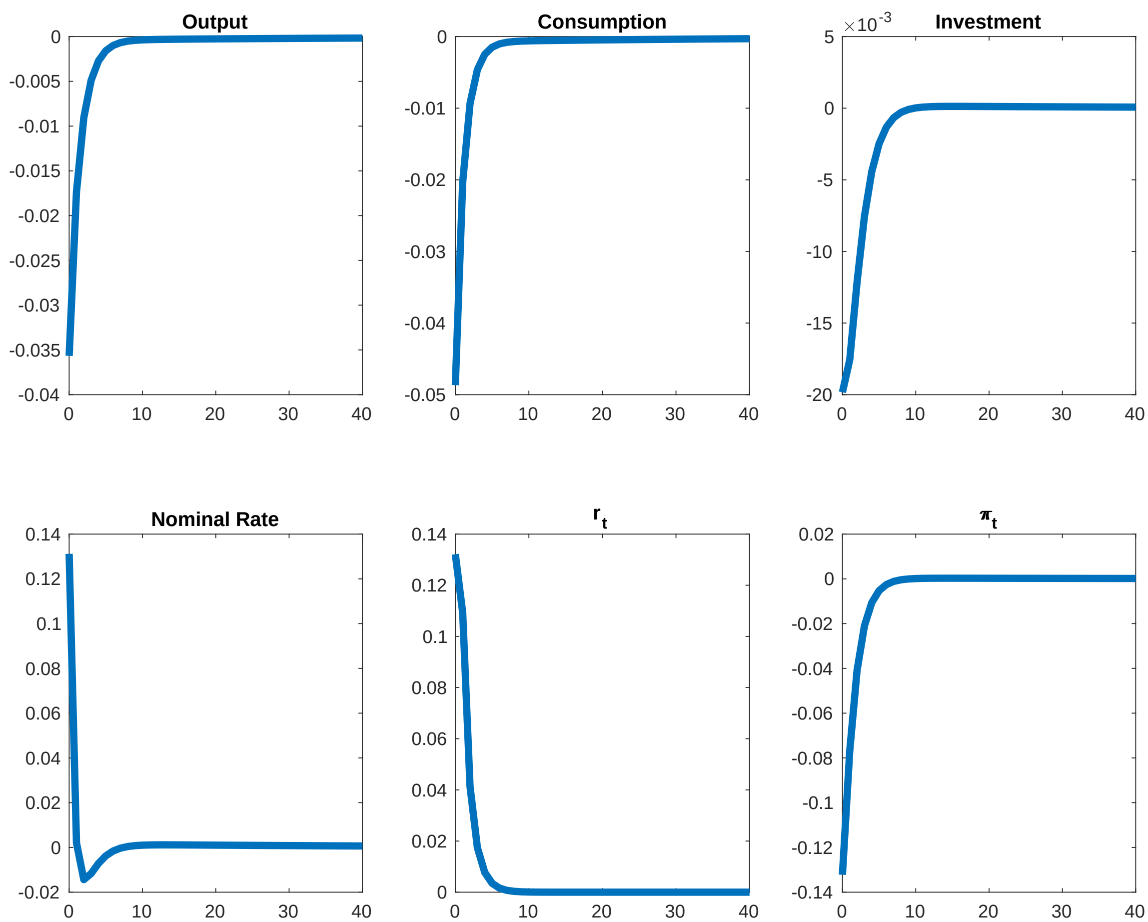
for a price sequence P_t^{IM}.

Return heterogeneity

- Evidence of heterogenous returns across households
- Incorporate return heterogeneity $\lambda^r_{i,t}(1+(1-\tau_k)r^a_t)$ on their assets a into the model
- This gives the following definition of $\Delta_{i,t}$

$$\begin{aligned}
\Delta_{i,t} = {} & (\gamma^C_t - 1)c^{IM,ss}_{i,t} && \text{Consumption} \\
& - (\gamma^H_t \gamma^W_t - 1)w^{IM,ss}_{i,t}(1-\tau_{ss})s_{i,t}h^{IM,ss}_{i,t} && \text{Labor} \\
& - \lambda_{i,t}(\gamma^\Gamma_t - 1)\Gamma^{CM}_{ss} && \text{Transfers} \\
& + a^{IM,ss}_{i,t}\lambda^r_{i,t}(1-\gamma^A_t + r_{ss}(1-\tau_k)(1-\gamma^A_t\gamma^r_t)) && \text{Assets} \\
& + a^{IM,ss}_{i,t+1}(\gamma^A_{t+1} - 1) && \text{Savings}
\end{aligned}$$

Monetary Policy Shock in RANK



25 BP innovation to the Taylor Rule in RANK

Mapping to Data

Use comprehensive data from the PSID to construct the HH budget constraint:

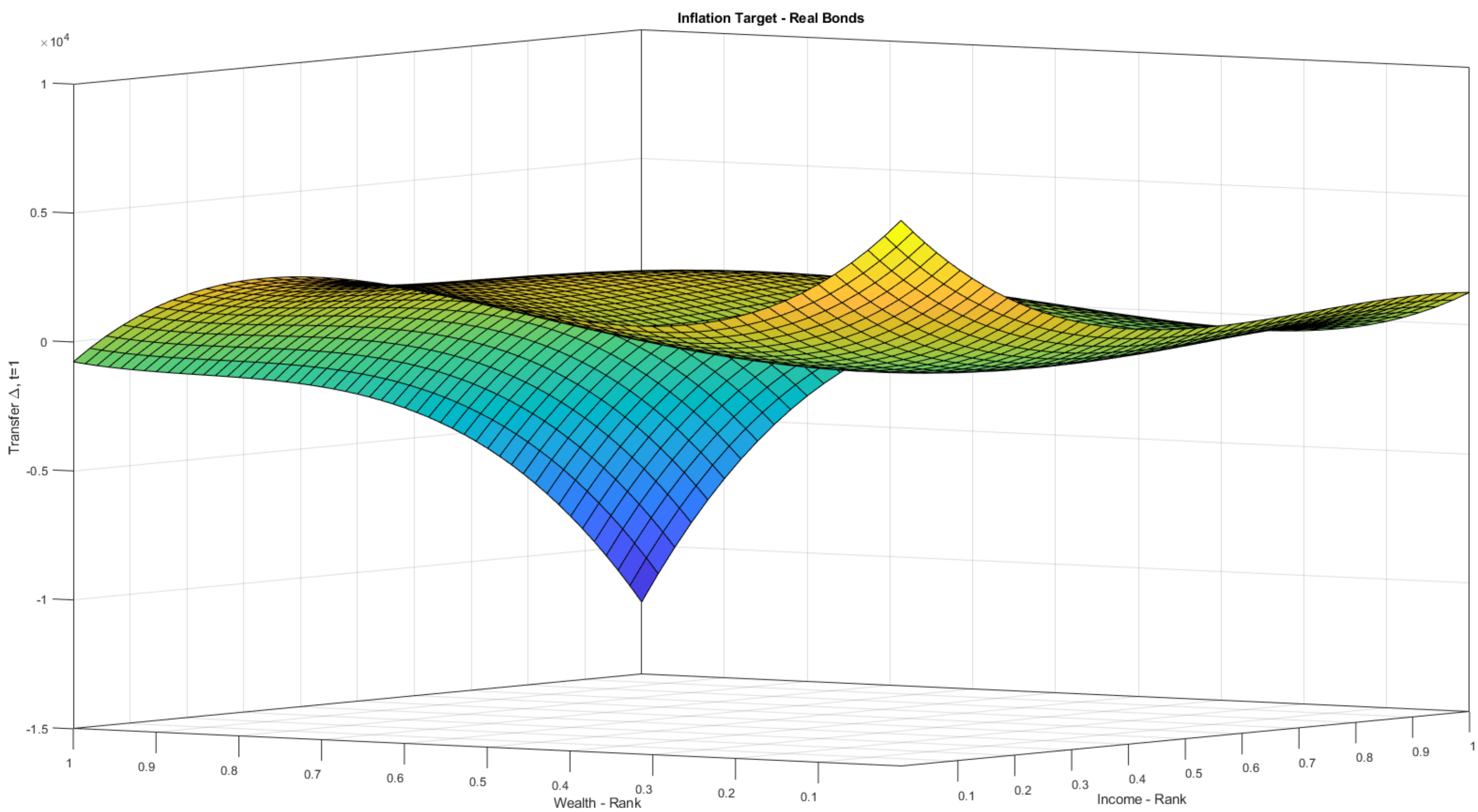
$$c_t + a_{t+1} = \lambda^r(1-(1-\tau_k)r^a_{ss})a_t + (1-\tau)wh_t s_t + \lambda_t \Gamma$$

- c_t, total household expenditures
- $\lambda^r(1-(1-\tau_k)r^a_{ss})a_t$, household wealth + asset income less the capital tax bill $T^k_{i,t}$, where λ^r allows for return heterogeneity.
- $(1-\tau)wh_t s_t$, household labor income less the labor portion of the tax bill $T^l_{i,t}$.
- $\lambda\Gamma$, total government and private transfers.
- a_{t+1}, calculated as the residual of the previous items such that the budget constraint holds.

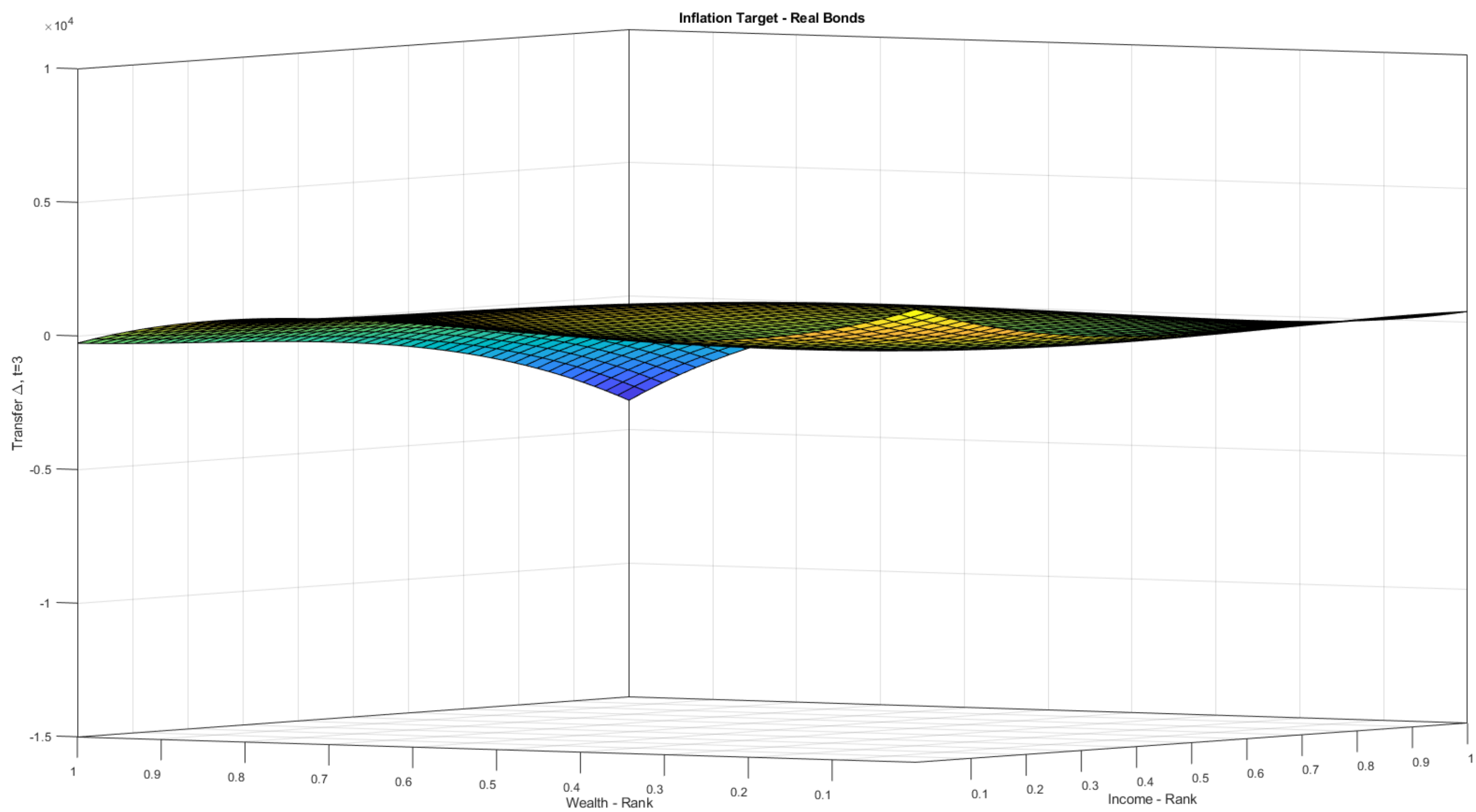
Aggregates in PSID

Aggregate Values in PSID	
Consumption	2,057,657,887
Saving	15,498,108,041
Wealth	15,047,297,172
Asset Income	227,404,732
Labor Income	3,014,223,912
Transfers	230,747,735
Dividends	93,742,496
Taxes	-830,245,388

DISTRIBUTION OF Δ_i AT $t = 0$



DISTRIBUTION OF Δ_i AT $t = 2$

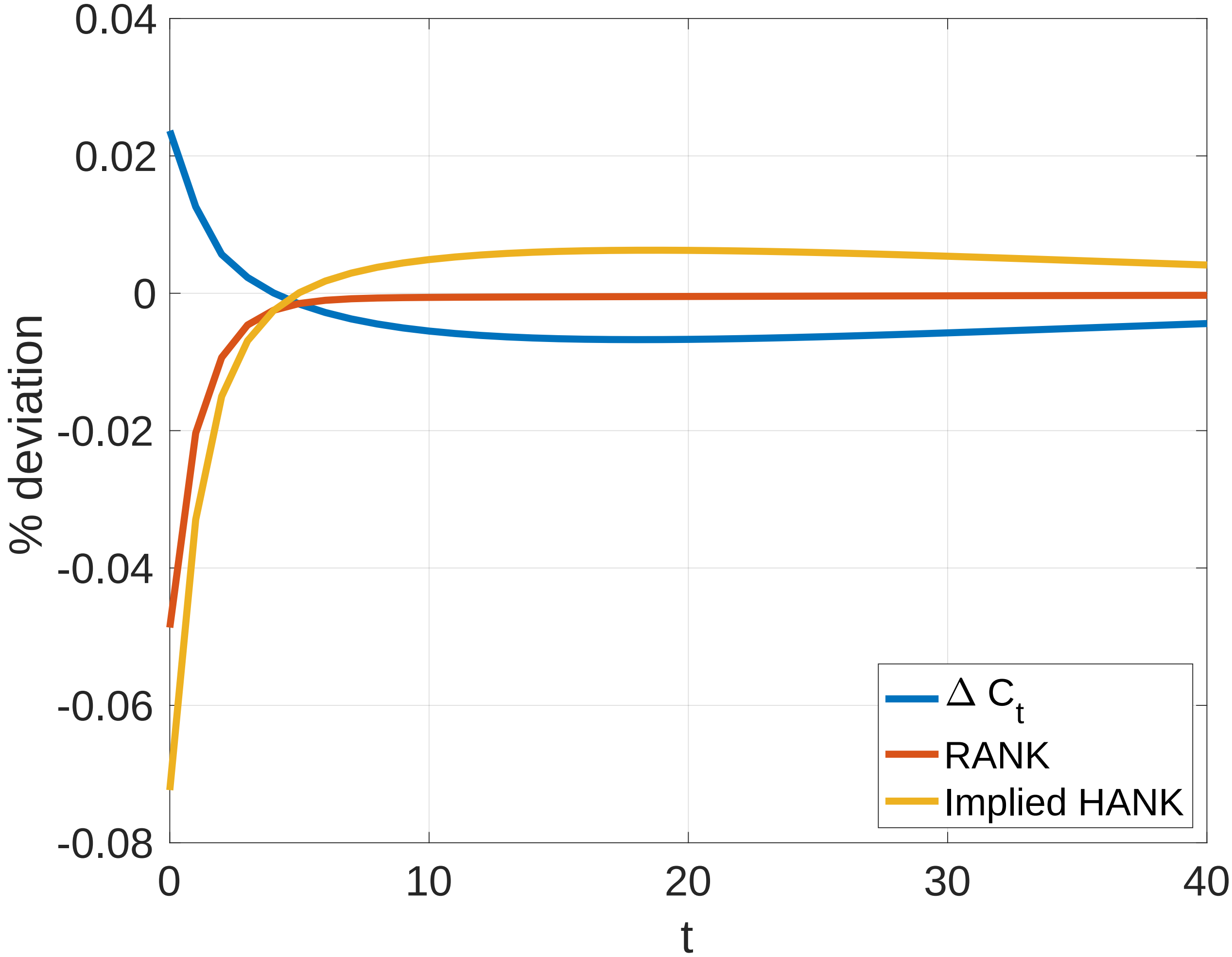


Going from Δs to aggregates

- We've now constructed $\Delta_k(a,y)$ in the data
- To construct impact on aggregate consumption ΔC_t we need the MPCs to those transfers
- Want $MPC_{t,k}(a,y)$, the *aggregate consumption* response in time t to a transfer in time k to a household with (a,y) in period k
- Can't directly measure in the data, so compute $MPC_{t,k}(a,y)$ in HA model

$$\Delta C_t = \sum_{k=0}^{\infty} \int_{a \in \mathscr{A}, y \in \mathscr{Y}} \Delta_k(a,y) MPC_{t,k}(a,y) dady$$

CONSUMPTION RESPONSE TO Δ



Conclusions

- Developed a new methodology to theoretically analyze the differences between market incompleteness/completeness.
- Find significant differences between RANK and (real/nominal) HANK
- (Nominal) Fiscal and monetary policies interact and should be studied jointly.
- Next steps:
  - Better understand the importance of nominal vs real fiscal policies.
  - Measures of MPCs directly from data.

Thanks!