Heterogeneity and Monetary Policy

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Low (Zero, Negative) interest rates generate constraints on traditional monetary policy instruments. ⇒ Models with ELB constraints.

Below-target inflation rates raise questions about central bank’s ability to control inflation. ⇒ Models with multiple equilibria.

Policy makers have become more concerned about consumption / income / wealth inequality and distributional effects of interventions. ⇒ Heterogeneous Agent New Keynesian Models.

Good modeling and measurement is a difficult task:
- More than forty years of research on the effects of unanticipated interest rate changes has left us with considerable uncertainty and ongoing debates about their measurement.
- What do we know about / how should we model: large-scale asset purchase programs, forward guidance, macroprudential policies (e.g., capital requirements)?
This presentation is based on joint research with

- Minsu Chang (Georgetown University)
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(technical) working paper available at https://web.sas.upenn.edu/schorf/:

“Heterogeneity and Aggregate Fluctuations”
Monetary policy decisions are informed by a variety of economic models.

Quantitative research prominently features:

- **dynamic stochastic general equilibrium (DSGE) models**: households, firms solve intertemporal optimization problems; monetary and fiscal authority follow mechanical rules; unexpected shocks to technology, preferences, and policy

- **vector autoregressions (VARs)**: \( Y_t = B_1 Y_{t-1} + B_\epsilon \epsilon_t \)

Traditionally, both classes of models abstract from household and firm heterogeneity.

- Is it important to model heterogeneity?
- Should CBs abandon representative agent models?
- Should CBs worry about distributional effects of monetary policy?
Outline

1. Macroeconometric Modeling at Central Banks
2. Heterogeneous Agent New Keynesian Models
3. A VAR with Heterogeneity
Macroeconometric Modeling at Central Banks
Vintages of (Central Bank) DSGE Models

**Pre-crisis:**
- variant of the Smets-Wouters (2003, 2007) model;
- extended by country-relevant features, e.g., multiple sectors, open economy component, detailed fiscal policy;
- mostly used for analysis of interest-rate based monetary policy.

**Crisis / Post-crisis:** more bells and whistles
- housing market, financial intermediation, financial frictions;
- zero lower bound on nominal interest rates;
- unconventional monetary policy, e.g., LSAP and forward guidance;
- macroprudential policies.

**Most recently:**
- household heterogeneity (HANK = heterogeneous agent New Keynesian);
- firm heterogeneity.
More Generally, How Much Detail Does an Economic Model Need?
It Depends on the Goal the Analysis...

- If the goal is to **predict micro-level outcomes**, then disaggregate variables need to be included.

- If the goal is to **predict aggregate outcomes**, it is not clear whether one needs to capture micro-level heterogeneity in the model.

- Increasing the **degree of realism of the model** potentially leads to a **more plausible story** accompanying the forecast / policy analysis.
  
  $\implies$ What is more important to user: **forecast accuracy** or **plausibility of the story**?

**Example:** nominal price rigidity

- Does an aggregate model have to have realistic implications about the frequency/magnitude of price changes at the micro level?
- Or does it suffice to get the slope of the (New Keynesian) Phillips curve right, which can be measured from aggregate data?
What Are the Constraints on Model Size?

- **Formulating** agents’ decision problems is typically not too difficult.

- **Solving for the optimal decision rules becomes more difficult**, the more equilibrium constraints need to be taken into account.

- **Occasionally-binding constraints** from financial frictions and ZLB render linear approximations inaccurate.

- Models with heterogeneity require the **tracking of cross-sectional distributions**.

- The larger the model:
  - the more parameters need to be identified from the data;
  - the greater the potential for misspecification;
  - the more difficult it becomes to interpret its output (competing mechanism, “black box”).
What Can / Does Academia Contribute?

**Macroeconomics:**
- Develop small-scale models that highlight important/novel economic mechanisms.
- Provide empirical evidence in support of these mechanisms.

**Computational:**
- Develop computational algorithms to solve models.

**Econometrics:**
- Estimation & inference for macroeconometric models: likelihood approximations, posterior simulators, specification tests.
- Structural change, regime switching, time-varying coefficients, conditional heteroskedasticity.
- Model selection, model averaging, forecast combination procedures.
- Methods to account for data revisions and real-time release of information; mixed frequency approaches.
Heterogeneous Agent New Keynesian Models
What is Different in Heterogeneous Agent NK Models?

**Some references:**

**Direct vs. Indirect Effects:**
- Consumption Euler equation: \( \hat{C}_t = -\frac{1}{\gamma} \sum_{\tau=0}^{\infty} E_t [\hat{R}_t - \hat{\pi}_{t+1}] \).
- Direct effect: real interest rate \( \downarrow \implies \) current consumption \( \uparrow \).
- Indirect effect: demand \( \uparrow \implies \) income \( \uparrow \implies \) consumption \( \uparrow \).

**Heterogeneity:**
- Marginal propensity to consume / change labor supply differ across households: e.g., borrowing constrained consumers \( \implies \) direct effect is zero.
- Other channels (Auclert): heterogeneity in: (i) earnings source; (ii) net nominal positions; (iii) difference between maturing assets and liabilities (unhedged interest rate exposures)
Model versus Data

**Bottom-Up Approach:**
- Measure relevant moments from micro data (Auclert): distribution of MPCs, covariance of MPC with income, net nominal positions, and unhedged interest rate exposures. Then try to predict aggregate effects of income / monetary policy shock using aggregation.
- Calibrate HA model to match income and wealth distribution (Kaplan, Moll, Violante); compute decomposition of interest rate change into various channels, compute aggregate effect of policy intervention from model.

**Potential Advantages:**
- More realistic description of propagation mechanism.
- More compelling welfare analysis accounting for distributional effects of monetary policy.
- Better predictions of effects on unconventional policies.

**How Should We Evaluate These Models?**
- Long history of interplay between VARs and DSGE models.
A VAR With Heterogeneity
Instead of building a **heterogeneous agent DSGE model** for monetary policy analysis,

we will build a **semi-structural model** that allows us to directly measure the **effect of unanticipated monetary policy shocks on cross-sectional distributions**, e.g., income distribution.

**Three types of potential questions:**
- Do distributional dynamics affect aggregate dynamics and vice versa?
- What is the effect of an aggregate shock on cross-sectional distributions?
- Effect of a change in a cross-sectional distribution on macroeconomic aggregates?

Vector Autoregressions (VARs)

- Typically, VARs for monetary policy are based on aggregate variables, e.g.,
  \[ Z_t = [\text{output growth, inflation, policy rate, velocity}]' \]

- Variables are linear function of their past plus shocks
  \[ Z_t = BZ_{t-1} + u_t \]

- Shocks are unanticipated changes in
  - monetary policy
  - fiscal policy
  - supply conditions, e.g., technology
  - demand conditions
Option 1:
- Track the income of specific households along with $Z_t$.
- **Advantage**: make predictions of how particular households respond to MP changes.
- **Disadvantage**: need panel data at relatively high frequency; difficult to model behavior at household level.

Option 2:
- Track the cross-sectional distribution income along with $Z_t$.
- **Advantage**: no panel data required; no need to model household-level behavior.
- **Disadvantage**: we are unable to make statements about specific individuals.

$\Rightarrow$ We choose **Option 2**.
Implementation

State-space Model:

- **State variables**: macroeconomic aggregates and cross-sectional (log) density of income,
- **State-transition equation**: VAR in state variables
- **Observations**: (noisy) measures of macroeconomic aggregates and a random sample from the cross-sectional distr. of income.
- **Measurement equation**: relate observations to the state variable.

Complications:

- Cross-sectional density is an infinite-dimensional object $\implies$ use finite-dimensional approximation.
- We approximate log densities by cubic splines with a relatively small number of knots:

\[
 p_t(x) = \exp\{\ell_t(x)\} = \exp\left\{\sum_{k=0}^{K} \alpha_k \zeta_k(x)\right\}.
\]
Empirical Analysis: Data

- **Aggregate time series:**
  - real per capita GDP growth
  - (Un)employment rate (CPS)
  - CPI inflation
  - Federal funds rate / Wu-Xia shadow rate
  - Log velocity \((M1/(GDP*CPI))\)

- **Repeated cross sections:**
  - Nominal weekly earnings / labor share of GDP
Earnings and GDP

**Average Log Earnings vs. GDP**

**Average Log Earnings/GDP vs. Labor Share**

Per-capita GDP is scaled by 2/3 to account for the labor share.
Weekly hours are multiplied by 52 to convert to annual.
Earnings/GDP Distribution (Including Zero Earnings of Unemployed)

Quantiles: 10, 20, 50%

Quantiles: 80, 90%

Seq. of Densities

Densities are normalized by fraction of individuals who are employed
VAR implicitly represents monetary policy through an interest rate feedback rule.

We are using a shadow rate which can be negative during times of zero short-term interest rates.

Shadow rate is an extrapolation from the medium and long-term yields that arguably captures unconventional monetary policies.

We need to impose some restrictions on the relationship between the VAR error term \( u_t \) and an unanticipated change in monetary policy:

\[
 u_t = B_\epsilon \epsilon_t, \quad \mathbb{E}[u_t u_t'] = \Sigma_u = B_\epsilon B_\epsilon', \quad \text{e.g.,} \quad B_\epsilon = \begin{bmatrix} b_{11}^\epsilon & b_{12}^\epsilon \\ b_{21}^\epsilon & b_{22}^\epsilon \end{bmatrix}, \quad \Sigma_u = \begin{bmatrix} \sigma_{11}^\epsilon & \cdot \\ \sigma_{21}^\epsilon & \sigma_{22}^\epsilon \end{bmatrix}
\]

Various approaches to identification:

- zero restrictions
- long-run restrictions
- sign restrictions
- federal funds futures
- narrative approach / external instruments

\( \implies \) We use a combination of sign and zero restrictions to set-identify response to monetary shock.
Impulse Responses of Aggregate Variables, 3 StdD Shock

- Identified set conditional on posterior parameter estimates: black w/ red hairlines
- 90% credible interval: blue dashed
VAR With Earnings Distribution

VAR Without Earnings Distributions

Takeaways, Part 1

- **Effects of surprise changes in monetary policy are generally difficult to identify.** Some recent innovations.

- **Increasing the dimension of model by adding cross-sectional distributions widens credible bands.**

- **Estimated identified sets** are similar with and without earnings distribution data.
Impulse Response of Density at Horizon $h = 4$, 3 StdD Shock

Earnings/GDP Distr.  

Difference Rel. To Baseline
IRF of Inequality Measures (Including Zero Earnings of Unemployed)

Fraction of Individuals Earning Less than per-capita GDP [%]

Gini Coefficient
Do interest rate changes have distributional effects?

• Conditional on posterior mean estimates, fraction of individuals with low earnings increases after monetary contraction.

• Inequality as measured by Gini coefficient increases.

• But, difficult to measure precisely $\implies$ wide credible bands.
Back to Our Three Questions

- Is it important to model heterogeneity?
- Should central banks abandon representative agent models?
- Should central banks worry about distributional effects of monetary policy?