Heterogeneous-Agent Macro Workshop

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with guest lecture by Marco Del Negro and Donggyu Lee

June 12–14 2023, NBER, Cambridge

Workshop objective: This workshop covers recent developments in the literature on heterogeneous-agent macroeconomics. The objective is twofold: 1) give you a solid understanding of the current state of literature on monetary and fiscal policy with heterogeneous agents (the so-called "HANK" literature) and, through this application, 2) introduce you to state-of-the-art solution methods for general equilibrium heterogeneous-agent models. The hope is to equip you with the necessary knowledge and tools to conduct your own research in the area.

On the methods side, we will cover the "sequence-space" approach to solving general equilibrium models with heterogeneous agents. We will go through the details of solving for steady states and impulse responses, as well as estimation methods for standard models.

Even though HANK is our main application, we emphasize that these methods are applicable to many other areas within heterogeneous-agent macroeconomics. For instance, we will cover and show you how to solve consumption-savings model with fixed costs of working, and price-setting models with menu costs.

We also emphasize practicality. The material comes with Python notebooks that contain the source code for all models and results that we cover in class. During our tutorials we will go through these notebooks, as well as simple problem-set type questions. There, we will share practical tips on how to set up models, solve them, and write code that is fast and efficient.

Our goal is to get you to the point where you can solve complex models in a limited amount of time. Because of this, some of our tutorials will using the sequence-space-jacobian (SSJ) toolbox. This will jump-start us by avoiding rewriting everything from scratch. Our objective, however, is not just to teach you how to use SSJ, but also to give you a deep understanding of the methods that it uses. For your own advanced application, you may want to either use SSJ, or write up your own sequence-space solution method. We'll cover both approaches.

Prerequisites. A solid grasp of macroeconomics at the level of a first-year PhD course (in particular dynamic programming and the standard 3-equation New Keynesian model) is essential. In addition, basic familiarity with Python is required (useful Python resources are provided below.) All the students attending the workshop have finished the 2nd year of their PhD or equivalent.

Location. Breakfast, lunch, and all courses take place at the NBER main office at 1050 Mass. Ave. Dinners will be at local restaurants. Look out for announcements each day about dinner venues.

Funding. Meals, flights and accomodation are covered by the NBER under the generous support of the National Science Foundation and the Chae Initiative on Macroeconomic Policy at Harvard.

Workshop material. Lecture notes will be posted as we go along on the NBER workshop webpage:

https://www.nber.org/conferences/heterogeneous-agent-macro-workshop-spring-2023.

Accompanying code will be posted as we go along on the class GitHub repo at:

https://github.com/shade-econ/nber-workshop-2023.

Python preparation. If you are relatively new to Python, we recommend having the Anaconda distribution of Python installed to make sure you have all necessary libraries. There are many outstanding resources you can find online, but two good introductory resources are the introductory lecture series at QuantEcon and the Python data science handbook (ignoring the machine learning content in the latter).

If you are accustomed to Matlab or Julia, QuantEcon's Matlab-Python-Julia cheatsheet can be useful, as can NumPy for Matlab users (ignoring now-obsolete "matrix" class at the end).

For the in-class tutorials, you will need SSJ installed on your laptop. For the discrete choice tutorial we will also use the Cubic-Spline package. You can install both via pip.

First lecture online. To save time on the first day, we have pre-recorded the first lecture. The link to the video recordings for the lecture is available in the GitHub repo. Please watch this lecture before class on Monday. You are encouraged to follow along and play around with the accompanying notebook yourself!

Other preparation. Before each day, you are encouraged to read ahead the class lecture notes. The references provided in the syllabus may also be useful.

If you would like even more preparation, you can go over last year's workshop material, as well the material in last year's GitHub repo.

Laptops. Please come with your laptop fully charged as well as a charger so that you can follow the tutorials. There will be power outlets in the classroom.

Class plan. The plan for each class is outlined below.

Time	Topic	Instructor
before Monday	*Warm-up*	
online	The standard incomplete markets model and methods, part I	Matt
Monday	*Methods and fiscal policy*	
8:30am	The standard incomplete markets model and methods, part II	Matt
10am	The standard incomplete markets model and methods, part III	Matt
11:30am	The canonical HANK model	Ludwig
2:15pm	Fiscal policy in the canonical HANK model	Ludwig
3:45pm	Tutorial: fiscal policy analysis	Ludwig
Tuesday	*Monetary policy and estimation*	
8:30am	Monetary policy in the canonical HANK model	Adrien
10am	Monetary policy topics	Adrien
11:30am	Tutorial: monetary policy analysis	Adrien
2:15pm	Tutorial: estimating the canonical HANK model	Adrien + Matt
3:30pm	Estimating HANK for central banks	Marco + Donggyu
Wednesday	*Advanced topics*	
8:30am	Discrete choice with extreme-value taste shocks	Bence
10:00am	Tutorial: discrete choice	Bence
11:30am	Non-rational expectations in the sequence space	Ludwig
2:00pm	Models of price setting and inflation	Matt

Background reading

Useful literature overviews

Heathcote, J., Storesletten, K. and Violante, G.L. (2009). Quantitative Macroeconomics with Heterogeneous Households. *Annual Review of Economics* 1(1):319–354

Krueger, D., Mitman, K. and Perri, F. (2016). Chapter 11 - Macroeconomics and Household Heterogeneity. In: J.B. Taylor and H. Uhlig (eds.) *Handbook of Macroeconomics*, vol. 2, pp. 843–921. Elsevier

Kaplan, G. and Violante, G.L. (2018). Microeconomic Heterogeneity and Macroeconomic Shocks. *Journal of Economic Perspectives* 32(3):167–194

Galí, J. (2018). The State of New Keynesian Economics: A Partial Assessment. *Journal of Economic Perspectives* 32(3):87–112

Methods

*Auclert, A., Bardóczy, B., Rognlie, M. and Straub, L. (2021). Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models. *Econometrica* 89(5):2375–2408

Auclert, A., Rognlie, M. and Straub, L. (2023b). Determinacy and Existence in the Sequence Space. *Manuscript*

Reiter, M. (2009). Solving Heterogeneous-Agent Models by Projection and Perturbation. *Journal of Economic Dynamics and Control* 33(3):649–665

Boppart, T., Krusell, P. and Mitman, K. (2018). Exploiting MIT Shocks in Heterogeneous-Agent Economies: The Impulse Response as a Numerical Derivative. *Journal of Economic Dynamics and Control* 89:68–92

Ahn, S., Kaplan, G., Moll, B., Winberry, T. and Wolf, C. (2018). When Inequality Matters for Macro and Macro Matters for Inequality. *NBER Macroeconomics Annual* 32(1):1–75

Day 1: Methods and fiscal policy

1. The standard incomplete markets model and methods

*Lecture slides 1

Deaton, A. (1992). *Understanding Consumption*. Oxford University Press, USA

Carroll, C.D. (1997). Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis. *Quarterly Journal of Economics* 112(1):1–55

Aiyagari, S.R. (1994). Uninsured Idiosyncratic Risk and Aggregate Saving. *Quarterly Journal of Economics* 109(3):659–684

Kaplan, G. and Violante, G.L. (2022). The Marginal Propensity to Consume in Heterogeneous Agent Models. *Annual Review of Economics* 14(1):747–775

2. The canonical HANK model

*Lecture slides 2

*Auclert, A., Rognlie, M. and Straub, L. (2023c). The Intertemporal Keynesian Cross. Working Paper 25020, National Bureau of Economic Research

Werning, I. (2015). Incomplete Markets and Aggregate Demand. Working Paper 21448, National Bureau of Economic Research

Auclert, A., Bardóczy, B. and Rognlie, M. (2023a). MPCs, MPEs, and Multipliers: A Trilemma for New Keynesian Models. *The Review of Economics and Statistics* 105(3):700–712

Broer, T., Hansen, N.J.H., Krusell, P. and Öberg, E. (2020). The New Keynesian Transmission Mechanism: A Heterogeneous-Agent Perspective. *Review of Economic Studies* 87(1):77–101

3. Fiscal policy in the canonical HANK model

*Lecture slides 3

*Auclert, A., Rognlie, M. and Straub, L. (2023c). The Intertemporal Keynesian Cross. Working Paper 25020, National Bureau of Economic Research

Woodford, M. (2011). Simple Analytics of the Government Expenditure Multiplier. *American Economic Journal: Macroeconomics* 3(1):1–35

McKay, A. and Reis, R. (2016). The Role of Automatic Stabilizers in the U.S. Business Cycle. *Econometrica* 84(1):141–194

Hagedorn, M., Manovskii, I. and Mitman, K. (2019). The Fiscal Multiplier. Working Paper 25571, National Bureau of Economic Research

Day 2: Monetary policy and estimation

4. Monetary policy in the canonical HANK model

*Lecture slides 4

Auclert, A. (2019). Monetary Policy and the Redistribution Channel. *American Economic Review* 109(6):2333–2367

Kaplan, G., Moll, B. and Violante, G.L. (2018). Monetary Policy According to HANK. *American Economic Review* 108(3):697–743

McKay, A., Nakamura, E. and Steinsson, J. (2016). The Power of Forward Guidance Revisited. *American Economic Review* 106(10):3133–3158

Werning, I. (2015). Incomplete Markets and Aggregate Demand. Working Paper 21448, National Bureau of Economic Research

5. Advanced topics in monetary policy

*Lecture slides 5

Bilbiie, F.O. (2021). Monetary Policy and Heterogeneity: An Analytical Framework. *Manuscript*

Acharya, S. and Dogra, K. (2020). Understanding HANK: Insights From a PRANK. *Econometrica* 88(3):1113–1158

Doepke, M. and Schneider, M. (2006). Inflation and the Redistribution of Nominal Wealth. *Journal of Political Economy* 114(6):1069–1097

Auclert, A., Rognlie, M. and Straub, L. (2020). Micro Jumps, Macro Humps: Monetary Policy and Business Cycles in an Estimated HANK Model. Working Paper 26647, National Bureau of Economic Research

6. Estimating the canonical HANK model

*Lecture slides 6

Auclert, A., Bardóczy, B., Rognlie, M. and Straub, L. (2021). Using the Sequence-Space Jacobian to Solve and Estimate Heterogeneous-Agent Models. *Econometrica* 89(5):2375–2408

Herbst, E.P. and Schorfheide, F. (2015). *Bayesian Estimation of DSGE Models*. Princeton University Press

Fernández-Villaverde, J., Rubio-Ramírez, J. and Schorfheide, F. (2016). Chapter 9 - Solution and Estimation Methods for DSGE Models. In: J.B. Taylor and H. Uhlig (eds.) *Handbook of Macroeconomics*, vol. 2, pp. 527–724. Elsevier

7. Estimating HANK for central banks

*Lecture slides 7

Acharya, S., Chen, W., Del Negro, M., Dogra, K., Gleich, A., Goyal, S., Matlin, E., Lee, D., Sarfati, R. and Sengupta, S. (2023). Estimating HANK for Central Banks. *Manuscript*

Day 3: Advanced topics

8. Discrete choice with extreme-value taste shocks

*Lecture slides 8

9. Non-rational expectations in the sequence space

*Lecture slides 9

*Auclert, A., Rognlie, M. and Straub, L. (2020). Micro Jumps, Macro Humps: Monetary Policy and Business Cycles in an Estimated HANK Model. Working Paper 26647, National Bureau of Economic Research

Guerreiro, J. (2022). Belief Disagreement and Business Cycles. *Manuscript*

10. Models of price setting and inflation

*Lecture slides 10

*Auclert, A., Rigato, R.D., Rognlie, M. and Straub, L. (2022). New Pricing Models, Same Old Phillips Curves? Working Paper 30264, National Bureau of Economic Research

Golosov, M. and Lucas, R.E. (2007). Menu Costs and Phillips Curves. *Journal of Political Economy* 115(2):171–199

Alvarez, F., Le Bihan, H. and Lippi, F. (2016). The Real Effects of Monetary Shocks in Sticky Price Models: A Sufficient Statistic Approach. *American Economic Review* 106(10):2817–2851

Alvarez, F. and Lippi, F. (2022). The Analytic Theory of a Monetary Shock. *Econometrica* 90(4):1655–1680