



Goethe Macro Training School

Heterogeneous-Agent Macroeconomics

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June 8–10, 2026, in Frankfurt, Germany

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, first-order impulse responses, and higher-order perturbations. We will also cover estimation methods, determinacy, truncation error reduction, and solutions for large-scale systems.

The workshop emphasizes practicality. The material comes with Python notebooks that contain the source code for many of the 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 use 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.)

Workshop material. All lecture notes and tutorial notebooks will be posted as we go along on the following workshop webpage:

<https://github.com/shade-econ/goethe-workshop-2026>

Python preparation. If you are relatively new to Python, we recommend having the Anaconda distribution of Python installed to make sure you have all the 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, which you can install 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 will be made available on the workshop website in June. Please watch this lecture before class on Monday. You are encouraged to follow along and play around with the accompanying notebook yourself!

Program. The full program is outlined below.

Time	Topic	Instructor
before Monday	The standard incomplete markets model and methods, part I (pre-recorded first lecture, self-study, available on course GitHub in June)	Matt
Sunday 19:00	Social event -- welcome get-together Apfelweinwirtschaft Dauth-Schneider (<i>location below</i>)	
Monday	Day 1	
8:15 - 8:50	— Registration & Light Breakfast —	
8:50	Welcome and Overview	
9:00 – 10:00	Review of the standard incomplete markets model	Matt
10:00 – 10:15	— Break —	
10:15 – 11:15	Intro to HANK models: Fiscal policy	Ludwig
11:15 – 11:30	— Break —	
11:30 – 12:30	Intro to the sequence space and Jacobians	Matt
12:30 – 14:00	— Lunch Break —	
14:00 – 15:00	Intro to HANK models: Monetary policy	Adrien
15:00 – 15:15	— Break —	
15:15 – 16:15	SSJ approach and toolkit	Matt
16:15	— Adjourn —	
Tuesday	Day 2	
8:15 – 9:00	— Light Breakfast —	
9:00 – 10:00	Fiscal and monetary policy topics	Adrien
10:00 – 10:15	— Break —	
10:15 – 11:00	Tutorial: fiscal and monetary policy in SSJ	Ludwig
11:00 – 11:15	— Break —	
11:15 – 11:45	Stochastic economies and estimation	Adrien
11:45 – 12:00	— Break —	
12:00 – 12:30	Household portfolios	Adrien
12:30 – 14:00	— Lunch Break —	
14:00 – 14:30	Determinacy in the sequence space	Matt
14:30 – 14:45	— Break —	
14:45 – 15:15	Large-scale models	Matt
15:15 – 15:30	— Break —	
15:30 – 16:00	Heterogeneous firms	Adrien
16:00	— Adjourn —	
Wednesday	Day 3	
8:15 – 9:00	— Light Breakfast —	
9:00 – 9:30	A HANK model for the Euro area	Rodolfo
9:30 – 9:45	— Break —	
9:45 – 10:15	Smooth methods for standard incomplete markets	Matt
10:15 – 10:30	— Break —	
10:30 – 11:00	Second order solutions in sequence space	Matt
11:00 – 11:15	— Break —	
11:15 – 11:45	Open economy HANK models	Ludwig
11:45 – 12:00	— Break —	
12:00 – 12:30	Non-rational expectations	Ludwig
12:30 – 14:00	— Lunch Break —	
14:00 – 14:30	Price setting	Ludwig
14:30 – 15:00	— Break —	
15:00 – 15:30	Optimal long-run policy	Ludwig
15:30	— Adjourn —	

Background reading

Useful literature overviews

*Auclert, A., Rognlie, M. and Straub, L. (2025c). Fiscal and Monetary Policy with Heterogeneous Agents. *Annual Review of Economics* 17(Volume 17, 2025):539–562

*Winberry, T., Auclert, A., Rognlie, M. and Straub, L. (2025). New Keynesian Economics with Household and Firm Heterogeneity. Manuscript in preparation for the *Journal of Economic Literature*.

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

Bilbiie, F.O. (2025a). *Heterogeneous Agent Macroeconomics: A Tractable New Keynesian Framework*. Book Project, MIT Press

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 Large-Scale Solutions in the Sequence Space**. *JPE:Macroeconomics*, forthcoming.

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

Moll, B. (2025). *The Trouble with Rational Expectations in Heterogeneous Agent Models: A Challenge for Macroeconomics*. *Economic Journal*, forthcoming.

Day 1

The standard incomplete markets model and methods

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

The canonical HANK model

Auclert, A., Rognlie, M. and Straub, L. (2025c). *Fiscal and Monetary Policy with Heterogeneous Agents*. *Annual Review of Economics* 17(Volume 17, 2025):539–562

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 Oberg, E. (2020). **The New Keynesian Transmission Mechanism: A Heterogeneous-Agent Perspective**. *Review of Economic Studies* 87(1):77–101

Fiscal policy in the canonical HANK model

Auclert, A., Rognlie, M. and Straub, L. (2024c). *The Intertemporal Keynesian Cross*. *Journal of Political Economy* 132(12):4068–4121

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

Monetary policy in the canonical HANK model

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

The sequence-space Jacobian method

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

Day 2

Advanced topics in monetary and fiscal policy

Auclert, A., Rognlie, M. and Straub, L. (2025c). **Fiscal and Monetary Policy with Heterogeneous Agents**. *Annual Review of Economics* 17(Volume 17, 2025):539–562

Bilbiie, F.O. (2024). **Monetary Policy and Heterogeneity: An Analytical Framework**. *The Review of Economic Studies* 92(4):2398–2436

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

Estimation on time-series data

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

Household portfolios

Auclert, A., Rognlie, M., Straub, L. and Tapák, T. (2024e). **When do Endogenous Portfolios Matter for HANK?** *Manuscript*

Bhandari, A., Bourany, T., Evans, D. and Golosov, M. (2023). **A Perturbational Approach for Approximating Heterogeneous-Agent Models**. *Manuscript*

Devereux, M.B. and Sutherland, A. (2011). *Country Portfolios in Open Economy Macro-Models*. *Journal of the European Economic Association* 9(2):337–369

Coeurdacier, N. and Rey, H. (2013). *Home Bias in Open Economy Financial Macroeconomics*. *Journal of Economic Literature* 51(1):63–115

Heterogeneous firms

Winberry, T., Auclert, A., Rognlie, M. and Straub, L. (2025). *Household and Firm Heterogeneity. New Keynesian Economics with Household and Firm Heterogeneity*. *Manuscript*

Ottonello, P. and Winberry, T. (2020). *Financial Heterogeneity and the Investment Channel of Monetary Policy*. *Econometrica* 88(6):2473–2502

Jeenas, P. (2025). *Firm Balance Sheet Liquidity, Monetary Policy Shocks, and Investment Dynamics*. *Manuscript*

Bernanke, B.S., Gertler, M. and Gilchrist, S. (1999). *Chapter 21 – The Financial Accelerator in a Quantitative Business Cycle Framework*. In: J.B. Taylor and M. Woodford (eds.) *Handbook of Macroeconomics*, vol. 1, Part C, pp. 1341–1393.

Day 3

Smooth methods and higher-order perturbation

Auclert, A., Rigato, R., Rognlie, M. and Straub, L. (2025a). Certainty Correspondence: Higher-Order Perturbation in the Sequence Space. *Manuscript*.

Bhandari, A., Bourany, T., Evans, D. and Golosov, M. (2023). **A Perturbational Approach for Approximating Heterogeneous-Agent Models**. *Manuscript*

Bilal, A. (2023). Solving Heterogeneous Agent Models with the Master Equation. *Manuscript*

Open-economy HANK models

Auclert, A., Rognlie, M., Souchier, M. and Straub, L. (2021b). *Exchange Rates and Monetary Policy with Heterogeneous Agents: Sizing up the Real Income Channel*. Working Paper 28872, National Bureau of Economic Research

Aggarwal, R., Auclert, A., Rognlie, M. and Straub, L. (2023). *Excess Savings and Twin Deficits: The Transmission of Fiscal Stimulus in Open Economies*. NBER Macroeconomics Annual 2022 37:325–412

Galí, J. and Monacelli, T. (2005). *Monetary Policy and Exchange Rate Volatility in a Small Open Economy*. Review of Economic Studies 72(3):707–734

de Ferra, S., Mitman, K. and Romei, F. (2020). *Household Heterogeneity and the Transmission of Foreign Shocks*. Journal of International Economics 124:1–18

Guo, X., Ottonello, P. and Perez, D.J. (2023). *Monetary Policy and Redistribution in Open Economies*. Journal of Political Economy Macroeconomics 1(1):191–241

Non-rational expectations in the sequence space

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. (2023). **Belief Disagreement and Business Cycles**. *Manuscript*

Bardóczy, B. and Guerreiro, J. (2023). **Unemployment Insurance in Macroeconomic Stabilization with Imperfect Expectations**. *Manuscript*

Price setting

Auclert, A., Rigato, R., Rognlie, M. and Straub, L. (2024c). **New Pricing Models, Same Old Phillips Curves?** *Quarterly Journal of Economics* 139(1):121–186

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

Optimal long-run policy

Auclert, A., Cai, M., Rognlie, M. and Straub, L. (2024a). **Optimal Long-Run Fiscal Policy with Heterogeneous Agents.** *Manuscript*

Aiyagari, S.R. (1995). **Optimal Capital Income Taxation with Incomplete Markets, Borrowing Constraints, and Constant Discounting.** *Journal of Political Economy* 103(6):1158–1175

Acikgoz, O., Hagedorn, M., Holter, H.A. and Wang, Y. (2018). **The Optimum Quantity of Capital and Debt.** *Working Paper*

Chien, Y. and Wen, Y. (2022). **The Ramsey Steady-State Conundrum in Heterogeneous-Agent Economies.** *FRB St. Louis Working Paper* 2022-09