Advanced Macroeconomics I: Identification in Macroeconomics

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Lectures:	Mon/Wed 10:00am–11.30pm (Room E52-432)
Recitations:	Fri 1:00pm–2.30pm (Room E51-372)
Office hours:	Instructor: by appointment (Room E52-554)
	TA: Mon 2:30pm–4:00pm (Room E52-548)
Website:	`https://canvas.mit.edu/courses/15529`

Description. This is a class in **empirical macroeconomics**, covering empirical methods and their relation to structural macroeconomic modeling. Topics include: state-space and sequence-space representations of structural macroeconomic models; basics of time series inference; time series methods for causal identification; uses and limitations of cross-sectional analysis; and a brief overview of non-linear methods. The **objective** is to bring students to the research frontier in these topics.

Prerequisites. Completion of the macroeconomics and econometrics classes in the first-year Ph.D sequence. Students from outside the Economics PhD program should contact the instructor to obtain permission to take the course.

Material. The class will be largely organized around required readings. Attached to this syllabus is a list of relevant papers; the starred (*) papers are essential reading before the lecture, while the optional readings are useful for a deeper understanding of the material. Handouts for each lecture will be made available on the course website.

While there is no textbook for the course, some of the time series material is sufficiently standard so that good textbook treatments are available. Good reference books include:

Brockwell, P. J., and Davis, R. A. (1991). *Time Series: Theory and Methods.* 2nd edition, Springer. (Very nice mathematical treatment of the classic theory of covariance stationary time series, though not aimed at economists.)

Hamilton, J. D. (1994). *Time Series Analysis.* Princeton University Press. (Comprehensive reference for time series econometrics methods developed before the mid-1990s.)

Cochrane, J. H. (2005). *Time series for macroeconomics and finance.* Manuscript, University of Chicago. (Accessible introduction to linear time series methods.)

Kilian, L., and Lütkepohl, H. (2017). *Structural Vector Autoregressive Analysis.* Cambridge University Press. (Recent reference on SVAR methods.)

Parts of my lecture notes for this time series part build on an econometrics class taught by Mikkel Plagborg-Møller. For further reference, you may also want to consult the great teaching materials provided by David Childers and Gabriel Chodorow-Reich.[1] There is some overlap between this course and those two, though with quite different emphasis.

Evaluation. Your performance will be evaluated based on class participation (10%), a problem set, referee report and replication of an empirical paper (20%), and a final exam (40%). The remaining 30% come from problem sets for Prof. Parker's half.

1. *Class participation.* Starred (*) papers are essential reading before the lecture. Parts of each class will revolve around discussion of those papers, so it is important that you are equipped to critically assess them.

2. *Problem set, referee report & paper replication.* Your first assignment will be a problem set. The second assignment is a referee report ($\approx$2-4 pages) on a paper that is discussed in one of the two readings below, but not otherwise included on the syllabus.[2]

   * Ramey, V. A. (2016). "Macroeconomic Shocks and Their Propagation." In *Handbook of Macroeconomics, Volume 2A*, edited by Taylor, J. B., and Uhlig, H., Elsevier, chapter 2, 71–162.

   * Nakamura, E., and Steinsson, J. (2018). "Identification in Macroeconomics." *Journal of Economic Perspectives* 32(3), 59–86.

   The third assignment will be the replication of an empirical paper, also taken from one of the two readings above. You will first replicate the main findings and then provide one small extension (e.g., a different sample period, a change in the specification, . . .).

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[1]See `https://donskerclass.github.io/CausalEconometrics.html` and `https://scholar.harvard.edu/chodorow-reich/classes/economics-2410hfc-advanced-topics-applied-macroeconomics`.

[2]A background document for refereeing best practice will be posted on the course webpage.

3. *Final exam.* At the end of the term you will take a final exam covering material from both halves of the course. For my half, the content of the problem set should give you a good indication of the kind of problems to expect.

Covid Policies. Please contact me if you are isolating in line with MIT's Covid policies. We will make arrangements for making up/excusing assignments on a case-by-case basis.

Reporting bias-related or other incidents. The Economics Department fully endorses the Institute Discrimination and Harrassment Response Office (IDHR) reporting process for any bias-related incident.[3] We encourage students to use this valuable resource if needed for any reason. This process is useful for addressing any issues that may arise with professors, teaching assistants, or other students in this course. If you've had a negative experience and aren't sure if IDHR is the place to go, they can also help you find the right office at MIT to receive support. The department values such reports as important to our pursuit of equitable and inclusive treatment for all students, faculty, and staff.

Accessibility and support. The Economics Department values an inclusive environment. If you need a disability accommodation to access this course, please communicate with us early in the semester. If you have your accommodation letter, please meet with the faculty so that we can understand your needs and implement your approved accommodations. If you have not yet been approved for accommodations, please contact Student Disability Services at `uaap-sds@mit.edu` to learn about their procedures. We encourage you to do so early in the term to allow sufficient time for implementation of accommodations that you may need.

Important dates. Below is a (preliminary) summary of important dates for this class. Changes will be announced via course email.

Oct 26 (Wed): First class

Dec 1 (Thu): Problem set, referee report & paper replication due

Dec 14 (Wed): Last class

Dec 19 (Mon): Final exam

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[3]You can submit a report at `https://idhr.mit.edu/submitincidentreport`.

Course outline

The following course outline is preliminary and may change without warning.

1. Overview: macroeconomic shocks *(≈ Lecture 1)*

   - Background: What is a macroeconomic "shock"? Why does modern macro take a shock-propagation perspective? What are policy shocks?
   - Outline for the rest of the class

2. Refresher: linear models *(≈ Lectures 2-3)*

   a) Linearized structural macroeconomic models

      - State-space methods
      - Sequence-space methods
      - Structural vector moving average (SVMA) representation

   b) Linear time series methods

      - Lag operators, linear filters, VARMA, spectral analysis
      - Wold decomposition

3. Semi-structural time series methods for identification & estimation of macroeconomic shocks *(≈ Lectures 4-7)*

   a) Identification assumptions

      - Background: the SVMA model identification challenge
      - Invertibility + X: exclusion restrictions (short-run, long-run), sign/magnitude restrictions, max-share, non-Gaussianity/heteroskedasticity
      - Identification without invertibility: instruments/proxies & *(optionally)* direct prior on SVMA coefficients, dynamic residual rotation & Blaschke matrices

   b) Estimation strategies

      - Overview: VAR, LP (+ intermediate shrinkage techniques)
      - LP/VAR population equivalence
      - Finite-sample recommendations

   Throughout we will illustrate these methods through applications to canonical macro shocks (monetary policy, fiscal policy, oil, technology).

4. Using macroeconomic shocks *(≈ Lectures 8-10)*

   a) Identifying structural macroeconomic equations

      - Regressions in impulse response space
      - Application: the Phillips curve

   b) Policy rule counterfactuals & optimal policy design

      - Full structural model estimation though impulse response matching
      - Semi-structural identification result: from policy shocks to policy rule counterfactuals
      - Application: optimal monetary policy & inequality

   c) Origins of business-cycle fluctuations

      - Semi-structural analysis: business-cycle anatomy, TFP (news) shocks, investment-specific technology shocks
      - Full structural model estimation through full-information (maximum likelihood, Bayesian) methods
      - Application: investment technology shocks & HANK model estimation

5. Cross-sectional analysis *(≈ Lectures 11-12)*

   a) What does cross-sectional variation identify?

      - Cross-household/firm analysis & sequence-space Jacobians
      - Cross-regional analysis & local general equilibrium effects

   b) The "missing intercept"/aggregation problem

      - "Micro"-based aggregation
      - Leveraging shock equivalence

   c) Cross-sectional data in empirical time series analysis *(if time permits)*

   d) Using cross-sectional data to learn about transmission channels *(if time permits)*

   Throughout we will illustrate these methods through well-known recent applications (mostly to fiscal spending multipliers & stimulus checks).

Reading list

Essential readings are listed first and marked with a star (*). Other readings are included for your reference. Original contributions are not always cited when good handbook/textbook references are available. The reading list is preliminary and may change without warning.

1 Overview: macroeconomic shocks

* Ramey, V. A. (2016). "Macroeconomic Shocks and Their Propagation." In *Handbook of Macroeconomics, Volume 2A*, edited by Taylor, J. B., and Uhlig, H., Elsevier, chapter 2, 71–162.

* Nakamura, E., and Steinsson, J. (2018). "Identification in Macroeconomics." *Journal of Economic Perspectives* 32(3), 59–86.

Granger, C. W. (1966). "The typical spectral shape of an economic variable." *Econometrica*, 150–161.

Summers, Lawrence H. (1991). "The Scientific Illusion in Empirical Macroeconomics." *The Scandinavian Journal of Economics* 93(2), 129–148.

Werning, I. (2016). Comment on "Is the macroeconomy locally unstable and why should we care?" *NBER Macroeconomics Annual*, 31(1), 540–552.

Beaudry, P., Galizia, D., & Portier, F. (2020). "Putting the cycle back into business cycle analysis." *American Economic Review*, 110(1), 1–47.

2 Refresher: linear models

Linearized structural models

* Fernández-Villaverde, J., Rubio-Ramírez, J. F., & Schorfheide, F. (2016). "Solution and estimation methods for DSGE models." In *Handbook of Macroeconomics* (Vol. 2, pp. 527-724). Elsevier.

* Auclert, A., Bardóczy, B., Rognlie, M., & Straub, L. (2021). "Using the sequence-space Jacobian to solve and estimate heterogeneous-agent models." *Econometrica*, 89(5), 2375-2408.

Fernández-Villaverde, J., Rubio-Ramírez, J. F., Sargent T. J., and Watson, M. W. (2007). "ABCs (and Ds) of Understanding VARs." *American Economic Review* 97(3), 1021–1026.

Smets, F., & Wouters, R. (2007). "Shocks and frictions in US business cycles: A Bayesian DSGE approach." *American Economic Review*, 97(3), 586–606.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). "Nominal rigidities and the dynamic effects of a shock to monetary policy." *Journal of Political Economy*, 113(1), 1–45.

Boppart, T., Krusell, P., & 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.

Linear time series models

* Hamilton: chapters 2–4, 10–12.

* Kilian and Lütkepohl: chapters 2.1–2.5.

  Brockwell and Davis: chapters 1.1–1.5, 2.1–2.9, 3.1–3.5, 5.1–5.5, 5.7, 11.1–11.4.

  Cochrane: chapters 3–6, 8

3 Time series methods for identification+estimation of macro shocks

Identification assumptions

1. *Identification problem, invertibility*

   * Fernández-Villaverde, J., Rubio-Ramírez, J. F., Sargent T. J., and Watson, M. W. (2007). "ABCs (and Ds) of Understanding VARs." *American Economic Review* 97(3), 1021–1026.

     Lippi, M., and Reichlin, L. (1994). "VAR analysis, nonfundamental representations, Blaschke matrices." *Journal of Econometrics* 63(1), 307–325.

     Leeper, E. M., Walker, T. B., & Yang, S. C. S. (2013). "Fiscal foresight and information flows." *Econometrica*, 81(3), 1115–1145.

Forni, M., Gambetti, L., and Sala, L. (2019). "Structural VARs and noninvertible macroeconomic models." *Journal of Applied Econometrics* 34(2), 221–246.

Plagborg-Møller, M., and Wolf, C. K. (2021). "Instrumental Variable Identification of Dynamic Variance Decompositions." *Journal of Political Economy*, forthcoming.

Chahrour, R., and Jurado, K. (2021). "Recoverability and Expectations-Driven Fluctuations." Manuscript, Duke University.

2. *Exclusion restrictions*

* Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1999). "Monetary policy shocks: What have we learned and to what end?" *Handbook of Macroeconomics*, 1, 65–148.

* Blanchard, O., and Quah, D. (1989). "The Dynamic Effects of Aggregate Demand and Supply Disturbances." *American Economic Review*, 79(4), 655–673.

Blanchard, O., & Perotti, R. (2002). "An empirical characterization of the dynamic effects of changes in government spending and taxes on output." *The Quarterly Journal of Economics*, 117(4), 1329–1368.

Ramey, V. A. (2011). "Identifying government spending shocks: It's all in the timing." *The Quarterly Journal of Economics*, 126(1), 1–50.

3. *Sign/magnitude restrictions*

* Uhlig, H. (2005). "What are the effects of monetary policy on output? Results from an agnostic identification procedure." *Journal of Monetary Economics* 52(2), 381–419.

* Baumeister, C., and Hamilton, J. D. (2015). "Sign Restrictions, Structural Vector Autoregressions, and Useful Prior Information." *Econometrica* 83(5), 1963–1999.

Mountford, A., & Uhlig, H. (2009). "What are the effects of fiscal policy shocks?" *Journal of Applied Econometrics*, 24(6), 960–992.

Gafarov, B., Meier, M., and Montiel Olea, J. L. (2018). "Delta-Method Inference for a Class of Set-Identified SVARs." *Journal of Econometrics* 203(2), 316–327.

Giacomini, R., and Kitagawa, T. (2020). "Robust Bayesian Inference for Set-Identified Models." *Econometrica*, forthcoming.

Wolf, C. K. (2020). "SVAR (Mis)Identification and the Real Effects of Monetary Policy Shocks." *American Economic Journal: Macroeconomics* 12(4), 1–32.

4. *Other invertibility-based methods*

   * Kilian and Lütkepohl: chapter 14.

   * Montiel Olea, J. L., Plagborg-Møller, M., and Qian, E. (2022). "SVAR Identification From Higher Moments: Has the Simultaneous Causality Problem Been Solved?" Working Paper.

   Rigobon, R. (2003). "Identification Through Heteroskedasticity." *Review of Economics and Statistics* 85(4), 777–792.

   Gouriéroux, C., Monfort, A., and Renne, J.-P. (2017). "Statistical inference for independent component analysis: Application to structural VAR models." *Journal of Econometrics* 196(1), 111–126.

   Francis, N., Owyang, M. T., Roush, J. E., & DiCecio, R. (2014). "A flexible finite-horizon alternative to long-run restrictions with an application to technology shocks." *Review of Economics and Statistics*, 96(4), 638–647.

   Brunnermeier, M., Palia, D., Sastry, K. A., & Sims, C. A. (2021). "Feedbacks: financial markets and economic activity." *American Economic Review*, 111(6), 1845-79.

5. *Instruments/proxies*

   * Stock, J. H., and Watson, M. W. (2018). "Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments." *Economic Journal* 128(610), 917–948.

   * Plagborg-Møller, M., and Wolf, C. K. (2021). "Instrumental Variable Identification of Dynamic Variance Decompositions." *Journal of Political Economy*, forthcoming.

   Gertler, M., and Karadi, P. (2015). "Monetary Policy Surprises, Credit Costs, and Economic Activity." *American Economic Journal: Macroeconomics* 7(1), 44–76.

   Nakamura, E., & Steinsson, J. (2018). "High-frequency identification of monetary non-neutrality: the information effect." *The Quarterly Journal of Economics*, 133(3), 1283–1330.

   Jarociński, M., & Karadi, P. (2020). "Deconstructing monetary policy surprises–the role of information shocks." *American Economic Journal: Macroeconomics*, 12(2), 1–43.

Känzig, D. R. (2021). "The macroeconomic effects of oil supply news: Evidence from OPEC announcements." *American Economic Review*, 111(4), 1092–1125.

6. *Other invertibility-robust methods*

Plagborg-Møller, M. (2019). "Bayesian Inference on Structural Impulse Response Functions." *Quantitative Economics* 10(1), 145–184.

Lippi, M., and Reichlin, L. (1994). "VAR analysis, nonfundamental representations, Blaschke matrices." *Journal of Econometrics* 63(1), 307–325.

Mertens, K., and Ravn, M. O. (2010). "Measuring the Impact of Fiscal Policy in the Face of Anticipation: A Structural VAR Approach." *Economic Journal* 120(544), 393–413.

Chahrour, R., and Jurado, K. (2021). "Recoverability and Expectations-Driven Fluctuations." Manuscript, Duke University.

Gouriéroux, C., Monfort, A., and Renne, J.-P. (2020). "Identification and Estimation in Non-Fundamental Structural VARMA Models." *Review of Economic Studies* 87(4), 1915–1953.

Estimation strategies

* Rubio-Ramírez, J. F., Waggoner, D. F., and Zha, T. (2010). "Structural vector autoregressions: Theory of identification and algorithms for inference." *Review of Economic Studies* 77(2), 665–696.

* Plagborg-Møller, M., & Wolf, C. K. (2021). "Local projections and VARs estimate the same impulse responses." *Econometrica*, 89(2), 955-980.

Sims, C. A. (1980). "Macroeconomics and Reality." *Econometrica* 48(1), 1–48.

Jordà, O. (2005). "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95(1), 161–182.

Barnichon, R., and Brownlees, C. (2019). "Impulse Response Estimation By Smooth Local Projections." *Review of Economics and Statistics* 101(3), 522–530.

Montiel Olea, J. L., and Plagborg-Møller, M. (2020). "Local Projection Inference is Simpler and More Robust Than You Think." *Econometrica*, forthcoming.

Li, D., Plagborg-Møller, M., & Wolf, C. K. (2021). "Local Projections vs. VARs: Lessons From Thousands of DGPs." arXiv preprint arXiv:2104.00655.

4   Using macroeconomic shocks

Identifying structural macroeconomic equations

* Barnichon, R., & Mesters, G. (2020). "Identifying modern macro equations with old shocks." *The Quarterly Journal of Economics*, 135(4), 2255–2298.

* Mavroeidis, S., Plagborg-Møller, M., & Stock, J. H. (2014). "Empirical evidence on inflation expectations in the New Keynesian Phillips Curve." *Journal of Economic Literature*, 52(1), 124–88.

Galí, J., & Gertler, M. (1999). "Inflation dynamics: A structural econometric analysis." *Journal of Monetary Economics*, 44(2), 195–222.

Campbell, J. Y., & Mankiw, N. G. (1989). "Consumption, income, and interest rates: Reinterpreting the time series evidence." *NBER Macroeconomics Annual*, 4, 185–216.

Hazell, J., Herreño, J., Nakamura, E., & Steinsson, J. (2022). "The slope of the Phillips Curve: evidence from US states." *The Quarterly Journal of Economics*, 137(3), 1299–1344.

Gruber, J. (2013). "A tax-based estimate of the elasticity of intertemporal substitution." *The Quarterly Journal of Finance*, 3(01), 1350001.

Policy rule counterfactuals

1. *History of thought: "Lucas program" & Sims-Zha approach*

   * Christiano, L. J., Eichenbaum, M., & Evans, C. L. (1999). "Monetary policy shocks: What have we learned and to what end?" *Handbook of Macroeconomics*, 1, 65–148.

   * Bernanke, B. S., Gertler, M., & Watson, M. (1997). "Systematic Monetary Policy and the Effects of Oil Price Shocks." *Brookings Papers on Economic Activity*, 1997(1), 91–157.

   * Sims, C. A., & Zha, T. (2006). "Does monetary policy generate recessions?." *Macroeconomic Dynamics*, 10(2), 231–272.

Hamilton, J. D., & Herrera, A. M. (2004). "Comment: oil shocks and aggregate macroeconomic behavior: the role of monetary policy." *Journal of Money, Credit and Banking*, 265–286.

Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). "Nominal rigidities and the dynamic effects of a shock to monetary policy." *Journal of Political Economy*, 113(1), 1–45.

Kilian, L., & Lewis, L. T. (2011). "Does the Fed respond to oil price shocks?" *The Economic Journal*, 121(555), 1047–1072.

2. *Recent developments & application to HANK*

* McKay, A., & Wolf, C. K. (2021) "What Can Time-Series Regressions Tell Us About Policy Counterfactuals?" Manuscript, MIT.

* Barnichon, R., & Mesters, G. (2020). "Identifying modern macro equations with old shocks." *The Quarterly Journal of Economics*, 135(4), 2255–2298.

Coibion, O., Gorodnichenko, Y., Kueng, L., & Silvia, J. (2017). "Innocent Bystanders? Monetary policy and inequality." *Journal of Monetary Economics*, 88, 70–89.

Acharya, S., Challe, E., & Dogra, K. (2020). "Optimal monetary policy according to HANK." Manuscript.

Bhandari, A., Evans, D., Golosov, M., & Sargent, T. J. (2021). "Inequality, Business Cycles, and Monetary-Fiscal Policy." *Econometrica*, 89(6), 2559–2599.

Inoue, A., & Rossi, B. (2021). "A new approach to measuring economic policy shocks, with an application to conventional and unconventional monetary policy." *Quantitative Economics*, 12(4), 1085-1138.

Beraja, M. (2021) "Counterfactual Equivalence in Macroeconomics" Manuscript, MIT.

Andersen, A. L., Johannesen, N., Jørgensen, M., & Peydró, J. L. (2021). "Monetary policy and inequality." Working Paper.

McKay, A., & Wolf, C. K. (2022) "Optimal Policy Rules in HANK" Manuscript, MIT.

Origins of business-cycle fluctuations

* Ramey, V. A. (2016). "Macroeconomic Shocks and Their Propagation." In *Handbook of Macroeconomics, Volume 2A*, edited by Taylor, J. B., and Uhlig, H., Elsevier, chapter 2, 71–162.

* Angeletos, G. M., Collard, F., & Dellas, H. (2020). "Business-cycle anatomy." *American Economic Review*, 110(10), 3030–70.

  Justiniano, A., Primiceri, G. E., & Tambalotti, A. (2010). "Investment shocks and business cycles." *Journal of Monetary Economics*, 57(2), 132-145.

  Auclert, A., Rognlie, M., & Straub, L. (2020). "Micro jumps, macro humps: Monetary policy and business cycles in an estimated HANK model." NBER Working Paper.

  Dieppe, A., Francis, N., & Kindberg-Hanlon, G. (2021). "The identification of dominant macroeconomic drivers: coping with confounding shocks." Working Paper.

5   Cross-sectional analysis

What does cross-sectional variation identify?

* Nakamura, E., & Steinsson, J. (2014). "Fiscal stimulus in a monetary union: Evidence from US regions." *American Economic Review*, 104(3), 753–92.

* Auclert, A., & Rognlie, M. (2018). "Inequality and aggregate demand." NBER Working Paper.

  Berger, D., Guerrieri, V., Lorenzoni, G., & Vavra, J. (2018). "House prices and consumer spending." *The Review of Economic Studies*, 85(3), 1502–1542.

  Koby, Y., & Wolf, C.K. (2020). "Aggregation in Heterogeneous-Firm Models: Theory and Measurement." Working Paper.

  Wolf, C. K. (2021). "Interest rate cuts vs. stimulus payments: An equivalence result." NBER Working Paper.

The "missing intercept"/aggregation problem

* Chodorow-Reich, G. (2019). "Geographic cross-sectional fiscal spending multipliers: What have we learned?" *American Economic Journal: Economic Policy*, 11(2), 1-34.

* Guren, A., McKay, A., Nakamura, E., & Steinsson, J. (2021). "What Do We Learn from Cross-Regional Empirical Estimates in Macroeconomics?" *NBER Macroeconomics Annual*, 35(1), 175–223.

* Wolf, C. K. (2021). "The missing intercept: A demand equivalence approach." NBER Working Paper.

Herreño, J. (2020). "The Aggregate Effects of Bank Lending Cuts." Working Paper.

Chodorow-Reich, G., Nenov, P. T., & Simsek, A. (2021). "Stock market wealth and the real economy: A local labor market approach." *American Economic Review*, 111(5), 1613–57.

Cross-sectional data in empirical time series analysis

Chang, M., Chen, X., & Schorfheide, F. (2021). "Heterogeneity and aggregate fluctuations." NBER Working Paper.

Liu, L., & Plagborg-Møller, M. (2021). "Full-information estimation of heterogeneous agent models using macro and micro data." arXiv preprint arXiv:2101.04771.

Identifying channels of shock propagation

* Holm, M. B., Paul, P., & Tischbirek, A. (2021). "The transmission of monetary policy under the microscope." *Journal of Political Economy*, 129(10), 2861-2904.