# Quantitative Macroeconomics

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**周四上午9：00-12:00，承泽园246教室**

1. **Course Description**

The objective of this course is to introduce graduate students to numerical methods and their computer implementations for solving economic models. Models in modern macroeconomics often are analytically intractable and have no closed-form solutions. In order to answer many interesting questions in the field, macroeconomists have been leaning more and more on numerical solutions of their models using powerful computers. In this course, we will learn many of the standard computational techniques required to solve such models. We will study computational methods that have seen many applications in economics and policy analysis. The economic applications will cover a wide range of problems including models from finance, macroeconomics, industrial organization and other research areas.

We begin by a brief survey of numerical methods required when analytical methods are not available for solving equations and systems of equations, for finding derivatives and integrals, and for solving optimization problems. After this, in the context of some standard representative agent dynamic stochastic general equilibrium models, we will look at methods that can be used to solve them, including value function iteration, policy function approximation, parameterized expectation algorithm, projection method and perturbation.

1. **Requirements**
2. Homework (50%). By its nature, the learning of methods requires using them. So there will be a number of hands-on homeworks assigned, which you should do carefully. I encourage you to talk to each other as you do these to speed up the learning. Learning computation for the first time is quite time-consuming, be ready to spend the time!
3. Project (50%). You will be required to submit a referee report on a computational paper from a list to be distributed at a later date. The referee report should consist of a summary of the paper, constructive commentary on the question and the execution of the solution - especially its computation and parameterization aspects - and some equally constructive suggestions for improvements or changes you would have liked to see. Slightly apart from a typical referee report, I ask you also to write a section at the end where you either propose an interesting extension of the paper, or a related question on which you yourself might consider writing a paper, employing methods learned in class. This is thus a combination of a referee report and a brief research proposal inspired by the paper you review. The last section of this project is a crucial part to be taken very seriously. To do a good proposal, it may be necessary for you to review other literature related to the paper at hand, and I expect not only a write-up of an idea, but also a fairly clear plan on how you would pursue the execution of the idea, computation included.
4. **Programming Languages**

The main programming languages used in this part is MATLAB and FORTRN, but you can freely use other programming languages, such as Python, R, C\C++, et al, this is up to you. So it helps if you have had previous programming experience in a language, but it is not a prerequisite - you can learn as you go. If you intend to work with computation in your research, now is the time to invest in learning a state-of-art programming language, such as Fortran. The speed will really matter if you ever plan to attempt any serious computation-based research. Matlab can be a fine substitute if you are not planning on taking computation far beyond this course. For both, there are lots of codes available online - which is a good way to learn. There is also a good Matlab primer available if you have never used it before, and there is a good reference for Fortran, by Metcalf and Reid, Fortran 90/95 Explained.

**Part 1: Solving Representative Agent Models**

by Professor Changhua Yu

**Textbook**

* Heer, B. and A. Maußner. *Dynamic General Equilibrium Modelling*. Springer, 2009.
* Judd, K. Numerical Methods in Economics. MIT Press, 1998.

**Other Relevant Books**

* Stokey, N., R. Lucas with E. Prescott. Recursive Methods in Economic Dynamics. 1989.
* Marimon, R. and A. Scott, eds. Computational Methods for the Study of Economic Dynamics. Oxford University Press, 1999.
* Michael Metcalf and John Reid, Fortran 90/95 Explained, Oxford University Press; Second edition (June 1 1999)
* Press, W., S. Teukolsky, W. Vetterling and B. Flannery. Numerical Recipes in Fortran77: The Art of Scientific Computing. Cambridge University Press, 2001. Available full-text online along with a Fortran 90 edition.

**Mini course outline (Week 1-5):**

1. **Basic Numerical Methods (1 week)**

* Differentiation/Integration, Optimization, Function Approximation: Heer and Maussner Ch 11, Judd Ch 4-7

1. **Value function iteration (1 week)**

* Heer and Maussner, 2008, Value Function Iteration as a Solution Method for the Ramsey Model

1. **Policy function iteration (1 week)**
   * Barillas, Francisco, and Jesús Fernández-Villaverde. "A generalization of the endogenous grid method." *Journal of Economic Dynamics and Control* 31.8 (2007): 2698-2712.
   * Hintermaier, Thomas, and Winfried Koeniger. "The method of endogenous gridpoints with occasionally binding constraints among endogenous variables." *Journal of Economic Dynamics and Control* 34.10 (2010): 2074-2088.
   * Mendoza, Enrique G., and Sergio Villalvazo. "FiPIt: A simple, fast global method for solving models with two endogenous states & occasionally binding constraints." *Review of Economic Dynamics* (2020).
   * Devereux, Michael B., and Changhua Yu. "International financial integration and crisis contagion." The *Review of Economic Studies* 87.3 (2020): 1174-1212.
2. **Projection method (1 week)**
   * Heer and Maussner, 2009, ch 6
   * Aruoba, S. Borağan, Jesus Fernandez-Villaverde, and Juan F. Rubio-Ramirez. "Comparing solution methods for dynamic equilibrium economies." *Journal of Economic dynamics and Control* 30.12 (2006): 2477-2508.
   * Kenneth, L. Judd, Lilia Maliar, Serguei Maliar and Inna Tsener (2017). "How to Solve Dynamic Stochastic Models Computing Expectations Just Once", *Quantitative Economics* 8 (3), 851-893.
   * Maliar,Lilia and Serguei Maliar, (2015). “Merging Simulation and Projection Aproaches to Solve High-Dimensional Problems with an Application to a New Keynesian model”, *Quantitative Economics* 6, 1-47
   * Maliar,Lilia and Serguei Maliar and Pablo Winant, (2019). “Will artificial intelligence replace computational economists any time soon?” CEPR working paper DP14024.
   * Maliar, Lilia, and Serguei Maliar. "Numerical methods for large-scale dynamic economic models." *Handbook of computational economics*. Vol. 3. Elsevier, 2014. 325-477.
3. **Perturbation (1 week)**
   * Heer and Maussner, 2009, ch 2
   * Andreasen, M. M., Fernández-Villaverde, J., & Rubio-Ramírez, J. F. (2018). The pruned state-space system for non-linear DSGE models: Theory and empirical applications. *The Review of Economic Studies*, 85(1), 1-49.

* Yu, Changhua. "Evaluating international financial integration in a center-periphery economy." *Journal of International Economics* 95.1 (2015):

**Part 2: Solving heterogeneous agent models**

**by Professor Bo Zhao**

**Text Book**

Heer, B. and A. Maußner. *Dynamic General Equilibrium Modelling*. Springer, 2009. (DGEM)

Judd, K. *Numerical Methods in Economics.* MIT Press, 1998. (NME)

**Mini course outline (Week 6-10):**

1. **Basic Numerical Methods (1 week)**

* Function Approximation, Differentiation/Integration, Root Finding, Optimization

DGEM Ch 11, NME Ch 4-7

1. **Stochastic Growth Model （1.5 weeks）**

DGEM Ch 4 & 6, NME Ch 10, 11 & 12.

* Aruoba, S. Boragan & Fernandez-Villaverde, Jesus & Rubio-Ramirez, Juan F., 2006. "Comparing solution methods for dynamic equilibrium economies," Journal of Economic Dynamics and Control, Elsevier, vol. 30(12), pages 2477-2508, December.

1. **Heterogenous-agent Model (2.5 weeks)**

DGEM Ch 7-8

* Christopher D. Carroll, The method of endogenous gridpoints for solving dynamic stochastic optimization problems, Economics Letters, Volume 91, Issue 3, 2006, Pages 312-320
* Barillas, Francisco & Fernandez-Villaverde, Jesus, 2007. "A generalization of the endogenous grid method," Journal of Economic Dynamics and Control, Elsevier, vol. 31(8), pages 2698-2712, August.
* Aiyagari, S. (1994). Uninsured Idiosyncratic Risk and Aggregate Saving. The Quarterly Journal of Economics, 109(3), 659-684
* Per Krusell & Anthony A. [Smith](https://ideas.repec.org/cgi-bin/refs.cgi) & Jr., 1998. "Income and Wealth Heterogeneity in the Macroeconomy," Journal of Political Economy, [University of](https://ideas.repec.org/cgi-bin/refs.cgi) Chicago Press, vol. 106(5), pages 867-896, October.
* Pierre-Olivier Gourinchas & Jonathan A. Parker, 2002. "Consumption Over the Life Cycle," Econometrica, Econometric Society, vol. 70(1), pages 47-89, January.
* Bo Zhao, Too poor to retire? Housing prices and retirement, Review of Economic Dynamics, Volume 27,2018,

**Part 3: Firm dynamics and estimation methods**

**by Professor Pin Yan**

**Textbook**

Adda and Cooper 2003. *Dynamic Economics: Quantitative Methods and Applications.*

**Mini course outline (Week 11-15):**

1. **Confronting Macro and Micro Data: Calibration and Structural Estimation**
2. **An Introduction to Models with Heterogeneous Firms**

* Hopenhayn, H. 1992. "Entry, Exit, and Firm Dynamics in Long Run quilibrium", Econometrica, 60, 1127-50.
* Hopenhayn, H. and R. Rogerson. 1993. "Job Turnover and Policy Evaluation: A General Equilibrium Analysis", Journal of Political Economy, 101, 915-38.

1. **Numerical Methods: Generalized Method of Moments (GMM)**

* Hansen, L. and K. Singleton. 1982. "Generalized Instrumental Variables Estimation of Nonlinear Rational Expectations Models", Econometrica, 50(5), 1269–1286.
* Whited, T., and G. Wu. 2006. “Financial Constraints Risk", The Review of Financial Studies, 19(2), 531-559.

1. **Numerical Methods: Simulated Maximum Likelihood (SML)**

* Dey, M. and C. Flinn. 2005. "An equilibrium Model of Health Insurance Provision and Wage Determination", Econometrica, 73(2), 571-627.

1. **Numerical Methods: Simulated Nonlinear Least Squares (SNLS)**

* Adda J. and R. Cooper. 2001. "Balladurette and Juppette: A Discrete Analysis of Scrapping Subsidies", Journal of Political Economy, 778-806.

1. **Numerical Methods: Simulated Method of Moments (SMM)**

* Bloom, N. 2009. "The Impact of Uncertainty Shocks", Econometrica, 77(3), 623-685.

1. **Parallel Processing and Other Computational Techniques**
2. **Extension to General Equilibrium Models**

* Bloom, N., M. Floetotto, N. Jaimovich, I. Eksten, and S. Terry. 2018. "Really Uncertain Business Cycles", Econometrica, 86(3), 1031-1065.