ECON7233: Continuous-time Models in Asset Pricing and Macroeconomics

TUE78 and THU89 — Spring 2025, Week 1 to Week 8

Instructor Information

Name: Kenji Wada

Webpage: https://sites.google.com/nyu.edu/kenji-wada/about?authuser=0

Office: TBW

Email: kenjiwada2402@ntu.edu.tw

Office Hours: After each class or by appointment

Class Information

Dates: February 16 - April 12

Time: Tuesday 14:20 to 16:20 and Thursday 15:30 to 17:20

Classroom: 社科608

Credits: 2

Course Description

This course provides an introduction to the frontier of continuous-time models in macroeconomics and asset pricing. The primary focus is to equip students with the mathematical and numerical techniques necessary to solve and characterize models in these areas, with particular emphasis on heterogeneous agent models. The course will explore recent continuous-time models in macroeconomics and asset pricing, illustrating key mathematical and numerical methods through practical examples. Please note that while this course does not aim to offer a comprehensive review of the existing literature, its primary objective is to teach students the fundamental mathematical and quantitative tools required to understand and conduct cutting-edge research in these fields. Additionally, the course highlights key model predictions from heterogeneous agent models, which can provide testable implications for macroeconomics and asset pricing in data.

This course is designed for graduate students who are interested in applying advanced modeling techniques in asset pricing and macroeconomics to their original research. Students are expected to have a solid understanding of core graduate-level subjects in macroeconomics, microeconomics, and econometrics. Familiarity with the fundamentals of stochastic calculus, as covered in the course "Introductory Stochastic Calculus with Applications to Economics and Finance," is also expected. We will provide a brief review of these concepts in the first week.

Additionally, students should be familiar with scientific programming software. While I will be using Matlab, students are welcome to use any suitable software, such as Julia or Python. John Stachurski and Tom Sargent have developed QuantEcon website, an excellent introduction to computational methods for economics using Python and Julia, which can be accessed here: https://quantecon.org/. For beginners in Matlab, the book "*Applied Computational Economics and Finance*" by Miranda and Fackler (2004) serves as an excellent practical introduction to computational methods for applied economic problems.

Course Objectives

The purpose of this course is to provide students with the mathematical and numerical techniques used in continuous-time macroeconomic and asset pricing theory. Students will engage with both analytical problems and the implementation of numerical methods learned during the lectures. These methods will be applied to solve macroeconomic and asset pricing models through problem sets. By the end of the course, students are expected to:

1. Understand how to solve and characterize continuous-time models both analytically and numerically.

2. Acquire practical skills needed to read and comprehend recent research papers in the fields of macroeconomics and asset pricing, thereby inspiring their own research ideas.

3. Present existing papers in the literature in a clear and concise manner.

Textbook

Textbook: There are no mandatory readings for this course. Lecture notes or slides will be delivered.

For some macroeconomic and asset pricing applications,

- He and Krishnamurthy (2013), “Intermediary asset pricing,” American Economic Review, 103(2): 732-770. A general equilibrium asset pricing model with financial intermediaries suitable for policy analysis during financial crises.
- He and Krishnamurthy (2019), “A macroeconomic framework for quantifying systemic risk,” American Economic Journal: Macroeconomics, 11(4): 1-37. A general equilibrium macroeconomic model with financial intermediaries matched with nonlinearity of macroeconomic and financial data.
- Achdou, Han, Lasry, Lions, Moll (2020), “Income and wealth distribution in macroeconomics: A continuous-time approach,” The Review of Economic Studies, 89(1): 45-86. Heterogeneous-agent incomplete market model.

For numerical methods,

- Judd (1998), Numerical Methods in Economics. Some relevant methods for solving differential equations.
- Duffie (2001), Dynamic Asset Pricing Theory. The Appendices cover numerical methods for PDEs derived from basic option pricing models.
- Candler (2001), “Finite-Difference Methods for Continuous-Time Dynamic Programming,” In Computational Methods for the Study of Dynamic Economies, chapter 8. Oxford University Press. A summary of upwind methods in the context of optimal controls in a consumption and saving problem.
- Miranda and Fackler (2004), " Applied Computational Economics and Finance," MIT Press. A good practical introduction for applied economic and financial problems in Matlab.

- Holmes (2007), Introduction to Numerical Methods in Differential Equations. A specialized textbook on numerical solutions of PDEs.
- Achdou, Han, Lasry, Lions, Moll (2020), "Income and wealth distribution in macroeconomics: A continuous-time approach," The Review of Economic Studies, 89(1): 45-86. The Appendices contain both mathematical and numerical applications of optimal control and Kolmogorov equations in a general equilibrium model with heterogeneous agents.
- Maxed, Peter (2023). "A Macro-Finance Model with Sentiment." Forthcoming in Review of Economic Studies. The Appendix contains excellent practical guidance of numerical methods to solve equilibrium nonlinear PDEs.

Homework

I will assign three problem sets throughout the course. For each problem set, students are required to submit both their answers and the corresponding code. I will check the submissions for completeness, but I will not provide detailed corrections. The problem sets will include both analytical and computational questions, which will require students to write code and implement the numerical methods covered in class. Deadlines for each problem set will be determined based on the course schedule and circumstances.

After the deadlines, answer keys and some sample codes will be posted to help students evaluate their own work.

Final Presentations

Students are required to select and present a paper that employs numerical methods in continuous-time macroeconomics and asset pricing during the final presentation in Week 8. The goal is for students to explain both the model and the numerical techniques used to solve it. Providing constructive criticism and presenting original research ideas based on the chosen paper will be highly valued.

I will provide a list of recommended papers for students to choose from, but students are not limited to this list. Students must inform me of their chosen paper by the end of Week 6 and obtain my approval before proceeding with the presentation. In addition, students are required to submit the presentation slides by the end of Tuesday in Week 7. This will allow for feedback from the instructor, which students are expected to incorporate into their final presentation.

Grading

The course grade is determined by the following components:

Problem sets	70%
Final Presentations	30%

Grade Scale

Final grades will be assigned according to the following scale subject to change:

A+	90 – 100	B-	65 – 69
A	85 – 89	C+	60 – 64
A-	80 – 84	C	55 – 59
B+	75 – 79	C-	50 – 54
B	70 – 74	F	0 – 49

Email Policy

I typically answer emails quickly, almost always within a day. Please feel free to contact me regarding class materials, assignments, and final presentations.

Tentative Schedule

The following is a *tentative* schedule for the course subject to changes.

Week	TUE78	THU89
1	Review: stochastic calculus	Option pricing
2	Numerical methods: linear PDEs and option pricing	Nonlinear PDEs and HJB equations
3	Local martingale and stopping times	Continue
4	Kolmogorov equations and boundary behavior: theory	Continue
5	Review on intermediary asset pricing	Continue
6	Macroeconomic model with financial frictions: theory	Numerical methods
7	Continue	No class (Holiday)
8	Student presentation	Continue