# Syllabus Quantitative Macroeconomics CEMFI – Spring 2025

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Last Updated: March 1st, 2025

Schedule. Tuesdays 9:30h-11:00h, and 11:30h-13:00h. Wednesdays 11:30h-13:00h.

**Course Description.** This course introduces the techniques of modern quantitative macroeconomics to study heterogeneous agent economies. We will study models with either (a) household heterogeneity–with a special focus on the life cycle dimension–or (b) firm heterogeneity–with a special focus on firm dynamics. One important aspect of the course is the emphasis on learning how to solve these economies on the computer. To this end, there will be problem sets that will guide you on how to solve the canonical models of Bewley-Imrohoroglu-Huggett-Aiyagari for the household heterogeneity part and Hopenhayn and Rogerson (1993a) for firm heterogeneity.

Topics. (see detailed contents below)

- 1. Dynamic Programming
- 2. Heterogenous Agents Models
- 3. Numerical Methods Applied to Heterogenous Agents Models
- 4. Some Extensions of the Heterogeneous Agent Model
- 5. Income Processes
- 6. Wealth Inequality
- 7. Firm Heterogeneity
- 8. Reading Group

**Requirements.** Students are expected to understand the basics of the Arrow-Debreu model with uncertainty, OLG models, the one-sector growth model, and real business cycle models covered in Macroeconomics I and II. The main tools you need to understand for this course are (1) Dynamic Programming, (2) a little bit of Measure Theory, and (3) Markov chains. We will cover these topics in the initial weeks. A comprehensive treatment can be found in Stokey and Lucas Jr (1989). The course will mainly be based on Lecture Notes and published or unpublished articles. You can find a nice treatment of several topics that we will cover in the course in Ljungqvist and Sargent (2012, chapters 2, 3, and 4). Judd (1998) and Miranda and Fackler (2004) provide in-depth coverage of useful quantitative methods for economists.

**Calendar.** The course is 10 weeks long, with three 90-minute sessions per week. In the bulk of the sessions we will go through the lecture notes. There will also be some review sessions with the TA. We reserve three Reading Group sessions at the end to discuss recent papers that relate to the topics covered in the course.

**Grading.** The final exam counts 70% of the final mark, homework grade counts 25%, and reading group sessions 5%.

**Homework.** There will be two types of problem sets: computer-based (4 of them) and paperand-pencil (2 of them). Plus a mixed one. Computer-based problem sets have to be solved in (stable) teams of two, but only one copy per team needs to be handed in. Paper-and-pencil problem sets follow the standard rules: you can work in teams, but every student has to submit its own solutions. Problem sets will be typically discussed in class on the date of submission.

**Coding and Computer Languages.** During the course you will have to do a substantial amount of coding. Students typically use Julia, Matlab, or Python. I use Matlab, but you can choose alternative programs. There will be a voluntary extra session on Matlab during the first week. If you are interested in learning Julia, QuantEcon is a good place to start.

**Contact.** You contact me via email at: federico.kochen@cemfi.es. You can ask me unresolved questions after class. In-person meetings are only by appointment.

**Teaching Assistant.** The course TA is Manuel Ruiz (manuel.ruiz@cemfi.edu.es). Manuel will take care of the paper-and-pencil sessions of the problem sets. He will be available to you if you need help with the computational problem sets.

# Contents of the Course

#### Part I. Dynamic Programming.

Estimated duration: 3 theory sessions

1. Dynamic Programming

The class lectures follow, loosely, Ljungqvist and Sargent (2012, chapters 3 and 4). The ultimate reference (all the theorems and some proofs) is Stokey and Lucas Jr (1989).

2. The neoclassical stochastic growth model: recursive formulation of the competitive equilibrium.

Brock and Mirman (1972) and Stokey, Lucas, and Prescott (1989, chapter 1)

#### Part II. Heterogeneous Agents Models.

Estimated duration: 3 theory sessions

- 1. What the RA Agent model cannot do
- 2. The inter-temporal consumption problem
  - The permanent income hypothesis
  - Uncertainty and the random walk

- Uncertainty and precautionary savings
- 3. The heterogeneous agents model in steady state.

Huggett (1993), Aiyagari (1994)

For a textbook exposition see Ljungqvist and Sargent (2012, Chapter 17).

### Part III. Numerical Methods Applied to Heterogeneous Agents Models.

Estimated duration: 3 theory sessions

- 1. Solving the household problem
  - Projection methods Judd (1992), Judd (1998, chapter 11) and McGrattan (1998)
  - A simple application: policy function iteration w/ piecewise linear approximation
- 2. Finding the steady state equilibrium.
  - Finding the stationary distribution: Montecarlo simulation, Young's method Young (2010)
  - Finding the equilibrium prices Aiyagari (1994) and Ríos-Rull (1998)
- 3. Accuracy

Judd (1992)

4. Solving non-linear equations

Judd (1998, chapter 5) or Heer and Maussner (2009, section 11.5)

## Part IV. Some Extensions of the Heterogeneous Households Model.

Estimated duration: 3 theory sessions

1. Life cycle

Huggett (1996)

2. Endogenous labor

Pijoan-Mas (2006), Heathcote, Storesletten, and Violante  $\left(2010\right)$ 

3. Discrete choices with extreme value shocks

4. Outside the Steady State

Krusell and Smith (1998), Ríos-Rull (1998), Krusell and Smith (2006), Boppart, Krusell, and Mitman (2018)

## Part V. Income Processes.

Estimated duration: 1 theory session

1. The standard income process and the evolution of earnings inequality

Storesletten, Telmer, and Yaron (2001), Storesletten, Telmer, and Yaron (2004), Heathcote, Storesletten, and Violante (2010)

- Heterogeneous income profiles
  Guvenen (2007), Guvenen (2009), and Guvenen and Smith (2014)
- 3. Non-linear earnings processes Guvenen, Karahan, Ozkan, and Song (2019), Arellano, Blundell, and Bonhomme (2017)
- 4. Endogenous earnings

Huggett, Ventura, and Yaron (2011)

#### Part VI. Wealth Inequality.

Estimated duration: 2 theory sessions

- 1. Some facts
- 2. Non-linear earnings

Castañeda, Díaz-Giménez, and Ríos-Rull (2003), De Nardi, Fella, and Paz-Pardo (2016)

 Heterogenous returns to savings Quadrini (2000), Cagetti and De Nardi (2006), Angeletos (2007), Hubmer, Krusell, and Smith (2019)

#### Part VII. Firm Heterogeneity.

Estimated duration: 5 theory sessions

A good survey on the topic can be found in Hopenhayn (2014a)

- 1. Some data
- 2. Entrepreneurship

Lucas (1978), Guner, Ventura, and Yi (2008)

3. Firm dynamics

Hopenhayn (1992), Hopenhayn and Rogerson (1993b), Restuccia and Rogerson (2008)

4. Misallocation

Hopenhayn (2014b), Hsieh and Klenow (2009), Bartelsman, Haltiwanger, and Scarpetta (2013)

5. Financial frictions

Moll (2014), Midrigan and Xu (2014)  $\,$ 

## Part VIII. Reading Group.

Estimated duration: 3 sessions

- 1. Empirical Analysis of Earning and Firm Dynamics
  - Guvenen (2009)
  - Sterk, Sedláček, and Pugsley (2021)
- 2. Wealth Inequality
  - Halvorsen, Hubmer, Ozkan, and Salgado (2024)
  - Peter (2021)
- 3. Financial Frictions and Misallocation
  - Boar, Gorea, and Midrigan (2025)
  - Guntin and Kochen (2024)

# References

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