Macroeconomics I

Josep Pijoan-Mas

CEMFI, 2024-2025

Course description. This is the first course of the macroeconomics sequence at CEMFI. In terms of topics, it focuses on the long-run behavior of economies. In terms of tools, it evolves around the neo-classical growth model in continuous time, including many different variations. The material will be presented primarily from a theoretical point of view, but we will contrast model predictions with empirical facts. As a preamble, we will devote the first two lectures to reviewing optimization methods in continuous time, providing you with the necessary mathematical tools to solve the models we will see later in the course.

Contents.
1. Dynamic Optimization in Continuous Time
2. The Neoclassical Growth Model
3. Multi-Sector Models and Growth
4. Endogenous Growth
5. Overlapping Generations Models
6. Firms

Schedule. Monday 11:30-13:00, Monday 15:00-16:30, and Wednesday 11:30-13:00.

Structure. The course lasts for 10 weeks with 3 sessions per week. We will normally have 2 sessions of theory and 1 to go through your homework every week. There will be two exceptions, with weeks 1 and 3, when all sessions will be theory.

Homework. There will be 8 problem sets for you to work at home. Of those, 7 will be paper-and-pencil style and 1 will be computational. For the 7 paper-and-pencil problem sets, every student will have to submit their own solutions individually. Only a few exercises will be graded (they will be specified in advance) and failure to submit will penalize the homework grade. For the computational problem set, solutions will be submitted by teams of two, and they will be graded.

Exam. There will be a 3-hours final exam at the end of the course.

Teaching assistant. Marta Domínguez will be the TA for the course. She will take care of most of the problem-set sessions and will run office hours.

Grading. The final exam counts 85% of the final mark, homework grade counts 10%, and class participation counts 5%.

Part I. Dynamic Optimization in Continuous Time.

- <u>Duration:</u> 2.5 theory sessions and no homework session.

- <u>Description</u>: We introduce the mathematical tools necessary to solve dynamic optimization problems in continuous-time settings, which will be useful for the rest of the course.

- <u>Program</u>:

    1. Calculus of Variations
    2. Optimal Control Theory (Hamiltonians)
    3. Dynamic Programming (Hamilton-Jacobi-Bellman Equations)

- <u>References:</u> This will be a math-intensive section without much economics. Chiang (1984) and Chiang (1992) are very good books. The mathematical appendix in Barro and Sala-i-Martin (1999) and Acemoglu (2009, chapter 7 and Appendix B) are also good references.

Part II. The Neoclassical Growth Model.

- <u>Duration</u>: 5 theory sessions and 3 homework sessions.

- <u>Description</u>: We will look at the horsework one-sector, exogenous growth model based on capital accumulation, and we will assess its empirical performance.

- <u>Program</u>:

    - Stylized Facts of Growth
    - The Solow Model
    - The Ramsey Model
    - Growth and Development Accounting

- <u>References</u>. The class notes for *Solow* and *Ramsey* will follow quite closely Barro and Sala-i-Martin (1999, chapters 1 and 2). For the *Solow Model*, additional references are Romer (1996, chapter 1) and Acemoglu (2009, chapter 2). For the *Ramsey Model*, additional references are Blanchard and Fischer (1991, chapter 2), Romer (1996, chapter 2) and Acemoglu (2009, chapter 8). For *Growth Accounting* you can have a look at Barro and Sala-i-Martin (1999, chapter 10) and for *Development Accounting* at Caselli (2005). The empirical performance of the Solow and Ramsey models is discussed in Acemoglu (2009, chapter 3) and Barro and Sala-i-Martin (1999, chapters 11 and 12). Several empirical facts discussed in class come from Jones (2016).

Part III. Multi-Sector Models and Growth.

- <u>Duration</u>: 3.5 theory sessions and 1 homework session.

- <u>Description</u>: We will extend the neoclassical framework to a multi-sector setting, and will study questions related to structural change of developing economies.

- <u>Program</u>:

    – The Multi-Sector Ramsey Model

    – Different Productivity Growth across Sectors

    – Non-Homothetic Preferences

- <u>References</u>. The class lectures do not follow any textbook, but you can find a good survey of structural change with data and a review of models in Herrendorf, Rogerson, and Valentinyi (2014). The part on *Different Productivity Growth* follows Ngai and Pissarides (2007). The part on *Non-Homothetic Preferences* follows Kongsamut, Rebelo, and Xie (2001). The structural change in transitional dynamics follows García-Santana, Pijoan-Mas, and Villacorta (2021). A textbook reference is Acemoglu (2009, chapter 20).

Part IV. Endogenous Growth.

- <u>Duration:</u> 4 theory sessions and 2 homework sessions.

- <u>Description</u>: We will study models in which growth stems not from capital accumulation, but from the generation of ideas as a by-product of firm-level decisions.

- <u>Program</u>:

    1. The AK Model

    2. Growth from Knowledge Externalities

    3. Growth from Expanding Varieties

    4. Schumpeterian Growth Models

- **References:** This part will track the development of endogenous growth theory in roughly chronological order, covering the most seminal papers along the way. The exposition will follow Barro and Sala-i-Martin (1999, chapters 4, 6 and 7) and Acemoglu (2009, chapters 11 through 15) closely. The basic model of growth with knowledge externalities is due to Romer (1986), and the foundational expanding-varieties growth model is due to Romer (1990). The first neo-Schumpeterian growth model with quality-ladder innovation is due to Aghion and Howitt (1992), and further developed by Grossman and Helpman (1991).

Part V. Overlapping Generations Models.

- <u>Duration</u>: 3 theory sessions and 1 homework session.

- <u>Description</u>: We will modify the household structure of the neoclassical growth model such that households have finite horizons and are born at different points in time.

- <u>Program</u>:

  - The basic OG model

  - Optimality

  - Altruism

  - Social Security

- References. The class lectures will somewhat follow Blanchard and Fischer (1991, chapter 3), but with very different notation. You can also have a slightly different approach with good intuitions in Romer (1996, chapter 2) and a very formal (and short) exposition in Barro and Sala-i-Martin (1999, chapter 3).

Part VI. Firms.

- <u>Duration</u>: 4 theory sessions 1 homework session.

- <u>Description</u>: We will zoom into the firm side of the neo-classical growth model by allowing for several extensions: heterogeneous firms, convex adjustment cost of capital, and the open economy.

- <u>Program</u>

  - Firm Heterogeneity

  - The q Theory of Investment

  - An Equilibrium Open Economy

- <u>References</u> The *Firm Heterogeneity* part is based on Lucas (1978) and follows the set up by Guner, Ventura, and Yi (2008). The basic model of the *q Theory* can be easily followed in Romer (1996, chapter 8), Acemoglu (2009, chapter 7) or in Adda and Cooper (2003, chapter 8). The *Open Economy* case follows Blanchard and Fischer (1991, chapter 2), although in the book they solve for the social planner problem. You can also look at Barro and Sala-i-Martin (1999, chapter 3).

Key words.

Calculus of Variations, Optimal Control, Dynamic Programming, Control and State Variables, Transversality Condition, Hamiltonian, Pontryagin's Maximum Principle, Bellman's Principle of Optimality, Hamilton-Jacobi-Bellman Equation, Poisson Point Process; Balanced Growth Path, Transitional Dynamics, Saddle Path Stability, Speed of Convergence, Diminishing Returns to Capital Accumulation, Neoclassical Production Function, Permanent Income Theory, Golden Rule, Modified Golden Rule, Dynamic Inefficiency, General Equilibrium; Structural Change, Dixit-Stiglitz Aggregator, Homothetic Demand, Baumol's Cost Disease; Learning-By-Doing, Externalities, Non-Rivalry, Non-Excludability, Knowledge Spillovers, Love-for-Variety, Monopolistic Competition, Free Entry, Expanding Varieties, Increasing Returns to Scale, Patents, Creative Destruction, Quality Ladder, Arrow Replacement Effect, Appropriability Effect, Business-Stealing Effect; PAYG Social Security, Fully Funded Social Security; Occupational Choice, Span-of-Control, Decreasing Returns to Scale, Average Firm Size, Convex Adjustment Costs, Tobin's Q, Small Open Economy, Horioka-Feldstein Puzzle, Current Account Balance.

References

ACEMOGLU, D. (2009): <u>Introduction to Modern Economic Growth</u>. Princeton University Press.

ADDA, J., AND R. COOPER (2003): <u>Dynamic Economics</u>. The MIT Press, Cambridge, Massachusetts.

AGHION, P., AND P. HOWITT (1992): "A Model of Growth through Creative Destruction," <u>Econometrica</u>, 60(2), 323–52.

BARRO, R., AND X. SALA-I-MARTIN (1999): <u>Economic Growth</u>. The MIT Press, Cambridge, Massachusetts.

BLANCHARD, O. J., AND S. FISCHER (1991): <u>Lectures on Macroeconomics</u>. The MIT Press, Cambridge, Massachusetts.

CASELLI, F. (2005): "Accounting for Cross-Country Income Differences," in <u>Handbook of Economic Growth</u>, ed. by P. Aghion, and S. Durlauf, vol. 1, chap. 9. Elsevier Science Publishers.

CHIANG, A. (1984): <u>Fundamental Methods Of Mathematical Economics</u>. McGraw-Hill.

———— (1992): <u>Elements Of Dynamic Optimization</u>. McGraw-Hill.

GARCÍA-SANTANA, M., J. PIJOAN-MAS, AND L. VILLACORTA (2021): "Investment Demand and Structural Change," <u>Econometrica</u>, 89(6), 2751–2785.

GROSSMAN, G. M., AND E. HELPMAN (1991): "Quality Ladders in the Theory of Growth," <u>Review of Economic Studies</u>, 58(3), 43 – 61.

GUNER, N., G. VENTURA, AND X. YI (2008): "Macroeconomic Implications of Size-Dependent Policies," <u>Review of Economic Dynamics</u>, 11(4), 724–744.

HERRENDORF, B., R. ROGERSON, AND A. VALENTINYI (2014): "Growth and Structural Transformation," in <u>Handbook of Economic Growth</u>, ed. by P. Aghion, and S. Durlauf, vol. 2, chap. 6, pp. 855–941. Elsevier Science Publishers.

JONES, C. (2016): "The Facts of Economic Growth," in <u>Handbook of Macroeconomics</u>, ed. by J. B. Taylor, and H. Uhlig, vol. 2, chap. 1. Elsevier Science Publishers.

KONGSAMUT, P., S. REBELO, AND D. XIE (2001): "Beyond Balanced Growth," <u>Review of Economic Studies</u>, 68(4), 869–882.

LUCAS, R. E. (1978): "On the Size Distribution of Business Firms," <u>Bell Journal of Economics</u>, 9(2), 508–523.

Ngai, R., and C. Pissarides (2007): "Structural Change in a Multisector Model of Growth," American Economic Review, 97, 429–443.

Romer, D. (1996): Advanced Macroeconomics. McGraw-Hill.

Romer, P. M. (1986): "Increasing Return and Long-run Growth," Journal of Political Economy, 94, 1002–36.

——— (1990): "Endogenous Technological Change," Journal of Political Economy, 98, S71–S102.