# NUMERICAL METHODS FOR ECONOMICS

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Hours:
Thursday 9:00-11:00 Aula Castellino
Thursday 14:00-16:00 Aula Castellino
We have also reserved the computer lab A in the first floor in the same slot

**Because of the pandemic, the course will begin online and will continue on line until the end of March. All the material for the lectures, classes and computer codes will be made available on line. The lectured will be uploaded using zoom and students can follow them and download them through moodle. Whenever I will write math concept, I will upload also the pdf of the notes as well as the audio with my comments. In addition, we will have every week or so an open office hour to discuss various issues.**

## The Course

The course is an introduction to contemporary numerical methods in quantitative economics: non linear equations, linear models, function approximation, numerical integration, stochastic difference equations, rational expectation equilibria, non- linear models, dynamic programming, markov chains and other tools used in contemporary economics.

The tools taught can be used in any field of economics. The spirit of the course is to help student realizing that contemporary economics has to rely on computer power and computing methods. Models will include an introeucion to Dynamic Stochastic General Equilibrium (DSGE) models. Nevertheless, Computer simulation is the *zeigest* of contemporary economics and examples are from all fields.

The main language used in the application is Python, a popular open source code that is now in becoming increasingly used in economics. Knowledge of Python or any other programming language is not essential, but some background in basic programming will be an advantage.

The material for the course will be available in Moodle

### Problem Sets

There will be approximately 5 problems sets to be uploaded into moodle and handed in with a combination of math and computer files. The computer script should be either a Jupyter notebook file (.ipynb or a spyder file .py) plus a **single** .pdf file if necessary.

**Exam and Simulation Essay**

The exam will be a combination of problems set (most likely 5) to be uploaded in moodle and a short eassy. See the separate file for description of the structure of the exam and the weights of the various parts.

## Main references and text

**Den-Haan, Wouter, Garibaldi, Pietro and Pontus Rendhal *"A Gentile Introduction to Computational Economics*", in progress (DGR)**

**Garibaldi, Pietro "A first pass to Numerical Economics". It will be available throughout the cours**e.

For some chapters there will also be lecture notes of a textbook that is in progress

More advanced stuff can be found at

Sargent, T. and J. Stachursky, "Quantitative Economics" freely available at www.quant-econ.net. Here after SAST, referred to the 2015 edition (the lectures are an on going project and are updated regularly, check website)

The theoretical background often uses as key references the following books. Key parts of the books will be made available to students wherever possible.

**Text Books on Dynamics Economics**

Janui Miao "*Economics Dynamics in Discrete Time"* (2014). Mit Press. Cambridge. Here after MIAO.

Adda Jerome and Russel Cooper "*Dynamic Economics*" MIT Press, (2004). Here after referred to AC

**Python General Books and Python for Economics and Statistics**

A further very good introduction to Python for Economics Statistics and Econometrics is

Sheppard, Kevin "*Introduction to Python for Econometrics, Statistics and Data Analysis*", 2nd edition, University of Oxford, available on-line in the authors' homepage.

Allen Downey (2012) "Think Python: How to Think Like a Computer Scientist" Freely available on the web.

The best introductory book I know for Python and programming is

Guttag, John V (2013) . "Introduction to Computation and Programming Using Python", MIT Press,

## 0 INTRODUCTION TO PYTHON AND TO SCIENTIFIC PYTHON

*References*

*Guttat (2013). Chapter 1-3*

*Stachursky (2015)* Notebook introduction to scientific Python. Available on at www.quant-econ.net

## 1 STATIC MODELS AND LINEAR MODELS:

Den-Haan, Wouter, Garibaldi, Pietro and Pontus Rendhal *"A Gentile Introduction to Computational Economics*", Chapter 1

## 2. NON LINEAR EQUATIONS

Den-Haan, Wouter, Garibaldi, Pietro and Pontus Rendhal *"A Gentile Introduction to Computational Economics*", Chapter 3

## 3. FUNCTION APPROXIMATION

Den-Haan, Wouter, Garibaldi, Pietro and Pontus Rendhal *"Function Approximation*", Chapter 2

## 4. INTRODUCTION TO DYNAMIC MODELS AND DETERMINISTIC GENERAL EQUILIBRIUM

Den-Haan, Wouter, Garibaldi, Pietro and Pontus Rendhal *"Inotroduction to Dynamic Models*", Chapter 2

Heer Burkhard, and Alfred Maussner (2004) Dynamic General Equilibrium Modeling, Computational Methods and Applications, chapter 1, 2nd edition. Springer. Chapter 1

## 5. DYNAMIC STOCHASTIC GENERAL EQUILIBRIUM (DSGE)

**Garibaldi, Pietro "A first pass to Numerical Economics"**

*Models*: Stochastic Ramsey solved with real linear stochastic difference equations; Basic Real Business Cycle. Montecarlo simulations

*Methods*: Blanchard Conditions in stochastic model and method of undetermined coefficients

*References:*

Heer Burkhard, and Alfred Maussner (2004) Dynamic General Equilibrium Modeling, Computational Methods and Applications, chapter 1, 2nd edition. Springer. Chapter 1

## 7. **DETERMINISTIC DYNAMIC PROGRAMMING: INTRODUCTION**

**Garibaldi, Pietro "A first pass to Numerical Economics"**

*Methods*: Value Function Iteration

*References*

Adda Cooper, AC, Chapter 2: Theory of Dynamic Programming

Adda Cooper ,AC Chapter 3 :Numerical Analysis

Sargent, T. and J. Stachursky, SAST, Infinite Horizon Dynamic Programming pag. 289

## 9. MARKOV CHAINS AND STOCHASTIC DYNAMIC PROGRAMMING

**Garibaldi, Pietro "A first pass to Numerical Economics"**

Methods: Pure (discrete) Markov Chains; ergodicity

*References*

Miao: Markov Chains section 3.1 in chapter 3, Markov Process (pages 63-73)

Sargent, T. and J. Stachursky : Finite Markov Chain, pag 196-210

## 10. SEARCH UNEMPLOYMENT

Mc Call lake problem; Diamond Mortensen Pissarides

Optimal stopping rule and dynamic programming.

Sargent, T. and J. Stachursky ,SAST A Lake Model of Employment and Unemployment