

Introduction

FIE463: Numerical Methods in Macroeconomics and Finance using Python

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About me

- Undergraduate studies in software engineering (& economics), PhD in Economics
- Research fields: Quantitative Macroeconomics & Household Finance
- 20+ years of programming experience:
 - Languages used previously (and mostly forgotten):
C/C++, Visual Basic, Java, JavaScript, PHP, Perl, SQL, Matlab, R
 - These days:
Python, Fortran, Unix shell scripts, Stata

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INTRODUCTION TO PYTHON

Why Python? ... and why not?

Why Python?

- Free and open-source
- Easy to learn, yet powerful and flexible syntax
- General-purpose language that can be used to solve many different problems
- Huge ecosystem of libraries and tools
- By now the most popular language overall
 - Most popular in machine learning
 - One of the two most popular in data science (together with R)
- It may not be the fastest, but offers easy ways to accelerate things (Cython, Numba, JAX, ML libraries)

What can you do with Python?

- Everything. The question is whether you should be using Python ...

Why not Python?

- You already know another language that solves your problem well
- You want to use an estimator/algorithm that is implemented elsewhere (Stata, R), but not in Python

Python popularity (1)

Since its creation in the 1990s, Python has climbed to the top of almost any programming language ranking.

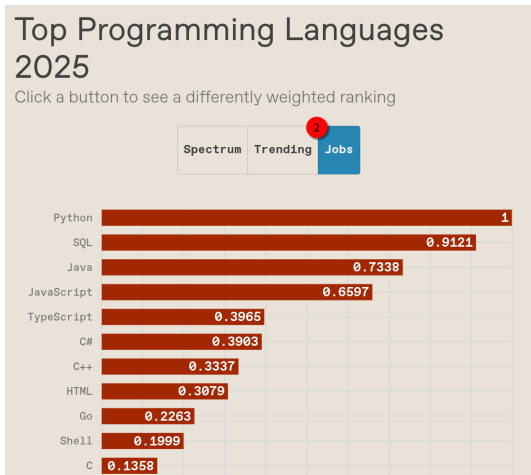


Figure 1: Source: IEEE The Top Programming Languages 2025

Python popularity (2)

“Which programming, scripting, and markup languages have you done extensive development work in over the past year?”



Figure 2: Source: [StackOverflow Developer Survey 2025](#)

Python popularity (3)

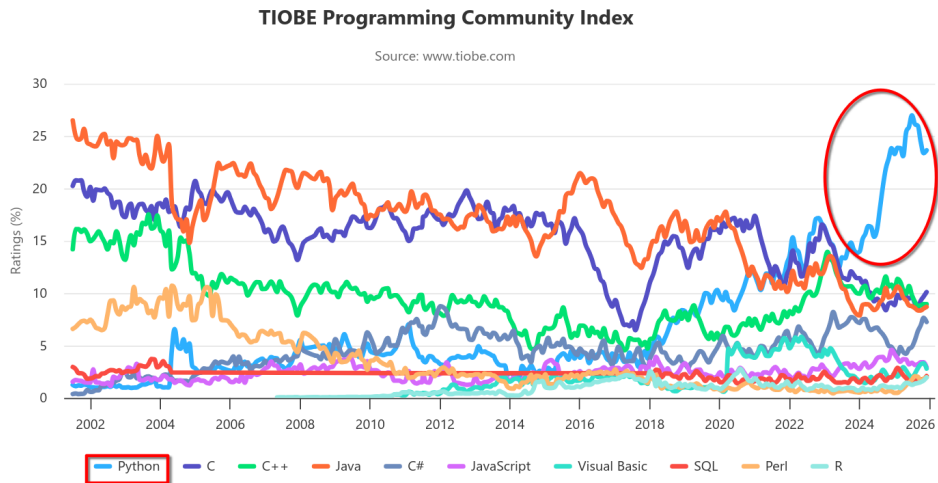


Figure 3: Source: TIOBE Index for December 2025

Python popularity (4)

GitHub: “AI leads Python to top language as the number of global developers surges”



Figure 4: Source: [GitHub Blog](#), October 2024

Python vs. other languages (1)

Matlab

- Proprietary, quite expensive
- Shipped as a complete software package from one vendor (plus optional toolboxes)
- (Legacy) industry standard, widely used
- Substantially less powerful syntax
- Pure Matlab is somewhat faster than pure Python, but Python is easier to accelerate

Julia

- Free, open source
- Focused on numerical computation, not on general-purpose computing
- Substantially faster than Python, but Python can be accelerated to similar speeds (using Numba)
- Popular among younger academics doing quantitative work
- Smaller ecosystem & less mature
- Not widely used or supported by Big Tech

Python vs. other languages (2)

R language

- Free, open source
- Focus on statistics, not on general-purpose computing
- Large ecosystem of packages for statistics, econometric modeling, and machine learning

Stata

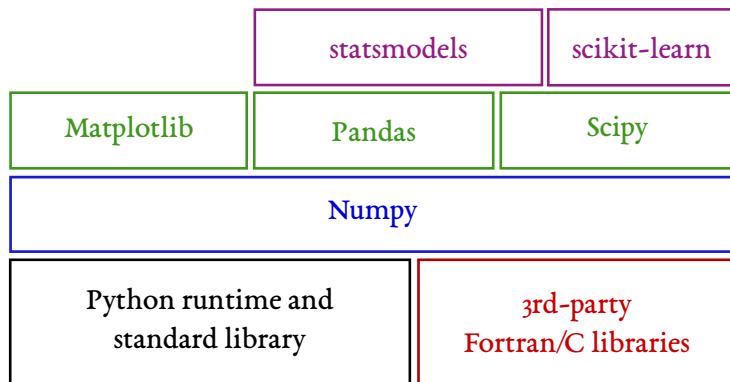
- Proprietary, quite expensive
- Focus on econometrics, in particular econometrics using large micro datasets
- Syntax was designed to run built-in commands, very inflexible for anything else
- If what you need is implemented, great! If not, it's very tedious to do it yourself (Mata is not great either)

PYTHON ECOSYSTEM

Python software stack

How things fit together

- “Python” is the language & standard library supported by the [Python Software Foundation](#)
- For numerical applications, we need additional third-party packages such as [NumPy](#), [SciPy](#), etc.



Python software stack (used in this course)

Core libraries for quantitative work

- **Python** language, runtime and standard libraries (“Python”)
- **NumPy**: implements n -dimensional arrays, linear algebra routines, random number generators
- **Matplotlib**: High-level plotting routines for visualization
- **Pandas**: Containers to handle heterogeneous data & routines for data analysis
- **SciPy**: Optimization routines, sparse matrices, integration, interpolation, linear algebra, statistics
- **scikit-learn**: routines used for machine learning (Ridge regression, Lasso, elastic net, etc.)

Python software stack (**not** covered in this course)

Econometrics & Machine learning

- [statsmodels](#): routines for estimating (linear) models
- [TensorFlow](#): ML library maintained by Google with Python API
- [JAX](#): Low-level API for automatic differentiation and accelerated linear algebra used to build ML models, developed by Google
- [PyTorch](#): Python interface to ML libraries originally developed by Facebook

Frameworks to speed things up

- [Numba](#): compiles Python code to machine code using LLVM
- [Cython](#): converts pseudo-Python to C code (advanced, don't use this)

Jupyter notebooks vs. Python files

This course often uses Jupyter notebooks, not “regular” Python scripts.

Jupyter notebooks

- File extension: `.ipynb`
- Interactive, dynamic notebooks
- Good for exploratory work
- Easy to share work with others, in particular if they are *not* data analysts or programmers
- Can be exported to other formats, e.g., PDFs, \LaTeX

Python scripts

- File extension: `.py`
- Interactive only in debugger
- For “serious” programming
- For libraries, reusable code
- Not useful to share with others who don't know Python

Jupyter notebooks

Explosive growth of Jupyter notebooks on GitHub that are used for data science, data visualization, and AI.

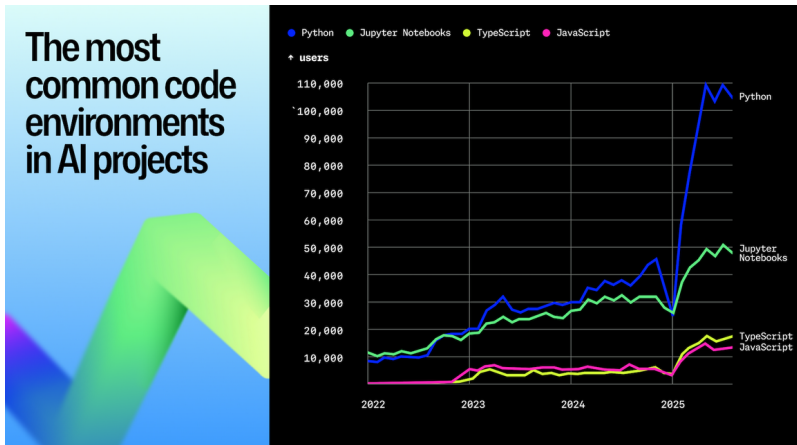


Figure 5: Source: [GitHub Blog](#), October 2025

SOFTWARE & TOOLS

Goal: learn to use industry-standard tools for programming in Python

- Python distribution: [Anaconda](#)
- Version control: [git](#)
- Code hosting: [GitHub](#)
- Editor: [Visual Studio Code](#)
- AI-assisted coding: [GitHub Copilot](#) and possibly other tools (e.g., [Gemini Code Assist](#), [Gemini CLI](#))

Why git? (and GitHub)

- Because everyone uses it: almost completely replaced all other version control systems over the last 19 years

Examples:

- Python: <https://github.com/python/cpython>
- NumPy: <https://github.com/numpy/numpy>
- SciPy: <https://github.com/scipy/scipy>
- Pandas: <https://github.com/pandas-dev/pandas>
- Matplotlib: <https://github.com/matplotlib/matplotlib>
- PyTorch (Meta's ML library): <https://github.com/pytorch/pytorch>
- TensorFlow (Google's ML library): <https://github.com/tensorflow/tensorflow>
- Keeps history of **your** code changes (and can restore previous versions)
- Keeps history of **others'** code changes
- Allows for decentralized coding in teams
- Allows synchronizing of code across devices

Why GitHub?

- Everyone uses it!
- Alternatives (less popular):
 - [GitLab](#)
 - [BitBucket](#)
- Offers many other services besides version control (issue tracking, Wiki, etc.)
- Register for free at <https://github.com/signup>
- Students can sign up for GitHub Pro for free (comes with higher GitHub Copilot usage quotas)

Why Visual Studio Code?

- Has become the most widely used editor for most languages (see [StackOverflow Developer Survey 2025](#))
- Free & open source
- Good support for almost any programming language and file format (e.g., Jupyter Notebooks) via extensions
- Natively supports git & GitHub (unlike older editors)
- Natively supports AI integration (GitHub Copilot)
- Almost any other recent "AI editor" (Cursor, Windsurf, Google Antigravity) is a clone of VS Code
- Alternative: PyCharm by JetBrains (free community edition is available, free professional edition for students)
- Note: [Visual Studio Code](#) completely independent of [Visual Studio](#), a commercial IDE from Microsoft for Windows development

VS Code is the most popular editor

“Which development environments and AI-enabled code editing tools did you use regularly over the past year?”

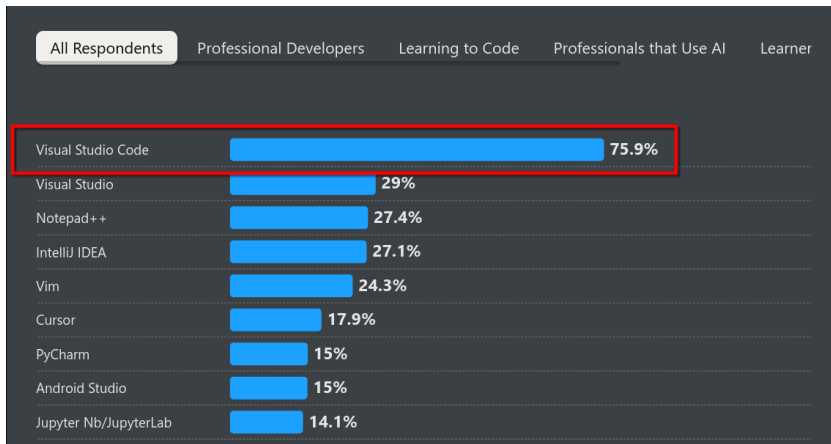


Figure 6: Source: [StackOverflow Developer Survey 2025](#)

COURSE OUTLINE & ASSESSMENT

Teaching approach

- 1 Lectures: introduce new concepts [Tuesday, 12:15–14:00]
- 2 Workshops: practice concepts from previous lecture [Thursday, 8:30–10:00]

Prerequisites

- No Python knowledge required
- Previous exposure to other programming languages (R, Julia, Matlab) is helpful

Course material

- Available on GitHub: <https://github.com/richardfoltyn/FIE463-V26>

Part 1 — Introduction to Python

Teaching weeks 3–6, January 20 – February 12

Contents

- Setting up a working environment
- Working with Visual Studio Code, Jupyter notebooks, git
- Basic programming concepts (syntax, data types, NumPy arrays)
- Control flow (conditional execution, loops)
- Functions and modules
- Random number generation
- Plotting with matplotlib
- Applications:
 - Maximization using grid search
 - Portfolio choice
 - Consumption-savings problems (partial equilibrium)

Teaching weeks 7–10, February 17 – March 12

Contents

- Advanced NumPy and SciPy
- Maximization and root-finding using standard algorithms
- Applications:
 - Labor supply & consumption-savings problems (including general equilibrium)
 - Portfolio choice
 - Overlapping-generations models (OLG)
 - Stochastic processes and simulation
 - Solving models with uncertainty

Teaching weeks 11–14, March 17 – April 9

- Introduction to pandas
- Processing data from various sources
- Introduction to unsupervised and supervised learning with scikit-learn
- Applications:
 - Obtaining macroeconomic & financial data from the internet
 - Predicting house prices, stock prices, or similar

Courses using Python at NHH

- 1 [FOR14](#) (BØA): Algorithms and Computer Programming with Python
 - 2 [BAN401](#): Applied Programming and Data Analysis for Business
 - 3 [BAN405](#): Python Programming for Data Science
 - 4 BAN436: Introduction to Python (1 week) [discontinued]
 - 5 BAN438: Application Development in Python [discontinued]
 - 6 [BAN442](#): From data to value: Machine Learning with Python (1 week)
-
- FIE463 overlaps with these in the first few weeks (intro to Python)
 - Parts 2 and 3 focus on applications in macroeconomics & finance, unlike the courses above

- **Individual programming assignment**
- Grading: Pass/Fail — Pass required to receive a grade in this course
- Hand-out date: Thursday, February 12 at 9:00
- Submission date: Wednesday, February 18 at 12:00

- 1 **Group project #1** (“Term paper”) [40%]
 - Hand-out date: Thursday, March 12 at 9:00
 - Submission date: Wednesday, March 18 at 12:00
 - 2 **Individual peer review** of another group’s project #1 [5%]
 - Hand-out date: Wednesday, March 18 at 15:00
 - Submission date: Tuesday, March 24 at 12:00
 - 3 **Group project #2** (“Term paper”) [50%]
 - Hand-out date: Thursday, April 9 at 9:00
 - Submission date: Wednesday, April 22 at 12:00
 - 4 **Individual peer review** of another group’s project #2 [5%]
 - Hand-out date: Wednesday, April 22 at 15:00
 - Submission date: Tuesday, April 28 at 12:00
-
- All 4 grade components must receive a passing grade to pass the course
 - Term papers are written in groups of 2–3. They cannot be done individually without good reason and prior approval

Goal: Use AI as a tool, not a crutch. You need to understand code to verify it.

Rules for this course

- **Part 1:** AI use is **discouraged**. Focus on building your own understanding.
- **Allowed:**
 - Coding assistant in lectures and workshops
 - Group projects and peer reviews (usage **must** be documented)
- **Forbidden:**
 - Handing in AI-generated output directly (copy/paste)
 - All text and analysis must be your own work

Note: We will have a dedicated workshop on GitHub Copilot (and possibly Gemini CLI/Gemini Code Assist) in Part 2.

Goal for today

Everyone should have a working environment up and running.

Steps:

- 1 Download and install Anaconda
- 2 Download and install [git](#)
- 3 Download and install [Visual Studio Code](#)
- 4 Create the FIE463 environment in the Terminal (Windows: Anaconda Prompt):
`conda create -f environment.yml`
- 5 Clone the course repository from GitHub in VS Code:
<https://github.com/richardfoltyn/FIE463-V26.git>
- 6 Run the notebook
`lectures/lecture00/test-environment.ipynb`
to verify that everything is working

ADDITIONAL RESOURCES

Additional resources — Books

Books

- [Think Python](#) by Allen B. Downey
General intro to Python, chapters are available as Jupyter notebooks.
- [Python for Everybody](#) by Charles R. Severance
General intro to Python with a focus on data analysis, available as PDF.

Online courses

- [QuantEcon lectures](#)
Python programming for economics & finance
- [Introduction to Programming and Numerical Analysis](#)
Python course at the University of Copenhagen, focusing on applications in macroeconomics

Additional resources

User guides and documentation

- [Numpy quick start tutorial](#)
- [Numpy tutorial for Matlab users](#)
- [scikit-learn user guide](#)

Code

- [QuantEcon library](#)
Collection of routines and tools for economics
- [QuantEcon repository](#)
Contributed code for solving economic problems in Python

Additional resources — Videos

Introduction to the command line / terminal:

- Absolute BEGINNER Guide to the **Mac OS** Terminal [17 min]
<https://youtu.be/aKRYQsKR46I>
- Git Bash - Simplest command line program for **Windows** [7 min]
<https://youtu.be/yoZ910JQzrg>

Introduction to using git

- Git for dummies [20 min] <https://youtu.be/mJ-qvsxPHpY>
- Git and GitHub Tutorial for Beginners [46 min] <https://youtu.be/tRZGeaHPoaw>
- Git Essentials in VS Code [30 min] <https://youtu.be/twsYxYaQikI>
Focuses on interacting with git and GitHub through VS Code