Introduction

FIE463: Numerical Methods in Macroeconomics and Finance using Python

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NHH Norwegian School of Economics

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Goals for today

1. Course introduction
2. Setting up your Python environment

Contents

1. Results from the student survey
2. Introduction to Python
   - Why Python?
   - Python vs. other languages
   - Python ecosystem
3. Software & tools
4. Course outline & assessment
   - Course outline
   - Assessment
5. Setting up your Python environment
6. Additional resources
   - Books & websites
   - Video tutorials

About me

- Undergraduate studies in software engineering (& economics), PhD in Economics
- Research fields: Quantitative Macroeconomics & Household Finance
- 25 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

Contact

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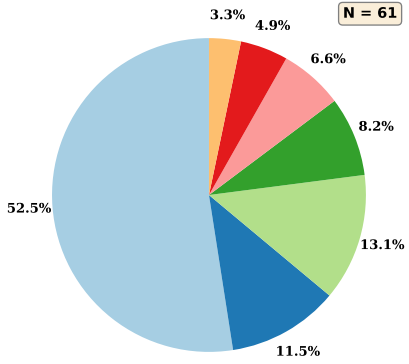
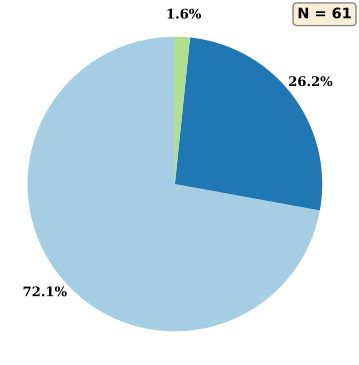
Results from the student survey

Results from the student survey

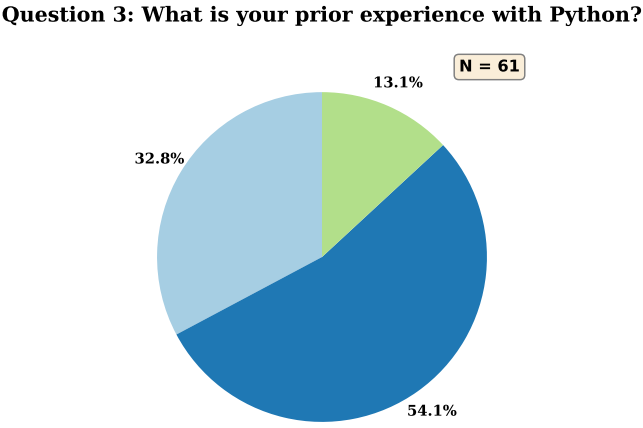
Question 1: What is your major at NHH?



Question 2: Which year are you in?



Results from the student survey



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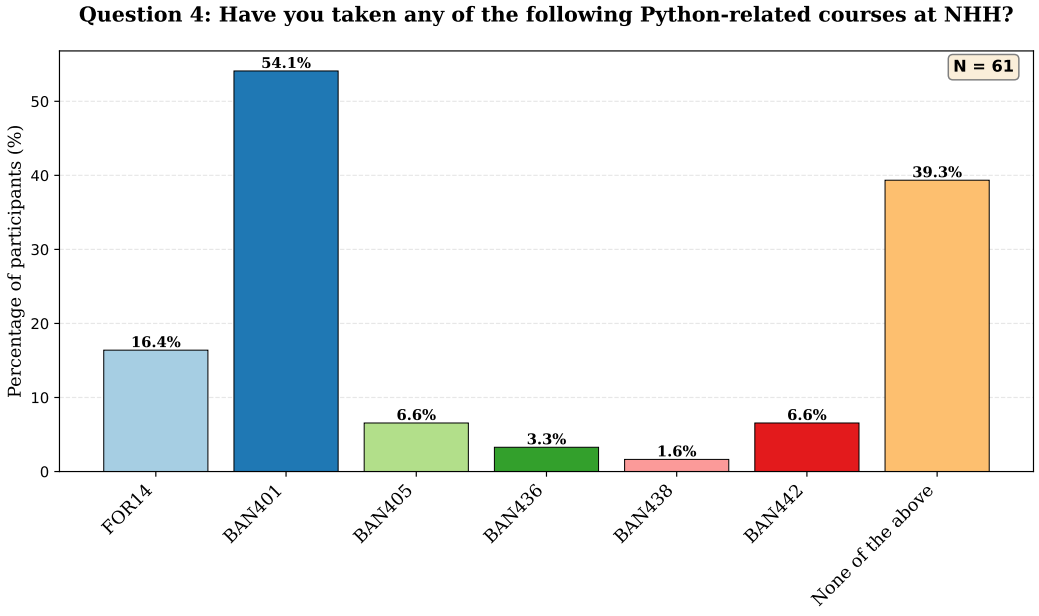

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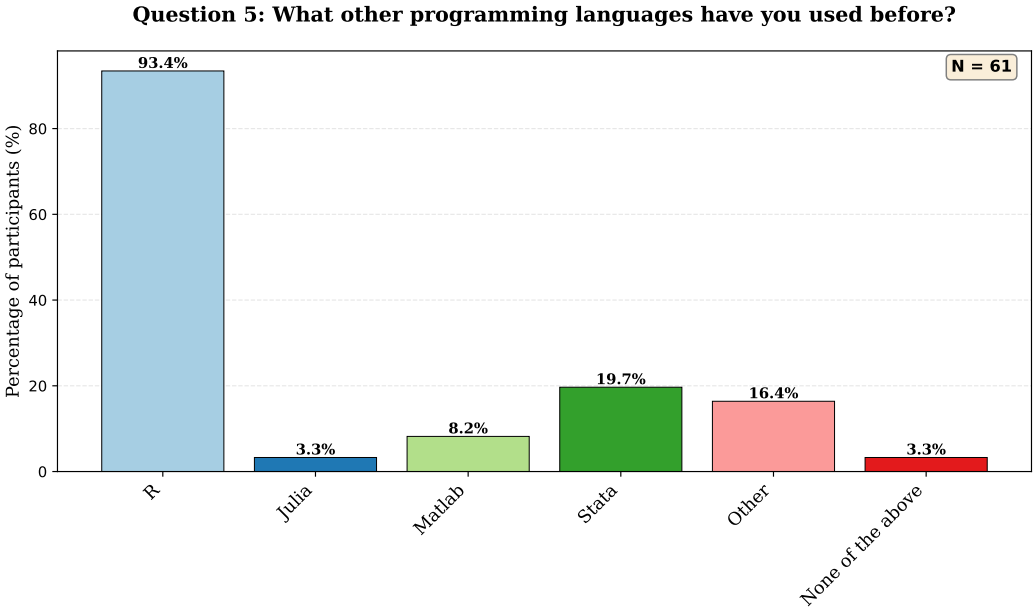

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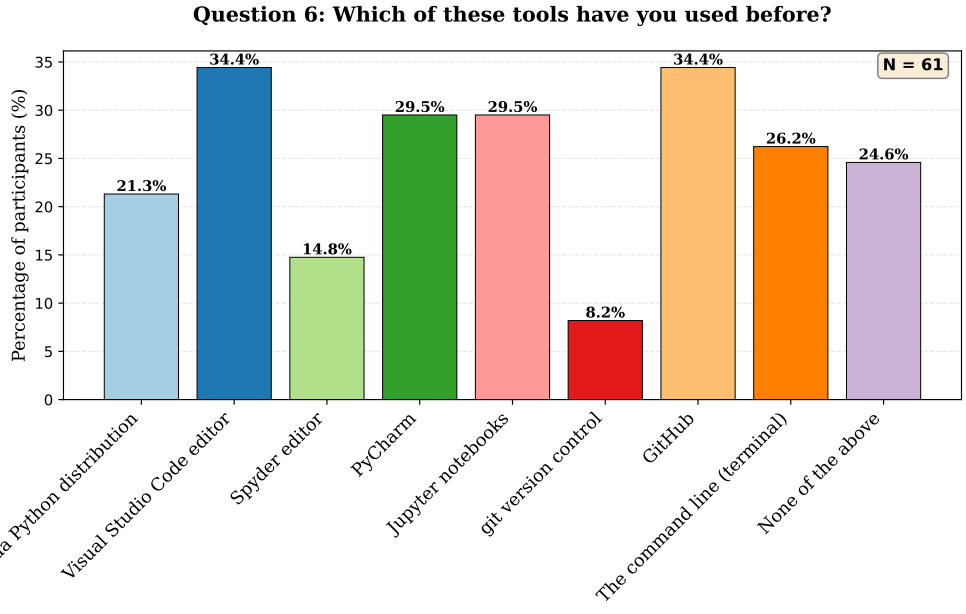

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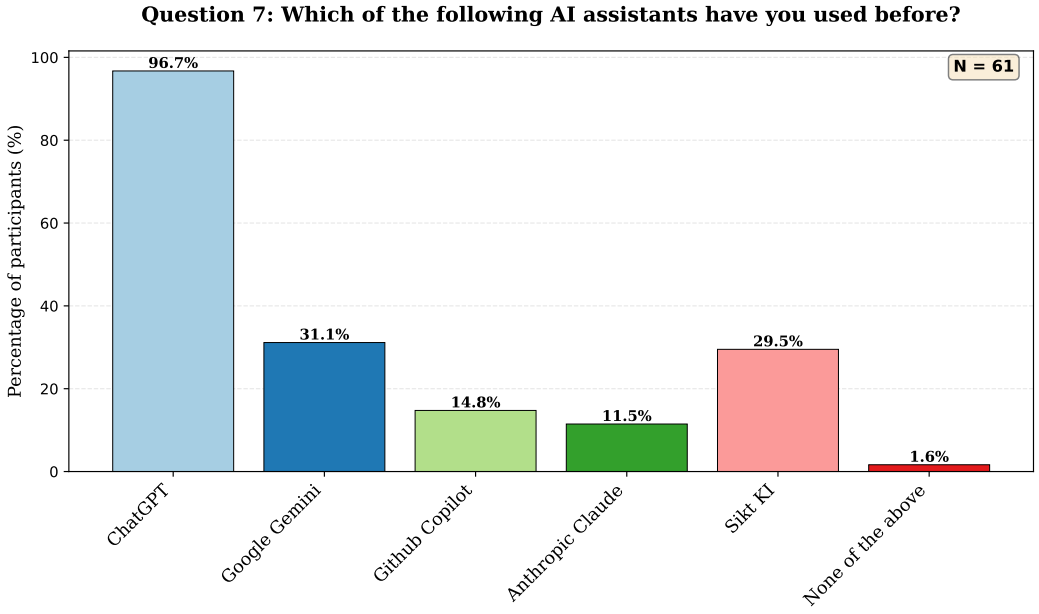


Introduction to Python

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 every programming language ranking.

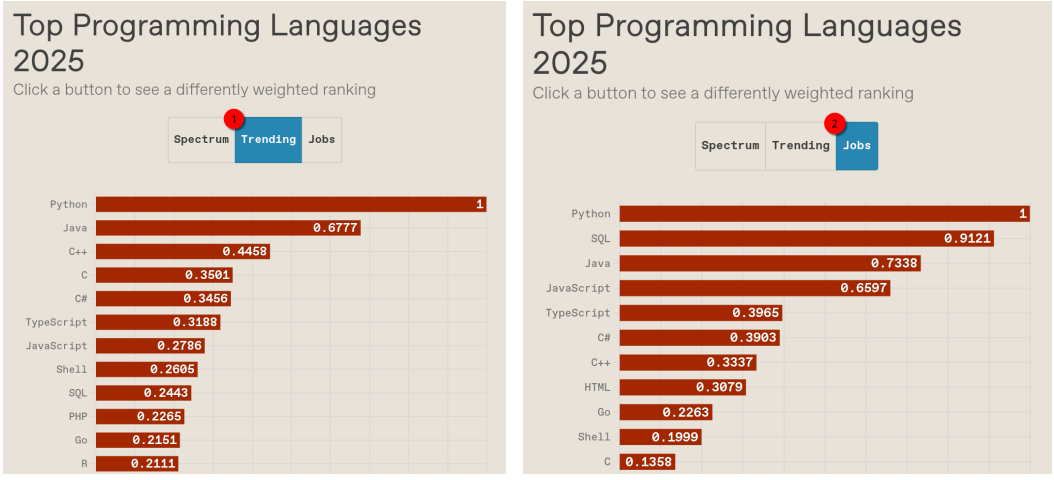


Figure 1: Source: IEEE The Top Programming Languages 2025

Python popularity (2)

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

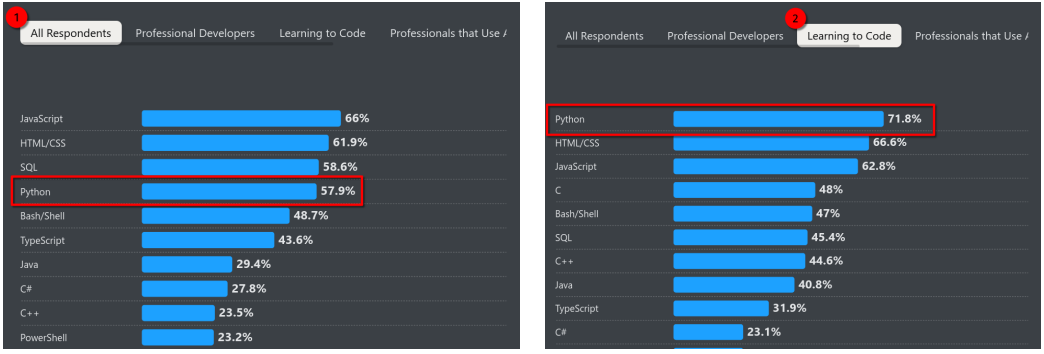


Figure 2: Source: StackOverflow Developer Survey 2025

Python popularity (3)

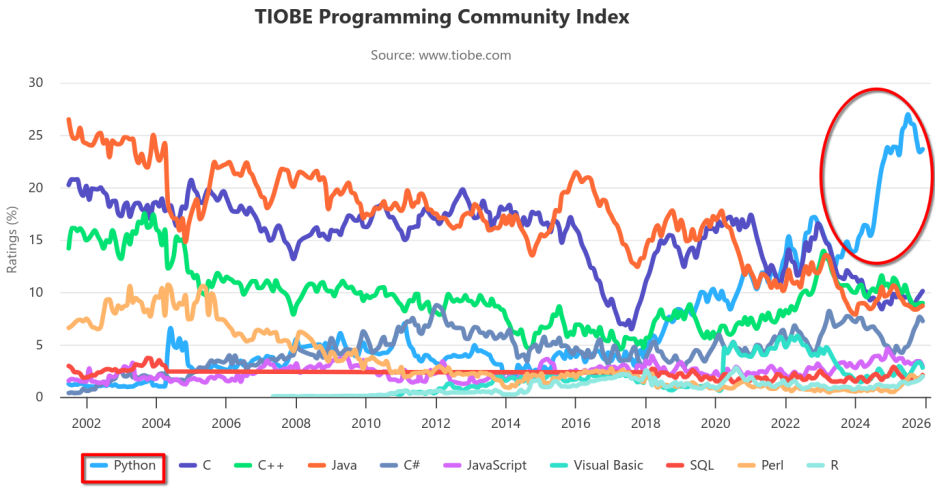


Figure 3: Source: TIOBE Index for December 2025

Python popularity (4)

GitHub: *"AI leads Python to top language as the number of global developers surges"*

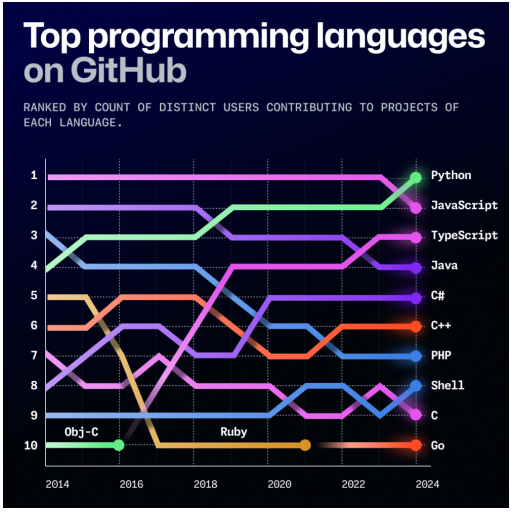


Figure 4: Source: GitHub Blog, October 2024

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
- Focused on statistics, not on general-purpose computing
- Large ecosystem of packages for statistics, econometric modeling, and machine learning

Stata

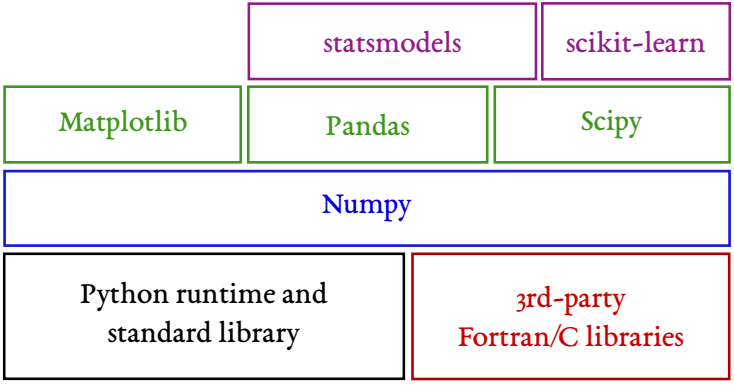
- Proprietary, quite expensive
- Focused on econometrics, in particular econometrics using large micro datasets
- Syntax was designed to run built-in commands, very inflexible for anything else
- If what you need is implemented, great! If not, it's very tedious to do it yourself (Mata is not great either)

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.

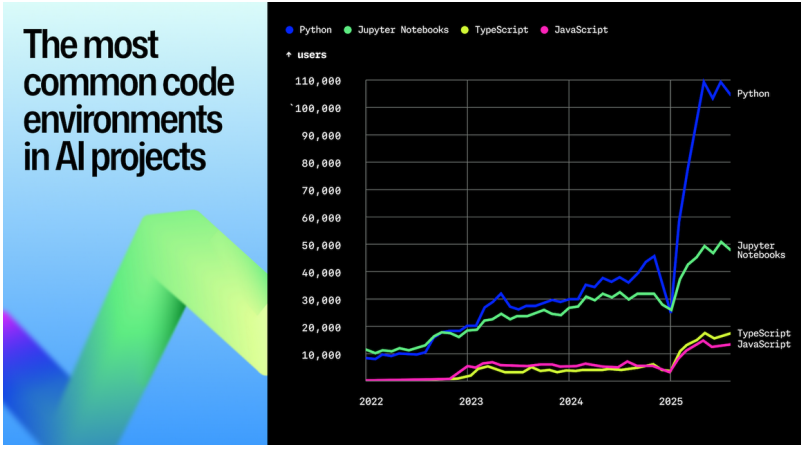


Figure 5: Source: GitHub Blog, October 2025

Software & Tools

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

GitHub

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)

Visual Studio Code

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 is 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?"

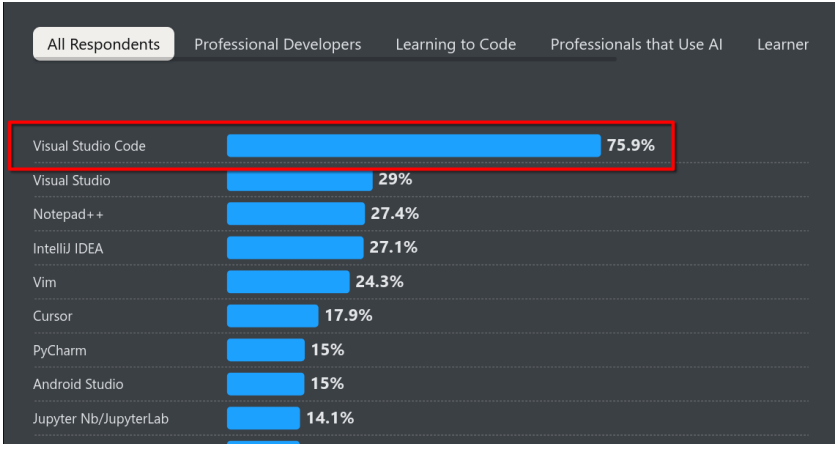


Figure 6: Source: StackOverflow Developer Survey 2025

Course outline & assessment

Course details

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)

Part 2 — Applications to models in macroeconomics & finance

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

Part 3 — Working with financial data

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

Course approval

- **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

Assessment

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

AI guidelines

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

Rules for this course

- **Encouraged**:
  - The AI learning companion on Sikt KI can help with installation issues, clarify concepts, explain solutions to exercises, or create additional exercises.
- **Allowed**:
  - Coding assistants in lectures and workshops
  - Coding assistants for group projects and peer reviews (usage **must** be documented)
  - However, use of coding assistants is **discouraged** in Part 1 of the course. Focus on building your own understanding.
- **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.

Setting up your Python environment

Setting up your Python environment

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. Clone the course repository from GitHub in VS Code:
   https://github.com/richardfoltyn/FIE463-V26.git
5. Create the FIE463 environment in the Terminal (Windows: Anaconda Prompt):
   1. Change to the directory where you cloned the GitHub repository, for example
      `cd "C:\Users\username\NHH\FIE463-V26"`
   2. Create the Anaconda environment using the `environment.yml` file:
      `conda env create -f environment.yml`
6. Run the notebook located at
   `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