Collegio Carlo Alberto

Python and Finance, Lorenzo Schoenleber

Course Description

The aim of the course is to provide a broad understanding, principles, and techniques of Python coding for the most popular quantitative applications, widely used in the financial industry and in academic research.

The course will cover various topics, with an emphasis on the hands-on implementation of those ideas in Jupyter Notebook and intuitively visualized output. A short introduction of Python (and some of the important packages) is given at the start of the course. The necessary historical financial data will be downloaded via various Python APIs straight from the web. To improve the performance of some of the quantitative models and investment strategies to forward-looking (option-implied) information is referred.

The course roughly splits into five parts (see below for more information): i) Risk Analytics, ii) Trading Strategies, iii) Portfolio Optimization, iv) Forecasting, and vi) Risk Management. Please note that you will require a good understanding of mathematics in order to understand some of this material.

I. Risk Analytics

The most important risk statistics (alpha, betas, average return, standard deviation, sharp ratio, information ratio, value at risk, conditional value at risk, drawdown, turnover) will be discussed and implemented in Python. These risk analytics serve as a solid foundation for benchmarking the investment strategies in the upcoming sections.

II. Trading Strategies - Factor Investing, Smart Beta, Signals, Sorting

With the boom in technological advancements in trading and financial market applications, algorithmic trading is being welcomed and accepted by exchanges all over the world. Smart beta investing combines the benefits of passive investing and the advantages of active investing strategies. In the lecture, some Fama-French type quant factors (HML, SMB, MOM, VOL) will be implemented.

III. Portfolio Optimization

State-of-the-art portfolio optimization techniques have been proven popular in investment management. In a first step the Mean-variance framework will be studied and enriched with various alternative specifications such as additional risk constraints, portfolio selection with higher moments, transaction costs, and robustness improvement methods via resampling. The optimization will be performed using SciPy which is a free and open-source Python library used for scientific computing.

IV. Forecasting (in-sample and out-of-sample)

In this section, we will discuss and apply various methods and aspects of forecasting financial quantities such as variance or returns but also macroeconomic variables such as GDP, industrial production, inflation, and so forth. Model Selecting methods such as Lasso and Ridge regressions are discussed and implemented in the next step. The forecasts are then applied to the before studied portfolio optimization techniques. In addition, this section serves a solid foundation of advanced forecasting methods applying machine learning techniques to improve the forecasting of financial quantities.

V. Advanced Risk Management Tools

In this section a discussion and an outlook of more sophisticated risk management models and tools is given, such as i) common distributions used in risk management (student t, pareto, multivariate normal), ii) additional ways to model dependencies, i.e. Copulas, iii) bootstrap procedures for VaR calculations.

Prerequisites: Knowledge of Python. Basic principles in Finance, Statistics, Probability theory, Optimization

Homework: Probably two take-home assignments which count for 50% of the overall grade. Group homework might be possible.

Exam: The final exam is to be taken in class and it is an open book exam.

Upon successful completion of this course, each student will be able to:

Program and analyze trading strategies in Python. Understand the fundamentals of factor investing and its nuances. Optimize a portfolio with respect to some risk criteria using the SciPy framework. Apply different forecasting methods to financial data or equity returns.

Texts/Readings

Textbook:

- Yves Hilpisch - Python for Finance - Analyze Big Financial Data
- Fabozzi, Kolm, Pachamanova, Focardi - Robust Portfolio Optimization and Management
- Prigent -Optimization and Performance Analysis
- Qlan, Hua, Sorensen - Quantitative Equity Portfolio Management - Modern Techniques and Applications
- Scherer - Portfolio Construction and Risk Budgeting

Factors

- Fama, French - The Cross-Section of Expected Stock Returns - 1992
- Fama, French - Common risk factors in the returns on stocks and bonds – 1993
- Carhart - On Persistence in Mutual Fund Performance - 1997
- Fama, French - Profitability Investment & Avg Returns – 2006
- Frazzini, Pedersen - Betting Against Beta – 2013
- Novy-Marx, Velikov - Betting Against Betting Against Beta – 2018

Forecasting

- Welch, Goyal - A Comprehensive Look at The Empirical Performance of Equity Premium Prediction, RFS 2007

Course Schedule

Table 1 **Course Schedule**

Week	Date	Topics, Readings, Assignments, Due Dates, Deadlines
1		Course Overview / Introduction to Python / Set-Up / Some Python Exercises (Pandas, Numpy)
2		Data APIs Theory and Implementation of Risk Analytics
3		Theory: Trading strategies - Factor Investing, Smart Beta, Signals, Sorting
4		Implement Fama-French type quant factors (HML, SMB, MOM, VOL) *Homework 1 – Deadline 2 Weeks*
5		Theory: Portfolio Optimization
6		Discuss Solutions to Homework 1 Implementation: Portfolio Optimization and resampling *Homework 2 – Deadline 2 Weeks*
7		Theory: Forecasting (in-sample and out-of-sample), Lasso and Ridge
8		Discuss Solutions to Homework 2 Implementation: Forecasting (in-sample and out-of-sample), Lasso and Ridge
9		Theory and Implementation of Advanced Risk Management Tools

Week	Date	Topics, Readings, Assignments, Due Dates, Deadlines
10		Q&A / Exam Type Exercises
Final Exam		Location and Time