MFE 2018-19
Michaelmas and Hilary Terms | Financial Econometrics

Financial Econometrics I and II

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1 Aims, objectives and intended learning outcomes

1.1 Basic aims

Financial econometrics I and II introduce students to modern financial econometrics, providing them with appropriate techniques for empirical investigation in financial economics. The course also provides background in probability theory for other courses in the MFE.

1.2 Specific objectives

The course assumes students possess basic knowledge of calculus and the probability theory of discrete random variables.

Financial Econometrics I (Michaelmas Term)

- *Basic concepts in probability*. Basic probability theory associated with continuous variables. Illustrated throughout with ideas of measuring the risk of holding an asset and portfolio. Multivariate distributions, covariances. Writing random variables in vectors and using matrices.
- *Conditional distributions in practice*. Regression models with random regressors. The relationship between the return on an asset and that of the market portfolio. Bayesian updating.
- *Convergence*. Introduce the idea of convergence in probability and a central limit theorem.
- *Simulation* and *asset price data*. Throughout the course, probabilistic ideas are illustrated using simulation and asset price data. Historical simulation.
- *Price processes*. Introduction to stochastic processes used in financial economics such as random walks, martingales, binomial trees, Poisson process.

- *Estimation and testing in econometrics*. Main concepts of estimation and testing in econometrics are introduced. Basic features of maximum likelihood and method of moments estimation. Consistency, hypotheses, power and bias. Likelihood-based testing.
- *Basic regression theory*. Deployment of basic linear regression emphasizing model building, evaluation and testing.
- *Time series modeling*. Stationarity, non-stationarity and integration.

Financial Econometrics II (Hilary Term)

- *Volatility*. Realistic models of asset price processes exhibit volatility clustering: ARCH, stochastic volatility, and realized volatility.
- *Value-at-Risk, Expected Shortfall and Density forecasting*. Volatility is often insufficient to summarize the uncertainty in an asset. VaR, ES and densities provide alternatives to conditional variances for measuring the riskiness of an asset.
- *Multivariate time series modeling*. Autoregressions, vector autoregressions, co-integration.
- *Multivariate models for financial time-series*. Copulas and Multivariate ARCH models.

1.3 Intended learning outcomes

Following class attendance, successful completion of assigned readings, assignments, both theoretical and empirical, and recommended private study, students should be able to

- Appreciate basic probability theory and use it to manipulate and characterize risk
- Model the relationship between multivariate variables
- Use econometric software to model, test, predict, understand and simulate financial data
- Have the tools to read texts, including recent research papers, which introduce new methods

2 Teaching resources

2.1 Lecturing

Lectures are provided by Jeremy Large (MT 1–4), Kevin Sheppard (MT 5–8 and HT 1–4), and James Wolter (HT 5–8).

Jeremy Large is a Fellow in Economics at St. Hugh's College. Jeremy completed his DPhil at Oxford and has worked in quantitative finance for nearly a decade.

Matthias Qian is a Departmental Lecturer at the Economics department which he joined this year. Matthias has completed his DPhil at Oxford; his research is on anomaly detection algorithms for time-series, with applications to real interest rates and the study of the price discovery on international equity markets. He manages and develops trading strategies for a private investment portfolio.

Kevin Sheppard is an Associate Professor of Financial Economics and a Fellow of Keble College. He joined Oxford in 2004 after completing his Ph.D. at UCSD. His research interests lie in modeling high-dimensional systems and measuring covariance using transaction data.

2.2 Class teachers

Zoe Fannon teaches classes in Hilary Term. She is a third year D.Phil. student (Economics) and has worked on econometric problems that are relevant to the insurance industry.

Tales Padilha teaches classes in Michaelmas Term. He is a first-year D.Phil. student (Economics) and his research focuses on time series econometric methods and their applications to financial econometrics and macroeconometrics.

2.3 Lectures and class meetings

Financial Econometrics I and II each consist of 24 lecture hours. These will be delivered using either 3 hour blocks or 1.5 hour blocks, at the discretion of the lecturer. Consult the course schedule for the precise dates, times and locations of the lectures. An assignment, designed to take 3 hours to complete, will be distributed after each lecture. These assignments are representative of the questions the final exam, and it is ***essential*** that sufficient effort made on these problems to ensure a satisfactory outcome in the course. For further details see section 2.4. Two classes will be given each week. The first will cover the assigned problem from the previous week and the second will offer a course in using MATLAB to analyze financial data. The MATLAB will be heavily utilized in the empirical assignments, in Asset Pricing in Hilary Term and in many electives in Trinity Term.

MATLAB

It is mandatory to develop sufficient empirical and computational skills to complete the final exam and formal practical assignments. Students will be given weekly non-assessed MATLAB exercises coordinated with the core course, and detailed answer sheets will be provided in subsequent weeks. Students must work through these assignments to prepare for the assessed empirical assignments in Hilary Term. Further information on MATLAB is available at `https://www.kevinsheppard.com/Category:MFE`.

2.4 Examinations

The course assessment consists of two components, practical and formal.

Practical

One take-home theoretical assignment and three empirical assignments covering the application of techniques developed in the course (10% each). These will be due in week 5 and 9 of each term. The empirical assignments are group work for up to 3 or 4 students and carry a 1,500 word/10 page limit.

Formal

A closed-book written exam, at the start of Trinity Term (in April 2019), examining the theory and practice of financial econometrics (60%). The exam will consist of two parts. The first part will consist of a set of short, compulsory questions which span the entire course. These questions will be either multiple choice and free response. The second part will consist of a choice of longer problems which will go into more depth about a particular topic covered in the course.

2.5 Lecture notes

Extensive and self-contained lecture notes linked into textbook expositions and research papers are provided by each lecturer throughout the course. The textbook suggestions and lecture notes are layered to benefit students with different technical backgrounds. It is *essential* that you read the notes prior to attending the lecture.

2.6 Software

Students are required to use various software packages to carry out calculations and perform empirical work. The MFE uses:

- MATLAB is a programming language with built-in support for matrices and sophisticated graphics and is commonly used in the finance industry. It will be used extensively throughout both parts of this course, as well as and in Asset Pricing II. All students are expected to attend 4 classes on MATLAB organized the first two weeks of the course. A student version of MATLAB is available from Oxford University Computing Services (OUCS) free of charge (See https://register.it.ox.ac.uk/self/index). It would be helpful if students can be familiar with MATLAB before the start of the course. We recommend reading a getting started guide for MATLAB. Book versions include Davis (2004) and Littlefield and Hanselman (2004).

- Excel is a common spreadsheet. Spreadsheets are the starting point for most data analysis. While the limitations of Excel become obvious quickly, knowledge of Excel is useful at all levels of econometrics.

2.7 Databases

The course makes extensive use of the Wharton Research Data Services (WRDS, pronounced the same as "words") system. In particular, asset price data from CRSP and TAQ is frequently utilized. The SBS library provides an introduction to this database and there is a brief introduction in the Virtual Library.

2.8 Requirements

The MFE's Maths Workbook provides a guide to the level of calculus and probability *before beginning the course* and includes numerous textbook references. We cannot emphasize enough how important it is for students to have completed this Workbook before coming to Oxford.

The course makes heavy use of basic mathematical tools and develops new ones. In particular, students are expected to be familiar with the following before coming to Oxford:

- Manipulation of algebraic expressions
- Solving and simplifying equations and inequalities
- Drawing and sketching graphs; sequences, series and limits
- Functions
- Differentiation and integration
- Simple unconstrained optimization
- Basic probability theory for discrete random variables

Over and above these topics, students should be comfortable expressing precise arguments in a mathematical notation.

Students come to the course from a variety of backgrounds. For this reason, specialist classes are provided at the start of the course to help students fill any gaps in their mathematical background. However, where students' mathematical backgrounds are limited, they are expected to have thoroughly prepared prior to the start of the course.

We provide the Maths Workbook to aid this preparation; we also provide a **diagnostic test**, which is given to all incoming students during the pre-course session in Oxford to try to identify to students any maths weaknesses they may have.

Students are expected to have read through either Koop (2006) or Brooks (2014) before they arrive in Oxford. This reading is **essential** for students with little background in probability or econometrics at the undergraduate level or for students who have not carried out any empirical work in finance. The Financial Econometrics course is more technical than these books but they will help you get into the material. If in doubt, please read both of these books.

3 Reading recommendations

Before students arrive in Oxford students MUST have read either (and preferably both) of

- Koop (2006) Ch. 1-12. Koop assumes less and is more appropriate if you are new to statistics or econometrics.
- Brooks (2014) Ch. 1, 4–6, 7.11-6.13 and 8–9. Sections specific to a software package can be ignored. Brooks goes into more detail than Koop and may be difficult if you do not have some familiarity with econometrics.

Extensive, mostly self-contained lecture notes are provided to students throughout the course. They are demanding and long. However, in econometrics less reading is required outside the lecture notes than in the other courses.

Nevertheless, students may find other books and articles helpful; and to help find them, the lecture notes suggest alternative treatments for each topic. These should be thought of as providing an alternative view of the material given in the lecture notes.

In the following list, textbooks named in **bold** serve as broad references for multiple portions of the MFE course across financial econometrics and asset pricing. The bibliography at the back of this document gives full details of these books.

General econometric textbooks

Greene (2007). General econometrics books at an introductory level.

Hayashi (2000). General econometrics books at a medium level.

Hamilton (1994). General textbook for time series econometrics.

Cameron and Trivedi (2005). General textbook for non-time series econometrics.

Greene (2007) maybe a good book for you to start out with, but we will do more advanced work than he covers. The technical level of Hayashi (2000) is pretty good for this course.

Financial Econometrics books

Campbell, Lo, and MacKinlay (1997). Nice balance of empirical work and method. Misses some major financial econometrics topics, but generally very strong and not a high technical level.

Gourieroux and Jasiak (2001). Higher technical level, less strong discussion of related literature. Rather self-contained.

Tsay (2002). Solid time series book on financial processes. Less emphasis on finance theory, but strong on statistics.

Taylor (2005). Similar to Campbell, Lo, and MacKinlay (1997), but more up to date.

Probability and Statistics

Mittelhammer (1999) contains a clear, accessible treatment of probability on the level of the course.

Hoel, Port, and Stone (1971) is an older introduction to statistics than Casella and Berger (2001) but may be more accessible for some students.

Specialist books

Arellano (2003). Elegant textbook on panel data econometrics. No emphasis on finance.

Christoffersen (2003). A textbook with a tractable introduction of risk management.

Cochrane (2001). General textbook on asset pricing with an emphasis on stochastic discount factors and generalized method of moments.

Hall (2005). A thorough treatment of the issues of generalized method of moments estimation with examples from both finance and economics.

Engle (1995). 20 classic papers on time-varying conditional volatility.

Singleton (2006). Good survey of empirical asset pricing at a high technical and empirical level.

Shephard (2005). 20 papers on time-varying volatility from a non-ARCH viewpoint.

Other recommendations

Hendry and Nielsen (2007) is a text designed to teach econometrics using maximum likelihood estimation as the organizing tool and not too technical.

A nice book on modern statistical theory is by Davidson and MacKinnon (2003), which would be of interest to students wishing to study econometrics after this year.

References

Arellano, Manuel (2003). *Panel Data Econometrics*. Oxford: Oxford University Press.

Brooks, Chris (May 2, 2014). *Introductory Econometrics for Finance Paperback*. 3rd ed. Cambridge University Press, p. 740.

Cameron, Colin A and Pravin K Trivedi (2005). *Microeconometrics*. Cambridge: Cambridge University Press.

Campbell, John Y, Andrew W Lo, and A Craig MacKinlay (1997). *The Econometrics of Financial Markets*. Princeton: Princeton Univeristy Press.

Casella, George and Roger L Berger (2001). *Statistical Inference (Hardcover)*. 2nd ed. Duxbury.

Christoffersen, Peter F (2003). *Elements of Financial Risk Management*. London: Academic Press Inc.

Cochrane, John H (2001). *Asset Pricing*. Princeton, N. J.: Princeton University Press.

Davidson, Russell and James G MacKinnon (2003). *Econometric Theory and Methods*. Oxford University Press.

Davis, Timothy A (2004). *Matlab Primer*. London: Chapman and Hall.

Engle, R F (1995). *ARCH: selected readings*. Oxford University Press, USA. isbn: 019877432X.

Gourieroux, Christian and Joann Jasiak (2001). *Financial Econometrics*. Princeton: Princeton University Press.

Greene, William H (Aug. 2007). *Econometric Analysis*. 6th ed. Prentice Hall, p. 1216.

Hall, Alastair R (2005). *Generalized Method of Moments*. Oxford: Oxford University Press.

Hamilton, James D (1994). *Time series analysis*. Princeton, N.J.: Princeton University Press.

Hayashi, Fumio (2000). *Econometrics*. Princeton University Press.

Hendry, David F and Bent Nielsen (2007). *An Introduction to Econometric Analysis*. Princeton.

Hoel, P G, S G Port, and C J Stone (1971). *Introduction to Probability Theory*. Boston: Houghton Mifflin.

Koop, Gary (Feb. 22, 2006). *Analysis of Financial Data*. 1st ed. New York: Wiley and Sons, p. 252.

Littlefield, Bruce L and Duane C Hanselman (2004). *Mastering Matlab 7*. Prentice Hall.

Mittelhammer, Ron C (1999). *Mathematical Statistics for Economics and Business*. Springer, p. 723.

Shephard, N (2005). *Stochastic volatility: selected readings*. Oxford University Press, USA. isbn: 0199257205.

Singleton, Kenneth J (2006). *Empirical Dynamic Asset Pricing: Model Specification and Econometric Assessment*. Princeton.

Taylor, Stephen J (2005). *Asset price dynamics, volatility, and prediction*. Princeton, N.J.; Oxford: Princeton University Press.

Tsay, Ruey (2002). *Analysis of Financial Time Series*. New York: Wiley.