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Day 0. 15.10.2014

STATISTICAL METHODS FOR FINANCE

Professor N. H. BINGHAM, Autumn 2014

6M47; 020-7594 2085; n.bingham@ic.ac.uk; Office hour Fri 4-5

Course website: My homepage.

This full-unit course consists of 38 lectures, in 19 2-hour days (4 hours Weeks 2-11 except for 2 hours Week 2: no lectures on Commemoration Day, Wed 22 October), Wed 10-12 + Fri 10-12, Room 140 – so start Day 1, Wed 15 Oct, finish Day 19, Fri 19 Dec. It is divided into seven chapters:

I Estimation [$4\frac{1}{2}$ hours, Days 1-3]
1. Parameters; likelihood [D1]
2. The Cramér-Rao inequality [D1]
3. Large-sample properties of maximum-likelihood estimators [D2]
4. Sufficiency and minimal sufficiency [D2]
5. Location and scale; tails [D2]
6. Complements [D3]

II Hypothesis Testing [3 hours, Days 3-4]
1. Formulation [D3]
2. The Neyman-Pearson lemma [D3]
3. Likelihood-ratio (LR) tests [D4]

III Multivariate Analysis. [$4\frac{1}{2}$ hours, Days 4-6]
1. Preliminaries; matrix theory [D4-5]
2. Singular-values decomposition (SVD) [D5]
3. Statistical setting [D5-6]
4. Sample and population [D6]
5. Principal components analysis (PCA) [D6]

IV Regression [6 hours, Days 7-9]
1. Least squares [D7]

2. The bivariate normal distribution [D7]
3. The multivariate normal distribution [D7-8]
4. Quadratic forms in normal variates [D8]
5. Estimation theory for the multivariate normal [D8-9]
6. Conditioning and regression [D9]
7. Generalised linear models (GLMs) [D9]

V Time Series [9 hours, Days 10-13]
1. Stationary processes and autocorrelation [D10]
2. The correlogram [D10]
3. Autoregressive processes, $AR(1)$ [D10]
4. General autoregressive processes, $AR(p)$ [D11]
5. Condition for stationarity [D11]
6. Moving average processes, $MA(q)$ [D11-12]
7. Autoregressive moving average processes $ARMA(p, q)$ [D12]
8. ARMA modelling; the general linear process [D12]
9. Wold decomposition; spectral methods; time and frequency domains [D12-13]
10. $ARCH$, $GARCH$ and Econometrics [D13]
11. State-space models and the Kalman filter [D13-14]
12. Complements [D14]

VI Non-parametrics [3 hours, Days 14-15]
1. Empiricals; the Glivenko-Cantelli theorem [D14]
2. Curve and surface fitting [D14-15]
3. Non-parametric likelihood [D15]
4. Limit theorems; Markov chains; MCMC [D15]

VII Bayesian Statistics [8 hours, Days 15-19]
1. Classical statistics and its limitations [D15]
2. Prior knowledge and how to update it [D15-16]
3. Prior and posterior densities [D16]
4. Examples [D16-17]
5. Pros and cons [D17-18]
6. Hierarchical models; Markov Chain Monte Carlo (MCMC) [D18]
7. Further Bayesian aspects [D18-19]

Problem sheets: 9 of them (Fridays, Weeks 3-11), divided between theory

and data analysis.
Exam: Standard format: 3 hours, 6 questions, do 5.
References
My website.

I have used links on my homepage to other courses I have taught, e.g.:
[IS] Introductory Statistics (which you have all seen);
[SP] Stochastic Processes (core course; NHB, 2010, 11; Tom Cass, 2012, 13);
[PfS] Probability for Statistics (core, MSc in Statistics; NHB, 2012, 13).
[Math428] (Mathematical Finance, MSc, Liverpool U., NHB, 2013, 14).
General Statistics.
[CB] George CASELLA and Robert L. BERGER, *Statistical inference*, Duxbury, 1990 (recommended for Ch. 6, Principles of data reduction, on sufficiency).
[R] C. R. RAO, *Linear statistical inference and its applications*, 2nd ed., Wiley, 1973 (1st ed. 1965).
Financial Statistics.
[LX] Tze Leung LAI and Hipeng XING, *Statistical models and methods for financial markets*, Springer, 2008.
[MFE] A. J. McNEIL, Rüdiger FREY and Paul EMBRECHTS, *Quantitative risk management: Concepts, tools, techniques.* Princeton UP, 2005.
[Lab] H. LABORDÈRE, *Analysis, geometry and modelling in finance: Advanced methods in option pricing.* Chapman & Hall, 2009.
[Gat] J. GATHERAL, *The volatility surface: A practioner's guide.* Wiley, 2006.
Markov chains.
[MeyT] S. MEYN and R. L. TWEEDIE, *Markov chains and stochastic stability*, 2nd ed., CUP, 2009 (1st ed. 1993).
Computer implementation.
[VR] W. N. VENABLES & B. D. RIPLEY, *Modern applied statistics with S*, 4th ed., Springer, 2002.
[Dal] P. DALGAARD, *Introductory statistics with R.* Springer, 2002.
III: *Multivariate Analysis.*
[MKB] K. V. MARDIA, J. T. KENT and J. M. BIBBY, *Multivariate Analysis*, Academic Press, 1979 [excellent; mathematical; technique-oriented].
[K] W. J. KRZANOWSKI, *Principles of Multivariate Analysis: A User's Perspective*, OUP, 1988 [very good; more statistical; problem-oriented].
[HJ] Roger A. HORN and Charles A. JOHNSON, *Topics in matrix algebra*, CUP, 1991.
[GvL] Gene H. GOLUB and Charles F. Van LOAN, *Matrix computation*, 3rd

ed., Johns Hopkins UP, 1996.
IV: *Regression*.
[BF] N. H. BINGHAM and John M. FRY: *Regression: Linear Models in Statistics*, Springer Undergraduate Mathematics Series (SUMS), 2010.
V: *Time Series*.
[W] P. WHITTLE, *Optimal control*. Wiley, 1996.
[BD1] Peter J. BROCKWELL and Richard A. DAVIS: *Introduction to Time Series and Forecasting* 2nd ed., Springer, 2002 (1st ed. 1996).
[BD2] Peter J. BROCKWELL and Richard A. DAVIS: *Time Series: Theory and Methods*, 2nd ed., Springer, 1991 (1st ed. 1987).
[Har] Andrew C. HARVEY, *Time series models*, 2nd ed., Harvester, 1993.
[G] C. GOURIÉROUX, *ARCH models and financial applications*, Springer, 1997,
[GM] C. GOURÉROUX and A. MONFORT, *Time series and dynamic models*, CUP, 1990.
Multivariate Time Series.
For some recent financial applications in this area, see e.g.
[BFK] N. H. BINGHAM, J. M. FRY and R. KIESEL, Multivariate elliptic processes. *Statistica Neerlandica* **64** no. 3 (2010), 352-366 [+ refs there].
VI: *Non-parametrics*.
[vdVW] Aad W. van der VAART and Jon A. WELLNER, *Weak convergence and empirical processes, with applications to statistics*, Springer, 1996;
[BKRW] P. J. BICKEL, C. A. J. KLAASSEN, Y. RITOV and J. A. WELLNER, *Efficient and adaptive estimation for semiparametric models*, Springer, 1998.
[Sil] B. W. SILVERMAN, *Density estimation for statistics and data analysis*, Chapman & Hall, 1986;
[O] A. OWEN, *Empirical likelihood*, Chapman and Hall, 2001.
VII: *Bayesian Statistics*.
[O'H] O'HAGAN, A.: *Bayesian Inference*. Edward Arnold, 1994.
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[R] Ch. P. ROBERT, *The Bayesian choice: A decision-theoretic motivation*, 2nd ed. Springer, 2001 (p/b 2007, 1st ed. 1994).
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