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Week 0. 17.1.2017

STATISTICAL METHODS FOR FINANCE

Professor N. H. BINGHAM (NHB) and Dr Blanka HORVÁTH (BH),
Spring 2017

Tue 9-11, Th 2-4, Weeks 16-25 (week beginning 16 Jan – week ending 24 Mar)
NHB: 6M47; 020-7594 2085; n.bingham@ic.ac.uk; Office hour Fri 2-3
BH: 6M20; b.horvath@ic.ac.uk; Office hour TBA

This full-unit core course consists of 40 lectures, in 10 4-hour weeks. The first three-quarters, 7.5w, will be taught by NHB: 3hpw theory, with 1hpw practical (data) problems/solutions etc., assisted by Aitor Muguruza (am5115@ic.ac.uk). The practical hour will be the first of the week (because of Aitor's timetable), on the material of the previous week.

The last quarter. 2.5w, will be taught by BH, with the emphasis on applications, data handling etc.

NHB, Weeks 1-7.5; Course website: My homepage.

I Estimation [Weeks 1-2]
1. Parameters; likelihood [W1]
2. The Cramér-Rao inequality [W1]
3. Large-sample properties of maximum-likelihood estimators [W1]
4. Sufficiency and minimal sufficiency [W2]
5. Location and scale; tails [W2]
6. CAPM [W2]

II Hypothesis Testing [Week 2]
1. Formulation
2. The Neyman-Pearson lemma
3. Likelihood-ratio (LR) tests
4. Testing linear hypotheses

III Multivariate Analysis. [Week 3]
1. Preliminaries; matrix theory

2. Singular-values decomposition (SVD)
3. Statistical setting
4. Sample and population
5. Principal components analysis (PCA)

IV Regression [Week 4]
1. Least squares
2. The bivariate normal distribution
3. The multivariate normal distribution
4. Quadratic forms in normal variates
5. Estimation theory for the multivariate normal
6. Conditioning and regression
7. Generalised linear models (GLMs)

V Time Series [Week 5]
1. Autoregressive moving average processes $ARMA(p, q)$
2. $ARMA$ modelling; the general linear process
3. Wold decomposition; spectral methods; time and frequency domains
4. $ARCH$, $GARCH$ and Econometrics
5. State-space models and the Kalman filter

VI Non-parametrics [Week 6]
1. Empiricals; the Glivenko-Cantelli theorem
2. Curve and surface fitting
3. Non-parametric likelihood
4. Limit theorems; Markov chains; MCMC

VII Bayesian Statistics [Week 7]
1. Classical statistics and its limitations
2. Prior knowledge and how to update it
3. Prior and posterior densities
4. Examples
5. Hierarchical models; Markov Chain Monte Carlo (MCMC)

Problem sheets: weekly; Solutions the week after.
Exam: Standard format: 3 hours, 6 questions, do 5.
References
My website: links on my homepage to other courses I have taught, e.g.:

[IS] Introductory Statistics (which you have all seen);
SMF1415: this course (then optional), 2014-15 (fuller treatment with more proofs: link on the SMF link on my homepage).
[SP] Stochastic Processes (core course; NHB, 2010, 11; Tom Cass, 2012 on);
[PfS] Probability for Statistics (core, MSc in Statistics; NHB, 2012,13,14,15).

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.
[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.
[Dal] P. DALGAARD, *Introductory statistics with R.* Springer, 2002.
[VR] W. N. VENABLES & B. D. RIPLEY, *Modern applied statistics with S*, 4th ed., 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).
[G] C. GOURIÉROUX, *ARCH models and financial applications*, Springer, 1997,
[GM] C. GOURÉROUX and A. MONFORT, *Time series and dynamic models*, CUP, 1990.

III/V: *Multivariate Time Series*.
[Han] E. J. HANNAN, *Multiple time series*, Wiley, 1970.
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;

VII: *Bayesian Statistics*.
[O'H] O'HAGAN, A.: *Bayesian Inference*. Edward Arnold, 1994.
[R] Ch. P. ROBERT, *The Bayesian choice: A decision-theoretic motivation*, 2nd ed. Springer, 2001 (p/b 2007, 1st ed. 1994).
[GCSR] A. GELMAN, J. B. CARLIN, H. S. STERN & D. B. RUBIN, *Bayesian data analysis*. Chapman & Hall, 1995.
[L] D. V. LINDLEY, *Making decisions*, 2nd ed., Wiley, 1985.