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Day 0. 8.5.2013

STATISTICAL METHODS FOR FINANCE

Professor N. H. BINGHAM, Summer 2013

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

Course website: My homepage.

This full-unit course consists of 24 lectures (6 weeks, $2+2 = 4$ hours per week), Wed 10-12 and Fri 10-12, Weeks 32-37, Wed 8 May – Fri 14 June. It is divided into seven parts:

I Estimation [3 hours, Days 1-2]

1. Parameters; likelihood [D1]
2. The Cramér-Rao inequality [D1]
3. Large-sample properties of maximum-likelihood estimators [D1]
4. Sufficiency and minimal sufficiency [D2]
5. Location and scale; tails [D2]
6. Complements [D2]

II Hypothesis Testing [2 hours, Days 2-3]

1. Formulation [D2]
2. The Neyman-Pearson lemma [D2]
3. Likelihood-ratio (LR) tests [D3]

III Multivariate Analysis. [3 hours, Days 3-4]

1. Preliminaries; matrix theory [D3-4]
2. Singular-values decomposition (SVD) [D4]
3. Statistical setting [D4]
4. Sample and population [D4]
5. Principal components analysis (PCA) [D4]

IV Regression [4 hours, Days 5-6]

1. Least squares [D5]
2. The bivariate normal distribution [D5]

3. The multivariate normal distribution [D5]
4. Estimation theory for the multivariate normal [D6]
5. Conditioning and regression [D6]
6. Quadratic forms in normal variates [D6]
7. Generalised linear models (GLMs) [D6]

V Time Series [5 hours, Days 7-9]

1. Stationary processes and autocorrelation [D7]
2. The correlogram [D7]
3. Autoregressive processes, $AR(1)$ [D7]
4. General autoregressive processes, $AR(p)$ [D7]
5. Condition for stationarity [D7]
6. Moving average processes, $MA(q)$ [D7-8]
7. Autoregressive moving average processes $ARMA(p, q)$ [D6]
8. ARMA modelling; the general linear process [D6]
9. Wold decomposition [D8]
10. $ARCH$, $GARCH$ and Econometrics [D8-9]
11. State-space models and the Kalman filter [D9]

VI Non-parametrics [2 hours, Day 9-10]

1. Empiricals; the Glivenko-Cantelli theorem [D9]
2. Curve and surface fitting [D9]
3. Non-parametric likelihood [D10]
4. Limit theorems; Markov chains; MCMC [D10]

VII Bayesian Statistics [5 hours, Days 10-12]

1. Classical statistics and its limitations [D10]
2. Prior knowledge and how to update it [D10]
3. Prior and posterior densities [D10]
4. Examples [D10-11]
5. Pros and cons [D11]
6. Markov Chain Monte Carlo (MCMC) [D12]
7. Further Bayesian aspects [D12]

Each 2-hour lecture slot will have its own handout, Days 1-12, and its own Problems and Solutions. These will be divided between theory and data analysis. We will pause for a 10-minute break half-way through.

The exam will be 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);
- [PfS] Probability for Statistics (core course, MSc in Statistics; NHB, 2012).
- [Math428] (Mathematical Finance, MSc, Liverpool U., NHB, 2013).

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 practitioner'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*.

[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).

[D] Peter J. DIGGLE: *Time Series: A Biostatistical Introduction*, OUP, 1990.

[Har] Andrew C. HARVEY, *Time series models*, 2nd ed., Harvester Wheatsheaf, 1993 (1st ed. 1981).

[G] C. GOURIÉROUX, *ARCH models and financial applications*, Springer, 1997,

[GM] C. GOURIÉROUX and A. MONFORT, *Time series and dynamic models*, CUP, 1990.

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;

[O] A. OWEN, *Empirical likelihood*, Chapman and Hall, 2001.

VII: *Bayesian Statistics*.

[O'H] O'HAGAN, A.: *Bayesian Inference*. Edward Arnold, 1994, Kendall's Advanced Theory of Statistics, Volume 2B.

[L] LEE, P. M.: *Bayesian Statistics: An Introduction*, 4th ed., Wiley, 2012 (1st ed. Edward Arnold, 1989).

[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.

