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Day 0. 9.5.2012

STATISTICAL METHODS FOR FINANCE

Professor N. H. BINGHAM, Summer 2012

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Course website: My homepage.

This full-unit course consists of 36 lectures (6 weeks, 3+3 = 6 hours per week), Wed 10-1 and Fri 10-1, Weeks 32-37, Wed 9 May – Fri 15 June. It is divided into seven parts:

I Estimation [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]

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

III Non-parametrics [Day 3]
1. Empiricals; the Glivenko-Cantelli theorem [D3]
2. Curve and surface fitting [D3]
3. Non-parametric likelihood [D3]

IV Bayesian Statistics [Days 4-6]
1. Classical statistics and its limitations [D4]
2. Prior knowledge and how to update it [D4]
3. Prior and posterior densities [D4]
4. Examples [D4-5]
5. Pros and cons [D5]

6. Further Bayesian aspects [D6]

V Regression [Days 6-8]
1. Least squares [D6]
2. The bivariate normal distribution [D7]
3. The multivariate normal distribution [D7]
4. Estimation theory for the multivariate normal [D8]
5. Conditioning and regression [D8]

VI Time Series [Days 8-11]
1. Stationary processes and autocorrelation [D8]
2. The correlogram [D9]
3. Autoregressive processes, $AR(1)$ [D9]
4. General autoregressive processes, $AR(p)$ [D9]
5. Condition for stationarity [D10]
6. Moving average processes, $MA(q)$ [D10]
7. Autoregressive moving average processes $ARMA(p, q)$ [D10]
8. ARMA modelling; the general linear process [D10]
9. Wold decomposition [D10]
10. $ARCH$, $GARCH$ and Econometrics [D11]

VII Multivariate Analysis. [Days 11-12]
1. Preliminaries; matrix theory [D11]
2. Singular values decomposition [D12]
3. Statistical setting [D12]
4. Sample and population [D12]
5. Principal components analysis (PCA) [D12]

Each 3-hour lecture slot will have its own handout, Days 1-12, and its own Problems and Solutions. We will pause for a 10-minute break half-way through.

The exam will be standard format: 3 hours, 6 questions, do 5. As this is a new course (in its present form: I taught the second half as a half-course last year), I will set a Mock Exam + Solutions.

Recommended texts:
General Statistics.
[CB] George CASELLA and Robert L. BERGER, *Statistical inference*, Duxbury,

1990 (recommended for Ch. 6, Principles of data reduction, on sufficiency, but not for Ch. 12 on linear regression).
Financial Statistics:
[LX] Tze Leung LAI and Hipeng XING, *Statistical models and methods for financial markets*, Springer, 2008.

IV: 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*. Edward Arnold, 1989.
V: Regression.
[BF] N. H. BINGHAM and John M. FRY: *Regression: Linear Models in Statistics*, Springer Undergraduate Mathematics Series (SUMS), 2010,
or the relevant chapters in most general books on Statistics.
VI: 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).
VII: 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; less mathematical, 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.
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,
and the references cited there.

More specialised texts will be cited as need arises, e.g.
[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.