

C4c: Quantitative Methods

Instructors: Abi Tamim Vanak (Coordinator: avanak@atree.org), Milind Bunyan, Jagdish Krishnaswamy.

Teaching Assistant: Nachiket Kelkar

Guest lecturers: TBA

Days & Time: Mondays and Tuesdays (11:00 – 11:50), Wednesdays (10:00 – 10:50 am)

Number of credits: 2

Course description

This course will introduce statistical methods with a critical view of frequentist approaches even as it introduces the fundamentals of alternate Information Theoretic and Bayesian approaches and interpretation. This course will consider and present statistics as an integral part of the scientific process rather than as an after thought. It will use R statistical software for all analyses and outputs. Examples and applications will be drawn from both social and natural sciences.

Contact time: Approximately 3 hours a week, including statistical laboratory in R.

Pre-requisites: Basic Mathematics and Statistics exposure at Bachelors and Masters level. Should have cleared Maths prerequisite at ATREE.

Topics

1. Role of statistics in the scientific method.
2. Probability as an expression of uncertainty. Laws of Probability.
3. Concept of Likelihood. Bayes theorem and Bayesian approach.
4. Probability distributions (discrete and continuous): Bernoulli, Binomial, Poisson, Normal.
5. Exploratory data analyses for univariate, bivariate and multi-variate data.
6. Sampling distributions. Central Limit Theorem.
7. Fundamentals of frequentist Hypothesis testing. Type 1 and Type 2 errors. P-values. The pitfalls of significance testing and null hypotheses.
8. Expected and actual frequencies: Chi-square analyses
9. Bayesian approach and inference.
10. Study design and sampling.
11. Linear models
12. Generalized Linear models
13. Fixed and random effects models
14. Non-linear models. Generalized Additive Models.
15. Quantile regression to deal with expression of response at higher levels when multiple unmeasured factors are present

16. Fundamentals of Time-series analyses. Temporal auto-correlation. Seasonality. Trend analyses. Generalized Least Squares models with auto-correlated errors
17. Concepts of spatial data analyses (geostatistics).
18. Multi-variate data and dimension reduction: factor analyses and principal component analyses.

Course evaluation: Three assignments of 10 marks each, one mid-term quiz of 20 marks. Final exam is of 50 marks.

Readings and Resources

1. Data Analyses and Graphics Using R. John Maindonald and John Braun. Second Edition. 2006. Cambridge Series in Statistical and Probabilistic Mathematics.
2. Introduction to Statistical Thought. Michael Lavine.
<http://www.math.umass.edu/~lavine/Book/book.html>
3. Hobbs, N.T., Hilborn, R., 2006. Alternatives to statistical hypothesis testing in ecology: a guide to self teaching. *Ecological Applications* 16, 5–19.
4. Johnson, Douglas H. 1999. The Insignificance of Statistical Significance Testing. *Journal of Wildlife Management* 63(3):763-772. Jamestown, ND: Northern Prairie Wildlife Research Center Online.
<http://www.npwrc.usgs.gov/resource/methods/statsig/index.htm>
(Version 16SEP99).
5. The Insignificance of Null Hypothesis Significance Testing *Political Research Quarterly* September 1999 52: 647-674.
6. Anderson, D.R., Burnham, K.P., Thompson, W.L., 2000. Null hypothesis testing: problems, prevalence, and an alternative. *The Journal of Wildlife Management*. 64, 912–923.

R Tutorials and Books for Help:

<http://tryr.codeschool.com/levels/1/challenges/5>

<http://www.cyclismo.org/tutorial/R/>

<http://www.statmethods.net/>

<http://cran.r-project.org/doc/manuals/R-intro.html>

Maindonald, J. and Braun, J. *Data Analyses and Graphics Using R*. Second Edition. 2006. Cambridge Series in Statistical and Probabilistic Mathematics.

Crawley, M. *The R Book*. John Wiley and Sons, UK.

Website for R software:

www.r-project.org

Schedule for Quantitative Methods (C4c)

	Date	Day	Topic(s)	Instructor
1.	11th Jan 2016	Monday	Intro: Role of statistics in the scientific method.	Abi Vanak
2.	12th Jan 2016	Tuesday	Probability as an expression of uncertainty. Laws of Probability.	Nachiket Kelkar
3.	13th Jan 2016	Wednesday	Intro to R	Nachiket Kelkar
4.	18th Jan 2016	Monday	Probability and probability distributions (discrete and continuous): Bernoulli, Binomial, Poisson, Normal	Nachiket Kelkar
5.	19th Jan 2016	Tuesday	" "	Nachiket Kelkar
6.	20th Jan 2016	Wednesday	R Lab	Nachiket Kelkar
7.	25th Jan 2016	Monday	Exploratory data analyses for univariate, bivariate and multi-variate data	Nachiket Kelkar
8.	27th Jan 2016	Wednesday	R Lab	Nachiket Kelkar
9.	1st Feb 2016	Monday	Exploratory data analyses for univariate, bivariate and multi-variate data	Milind Bunyan
10.	2nd Feb 2016	Tuesday	Sampling distributions. Central Limit Theorem	Jagdish Krishnaswamy
11.	3rd Feb 2016	Wednesday	R Lab	Jagdish/ Milind
12.	8th Feb 2016	Monday	Sampling distributions. Central Limit Theorem	Jagdish Krishnaswamy

13.	9th Feb 2016	Tuesday	Fundamentals of frequentist Hypothesis testing. Type 1 and Type 2 errors. P-values. The pitfalls of significance testing and null hypotheses.	Abi Vanak
14.	10th Feb 2016	Wednesday	Expected and actual frequencies: Chi-square analyses	Abi Vanak
15.	15th Feb 2016	Monday	Study design and sampling methods – GUEST LECTURE	TBA
16.	16th Feb 2016	Tuesday	Study design and sampling methods – GUEST LECTURE	TBA
17.	17th Feb 2016	Wednesday	Linear models	Abi Vanak
18.	22nd Feb 2016	Monday	Generalized Linear models	Abi Vanak
19.	23rd Feb 2016	Tuesday	Generalized Linear models	Abi Vanak
20.	24th Feb 2016	Wednesday	R Lab	Abi Vanak
21.	29th Feb 2016	Monday	Fixed and random effects models	Abi Vanak
22.	1st March 2016	Tuesday	" "	Abi Vanak
23.	2nd March 2016	Wednesday	R Lab	Abi Vanak
24.	7th March 2016	Monday	Non-linear models. Generalized Additive Models	Milind Bunyan
25.	8th March 2016	Tuesday	R Lab	Milind Bunyan

26.	9th March 2016	Wednesday	Quantile regression to deal with expression of response at higher levels when multiple unmeasured factors are present	Milind Bunyan
27.	14th March 2016	Monday	Fundamentals of Time-series analyses. Temporal auto-correlation. Seasonality. Trend analyses.	Milind Bunyan
28.	15th March 2016	Tuesday	" "	Milind Bunyan
29.	16th March 2016	Wednesday	R Lab	Milind Bunyan
30.	21st March 2016	Monday	Concept of Likelihood. Bayes theorem and Bayesian approach	Jagdish Krishnaswamy
31.	22nd March 2016	Tuesday	" "	Jagdish Krishnaswamy
32.	23rd March 2016	Wednesday	R Lab	Jagdish Krishnaswamy
33.	28th March 2016	Monday	Bayesian approach and inference	Jagdish Krishnaswamy
34	29th March 2016	Tuesday	" "	Jagdish Krishnaswamy
35	30th March 2016	Wednesday	R Lab	Jagdish Krishnaswamy
36	4th April 2016	Monday	Concepts of spatial data analyses (geostatistics).	Jagdish Krishnaswamy

37	5th April 2016	Tuesday	Multivariate data and dimension reduction: factor analyses and principal component analyses.	Jagdish Krishnaswamy
38	6th April 2016	Wednesday	R Lab	Jagdish Krishnaswamy

R tutorials and exercises will be on Wednesday 11-12 PM