# Bayesian modelling

## Prof. Guido Consonni; Prof. Raffaele Argiento

[Teaching syllabus borrowed from the Degree in *Statistical and actuarial sciences*, including the course name *Statistical modelling (Bayesian statistics)*]

***COURSE AIMS AND INTENDED LEARNING OUTCOMES***

Bayesian statistics is a powerful methodology that over the years has gained wide recognition because it is sound, flexible, produces clear answers, and makes use of a variety of information. It has become an indispensable resource for scientific and social science researchers. The course will deal with *foundations*, *models* and *computation.*

At the end of the course the student is expected to:

know i) foundational aspects (features of Bayesian versus frequentist approach, subjective probability, exchangeability, conjugate priors); ii) Bayesian analysis of hierarchical, linear, and generalized linear models); iii) computational tools Markov Chain Monte Carlo). - *Knowledge and understanding;*

to be able to carry out Bayesian inference in standard models, as well as in regression and hierarchical modelling setups (model formulation and implementing a computational algorithm, typically through a package. Knowledge should be adequate to understand models and output of an empirical report or of an expository scientific paper. *Applying knowledge and understanding;*

be able to evaluate a statistical model, and the resulting findings -*Making judgements;*

be able to describe with an appropriate statistical language a model used in the analysis and to communicate the results of empirical findings using appropriate summaries. - *Communication skills;*

acquire a conceptual framework and technical tools to advance his/her studies in the methods and techniques of Bayesian Statistics and Data Science. *Lifelong learning skills.*

***COURSE CONTENT***

The course is divided in two modules

## Module 1 Guido Consonni

* Independence, conditional independence and exchangeability
* Prior, posterior and predictive distributions
* Bayesian inference for exponential families with conjugate priors
* Noninformative priors and Jeffreys priors
* Monte Carlo approximation and posterior approximation with the Gibbs sampler
* Bayesian hierarchical modelling

## Module 2 Raffaele Argiento

* + Markov Chain Monte Carlo methods
  + Metropolis-Hastings and the Gibbs sampler algorithms; criteria for assessing convergence
  + Multivariate normal model
  + Overview of software environments for applied Bayesian modelling (OpenBUGS/STAN)
  + Bayesian analysis of the linear and generalized linear regression model
  + Bayesian model selection via spike-and-slab priors

***READING LIST***

P.D. Hoff, *A first course in bayesian statistical methods*, Springer*,* 2009.

I. Ntzoufras, *Bayesian modeling using WinBUGS,* John Wiley & Sons, 2011*.*

Language and environment:

R - http://www.r-project.org/

OpenBUGS <http://www.openbugs.net/w/FrontPage>

Stan - https://mc-stan.org/

Class notes*,* coding and further material will be posted on the University platform Blackboard

***TEACHING METHOD***

A blend of lectures, coding, data analysis and discussion in class (60 hours). Exercise and lab sessions (20 hours).

***ASSESSMENT METHOD AND CRITERIA***

Written project involving modelling and data analysis together with a presentation including questions and answers.

***NOTES AND PREREQUISITES***

Students enrolling in this course are expected to know data analysis, probability and frequentist inference, at the level of Statistics courses usually taught in a bachelor degree in Economics; see for instance the topics covered in ‘Statistica (analisi dei dati e probabilità) and ‘Statistica applicata’ (or ‘Statistics’ and ‘Applied Statistics’) at this University. They should also have a fair knowledge of the R-language It is also recommended that they have attended the following courses: Mathematical methods and probability, Statistical inference and Applied linear models taught within this MSc programme.

Should face-to-face lectures not be possible out of health considerations related to COVID-19, we will move classes online. Students will be notified in advance.