# Bayesian modelling

## Prof. Federico Castelletti; Prof. Guido Consonni

***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, conjugate priors, noninformative and Jeffreys’ 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 analytical and visual 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

* Prior, posterior and predictive distributions
* Exponential families and conjugate priors
* Noninformative and Jeffreys priors
* Monte Carlo approximation and posterior approximation
* Bayesian hierarchical modelling

## Module 2 Federico Castelletti

* + Markov Chain Monte Carlo methods: Metropolis-Hastings and Gibbs sampler algorithms; criteria for assessing convergence
	+ Multivariate Normal model
	+ Overview of software environments for applied Bayesian modelling (R/JAGS/STAN)
	+ Bayesian analysis of the linear and generalized linear regression model
	+ Bayesian linear model selection and variable selection
	+ Elements of Bayesian graphical modelling

***READING LIST[[1]](#footnote-1)***

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/

JAGS https://mcmc-jags.sourceforge.io/

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; presentation of the results of the project and answers to questions on topics of Module I and II.

***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.

1. I testi indicati nella bibliografia sono acquistabili presso le librerie di Ateneo; è possibile acquistarli anche presso altri rivenditori. [↑](#footnote-ref-1)