CURRENT TRENDS IN BAYESIAN METHODOLOGY APPLICATIONS
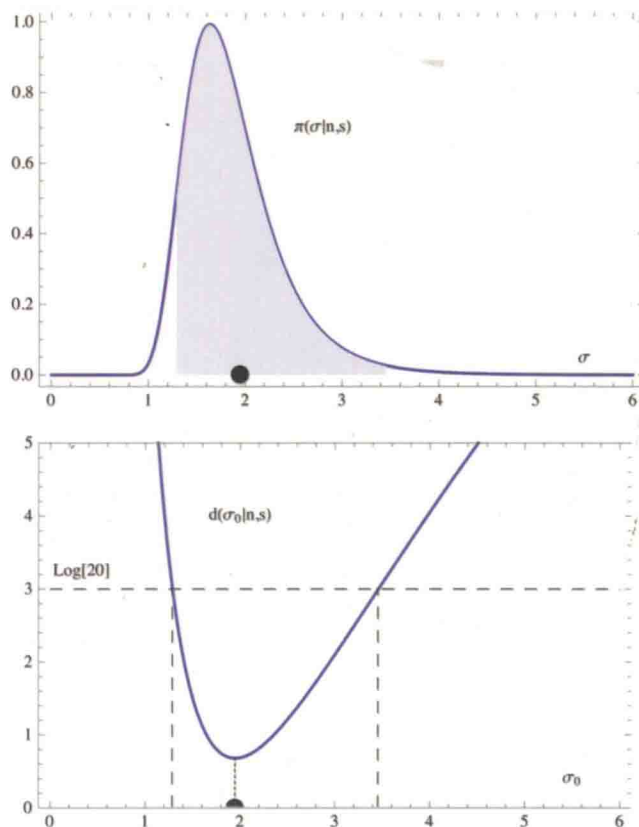
Edited by

Satyanshu Kumar Upadhyay
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A CHAPMAN & HALL BOOK

CURRENT TRENDS IN BAYESIAN METHODOLOGY WITH APPLICATIONS

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CURRENT TRENDS IN
BAYESIAN METHODOLOGY
WITH APPLICATIONS

Dedicated to my Parents and my Teacher Prof. Manju Pandey

– **Satyanshu K. Upadhyay**

Dedicated to my late Mother Mrs. Siddheswari Devi

– **Umesh Singh**

Dedicated to my late Parents Mr. Debendranath Dey and Mrs. Renuka Dey

– **Dipak Dey**

Dedicated to my Teachers Prof. M. Rajagopalan and Prof. G. Nanjundan

– **Appaia Loganathan**

Preface

The year 2013 can be considered an important year in the history of statistics, with six important global societies declaring the year as the International Year of Statistics. More than 128 countries participated in the International Year of Statistics. It added to its importance because 2013 was 300th anniversary of Jacob Bernoulli's Ars conjectandi and 250th anniversary of Bayes' theorem. India enthusiastically participated in this declaration by organizing an important Bayesian event in January, 2013 that may be considered the beginning of the celebrations of the International Year of Statistics in India. The 20th birth anniversary of International Society for Bayesian Analysis and 250th birth anniversary of the Bayes theorem in the presence of as many as 10 past, future and present presidents of ISBA was another important event celebrated in 2013 and simultaneously a highly desired publication in the form of the current volume *Current Trends in Bayesian Methodology with Applications* was decided to be brought out. We are happy that our thought has taken the shape of reality.

Bayesian statistics has expanded its coverage enormously in the past two to three decades. The Bayesian methods of reasoning are now applied to a wide variety of scientific, social, and business endeavours including areas such as astronomy, biology, economics, education, engineering, genetics, marketing, medicine, psychology, public health, sports, among many others. There are certain situations where Bayesian statistics appears as the only paradigm that offers viable solutions and this has become possible because of the tremendous development of Bayesian theory, methodology, computation and applications. The subject became the forefront of practical statistics with the advent of high-speed computers and sophisticated computational techniques especially in the form of Markov Chain Monte Carlo methods and sample based approaches. In fact, Bayesian modelling in complex problems freely combines components of different sorts of modelling approaches with structural prior information, unconstrained by whether such model combinations have ever been studied or analysed before.

Bayesian publications have also increased enormously in the last thirty years. Why then another publication on Bayesian statistics? The importance of the present volume may be realized from the fact that although the literature on Bayesian statistics is enormous, we do not find any single book that provides various aspects at one place. The literature is undoubtedly widely scattered, and journal articles rarely provide the conceptual background necessary for non-experts to understand and apply the approaches to their own

problems. Moreover, the cost of recent publications is getting so high that researchers find it difficult going through the massive amount of literature.

The present volume consists of thirty chapters. We have topics on biostatistics, econometrics, reliability and risk analysis, spatial statistics, image analysis, shape analysis, Bayesian computation, clustering, uncertainty assessment, applications to high-energy astrophysics, neural networking, fuzzy information, objective Bayesian methodologies, empirical Bayes methods, small area estimation, and a lot more. All the articles focus on Bayesian methodologies but each is self-contained and independent so that the present volume may lessen the competition with research level journals and may simultaneously act as a good reference for the researchers and graduate level students. We have preferred to include chapters giving an overview to the area including some theoretical insights and simultaneously expected to emphasize the work of others, give motivating examples, but omit sophisticated technical details. The present volume can be considered as a physical insignia of the inspiration by several experts in the field, which will be quite helpful for the future researches.

Though there may be topics closely related to each other, there is no need to maintain the sequence for reading the chapters. The sequence in the volume is purely alphabetical according to the last name of the first author and, in no way should be taken to mean any preferential order.

We fail in our duties if we do not express our sincere indebtedness to our referees, who were quite critical and unbiased in giving their opinion. We do realize that in spite of their busy schedules they offered us every support in timely commenting on various manuscripts. Undoubtedly, it is the joint endeavor of the contributors and the referees that emerged in the form of such an important and significant volume for the Bayesian world. We sincerely thank them all; the space constraint restricts us to mention the names individually.

We thankfully acknowledge the support rendered by John Kimmel, Executive Editor, Statistics, CRC Press, Taylor & Francis Group, who always stood behind us and always helped us with several of our unusual queries.

We express our indebtedness to everyone who was associated with us directly or indirectly while the work was in progress. The list is certainly too lengthy to be exhaustive but we would like to give special mention to Anuradha, Asha, Rita, Shakila, Geetika, Vertika, Debosri, Om Shankar, Naganandhini, Sangeetha, Rakesh, Rijji, Reema, Praveen, among others. At last but not the least, we express our thankfulness to Mr. Duvvuri Venu Gopal, Banaras Hindu University, who is credited with the present shape of the volume.

– **The Editors**

Foreword

It is a great pleasure to see a new book published on current aspects of Bayesian Analysis and coming out of India. This wide scope volume reflects very accurately on the present role of Bayesian Analysis in scientific inference, be it by statisticians, computer scientists or data analysts. Indeed, we have witnessed in the past decade a massive adoption of Bayesian techniques by users in need of statistical analyses, partly because it became easier to implement such techniques, partly because both the inclusion of prior beliefs and the production of a posterior distribution that provides a single filter for all inferential questions is a natural and intuitive way to process the latter. As reflected so nicely by the subtitle of Sharon McGrayne's *The Theory That Would Not Die*, the Bayesian approach to inference "cracked the Enigma code, hunted down Russian submarines" and more generally contributed to solve many real life or cognitive problems that did not seem to fit within the traditional patterns of a statistical model. Two hundred and fifty years after Bayes published his note, the field is more diverse than ever, as reflected by the range of topics covered by this new book, from the foundations (with objective Bayes developments) to the implementation by filters and simulation devices, to the new Bayesian methodology (regression and small areas, nonignorable response and factor analysis), to a fantastic array of applications. This display reflects very well on the vitality and appeal of Bayesian Analysis. Furthermore, I note with great pleasure that the new book is edited by distinguished Indian Bayesians, India having always been a provider of fine and dedicated Bayesians. I thus warmly congratulate the editors for putting this exciting volume together and I offer my best wishes to readers about to appreciate the appeal and diversity of Bayesian Analysis.

– **Christian P. Robert**

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