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Editorial: Why bayes?

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Why Bayes?
An Introduction to the Special Issue
on
Bayesian Inference in Economics

This is an exciting time to be Bayesian. New models are continually springing into existence, innovative estimation algorithms are advancing our analytical capabilities, and applications have produced important scientific evidence in a variety of areas. Bayesian methods have opened exciting new frontiers in empirical analysis; the field is healthy and growing, steadily gaining prominence in various branches of the social sciences, including economics, political science, sociology, and business disciplines such as marketing and finance. The present volume is a testament to these developments, offering important new Bayesian contributions in economics.

Even though Reverend Thomas Bayes' theorem was published 250 years ago, its full power was unleashed only recently thanks to major advances in computer technology and computational and simulation methodology. This has made the benefits of Bayesian analysis more widely accessible to empirical researchers and has enabled the estimation of ever more realistic and sophisticated empirical models. And despite the uneven progress in the development and application of Bayesian across disciplines, most branches of the social sciences are now making full use of these techniques and methods.

So why is Bayesian inference so appealing? And why should new and established researchers, Bayesian and non-Bayesian alike, seek to acquire new tools and enhance their understanding of Bayesian theory, modeling, and estimation methodology? One reason is that the theoretical foundations of the Bayesian approach are very elegant and intellectually engaging. Bayes' theorem is a simple, yet powerful, result that links sample and non-sample information and provides a unified framework for addressing model and parameter uncertainty, forecasting, model averaging, and covariate effect estimation. For a parameter vector $\theta \in \Theta \subseteq \Re^k$ and data y, Bayes theorem states that the posterior density $\pi(\theta|y)$ relates to the likelihood $f(y|\theta)$ and prior density $\pi(\theta)$ through the relationship

$$\pi\left(\theta|y\right) = \frac{f\left(y|\theta\right)\pi\left(\theta\right)}{\int f\left(y|\theta\right)\pi\left(\theta\right)d\theta}. \tag{1}$$

Information contained in the sample is incorporated through the likelihood function, and non-sample information (including results from previous studies, theoretical constraints and considerations) is captured through the prior. A measure of the adequacy of the model is given by the denominator quantity on the right hand side of (1), known as the marginal likelihood. For any two competing models, the ratio of their marginal likelihoods, known as the Bayes factor, is relevant for determining the posterior model probabilities for the purpose of model comparison and model averaging. As a consequence, the posterior distribution is the single main object of interest in Bayesian inference. This uniqueness can be contrasted with the multiplicity of possible estimators in the frequentist framework, which often leads to uncomfortable trade-offs and an uneasy choice among alternatives.

Although it is well known that Bayesian estimators are admissible, consistent, satisfy the likelihood principle, allow *ex post* probability interpretation of interval estimates, and generalize other estimators, the theoretical advantages alone were not successful in turning the tide in favor of the Bayesian apptoach. Instead, it was practical considerations which have steadily changed the momentum. With the advent of powerful computing and modern Markov chain Monte Carlo (MCMC) simulation methods, the difficult task of summarizing $\pi(\theta|y)$ has been related to that of obtaining draws $\theta \sim \pi(\theta|y)$ and using the resulting sample $\{\theta\}$ to describe the features of $\pi(\theta|y)$. Similarly, the integral in the denominator of (1) can now routinely be estimated through a variety of methods that employ averages with respect to draws from $\pi(\theta|y)$ instead of relying on traditional integration methods that break down or become computationally overwhelming in high dimensions.

An important advantage of simulation-based inference is the ability to easily accommodate latent variables and nuisance parameters. If the statistical model involves the latent vector z and is specified in terms of $f(y, z|\theta)$, in many instances the likelihood function $f(y|\theta) = \int f(y, z|\theta)d\theta$ may be unavailable directly because the integral over z may be difficult to evaluate. While this would make frequentist estimation infeasible, Bayesian simulation, in which the MCMC sampler is augmented with the latent z, can be quite straightforward. Specifically, instead of sampling from $\pi(\theta|y) \propto f(y|\theta)\pi(\theta)$, which would be complicated by the intractability of $f(y|\theta)$, we can sample $\pi(\theta, z|y) \propto f(y, z|\theta)\pi(\theta)$. In many cases, the presence of the latent z can actually facilitate (rather than complicate) simulation. After a sample of draws $\{\theta, z\} \sim \pi(\theta, z|y)$ has been generated, the required sample $\{\theta\} \sim \pi(\theta|y)$ is obtained by simply ignoring the sampled $\{z\}$. Not only is this much easier than sampling $\pi(\theta|y)$ directly, but such data augmentation techniques have indeed led to major advances in statistical modeling and estimation, especially in discrete data analysis, and hierarchical models in cross-sectional, panel, and time series contexts. These advances have enabled researchers to specify and estimate models that are otherwise difficult or impossible to analyze by frequentist techniques. The simplicity, versatility and modularity of the techniques popularized a "Bayes by convenience" approach to dealing with difficult econometric problems among non-Bayesians. Although this development may not seem fully satisfactory to "Bayes by conviction" researchers, it has nonetheless been the most successful method for spreading the Bayesian message. In other words, demonstrating that sophisticated models can easily be analyzed by Bayesian methods has had a profound effect on the acceptance of the methodology. As researchers receive additional exposure to these ideas, "convenience" may eventually lead to "conviction" and the further development, refinement and more effective harnessing of state-of-the-art computational techniques.

The special issue of the journal provides new Bayesian methodology and examines an array of topics in model formulation, estimation, and applications.

The articles in this volume also emphasize practical implementation and examine innovative applications in economics. The choice of topics and the balance between cutting-edge modeling and estimation methods on the one hand, and new applied research on the other, will hopefully be useful to students and researchers in academia, government, and business. I also hope that the volume will be a fitting tribute to the International Year of Statistics, and will offer an appropriate way to mark the 250th anniversary of the publication of Bayes' theorem. The volume is also a recognition of the extraordinary advances in Bayesian methods over the past few decades.

Dedication

During the preparation of this volume, a devoted Bayesian and dear friend, Wolfgang Polasek, passed away after a lengthy battle with cancer. Wolfgang was a dedicated econometrician who worked hard to his last days. He was always cheerful, eager to get involved in ambitious projects, and deeply committed to helping younger members of the profession.

Wolfgang has held faculty positions in Austria, Switzerland, and Portugal, and had visiting appointments at over a dozen prestigious universities around the world. He has authored and co-authored numerous articles, written and edited several books, organized and co-edited several journal special issues, and obtained multiple research grants from governmental and inter-governmental institutions. He organized numerous conferences in Austria and travelled around the world to attend professional meetings, present his research, and further the Bayesian cause.

Wolfgang will be missed dearly. This volume is dedicated to his memory.

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