Probability and Social Science. Methodological Relationships Between the Two Approaches. 2012. By DANIEL COURGEAU. "Methodos" Series, vol. 10. Dordrecht: Springer. Pp. xxxiii+308. £126.00 (hardcover). ISBN: 978-94-007-2878-3.

'Probability is the most important concept in modern science,
especially as nobody has the slightest notion what it means'
– Bertrand Russell, in a 1929 lecture (quoted in Stevens 1951, p.44)

The purpose of this book is to examine historical connections between probability and social science, especially demography. The author, Daniel Courgeau, Professor Emeritus at INED, Paris, is a distinguished French demographer, renowned for his pioneering work on event history analysis and multi-level modelling in population studies, and for his keen interest in probability issues. It is a fine coincidence that such a volume was published in the year commemorating the 350th anniversary of both John Graunt's *Bills of Mortality*, which marks the beginning of modern social science, as well as of *Logic, or The Art of Thinking* by Antoine Arnauld and Pierre Nicole, whom the Author sees as precursors of applied probability and statistical decision analysis.

The book is in two parts, the first dealing with the history of probability and its impact on the social sciences, and the second one, conversely, with how advances in these sciences influenced the developments of probability theory. These two parts are preceded by a chapter that gives a general introduction to the whole volume. It outlines the history of probability and the social sciences, especially since the 17th century, and provides the reader with a roadmap through the entire book. Each of the two parts has a separate brief introduction and a succinct conclusion. The volume ends with a chapter presenting a general conclusion, which is slightly longer and broader in scope. Importantly for readers in a hurry who nevertheless want to have a flavour of the contents, the general introduction, the introductions to each part, and the concluding chapter are almost 'standalone', and make it possible to grasp the main messages quickly.

Part I of the book discusses three competing approaches to the interpretation of probability. The first is designated 'objectivist' (linked to the relative frequency of events), and the book sketches the evolution of this approach from the classical definition to contemporary frequentist interpretations by Egon Pearson, Jerzy Neyman or Sir Ronald Fisher. In the second, described as 'epistemic-subjectivist', probability is described as a state of knowledge closely linked with the concept of utility, and is the approach rooted in Thomas Bayes's famous theorem, its generalization by Pierre-Simon de Laplace, and the 20th century work of Frank Ramsey, Bruno de Finetti, and Leonard Savage. The third approach, 'epistemic-logicist', with John Maynard Keynes and Harold Jeffreys as its key supporters, sees probability as a logical relationship between propositions, based on Boolean algebra and linked with the notion of entropy. (Interestingly, the book suggests that in later life Keynes flirted with the subjectivist stance, but ultimately rejected it for its inability to ensure the rationality of beliefs (p. 88). Here some readers might be surprised by the absence of the work of Bertrand Russell on probability (cf. Jeffreys 1950), which is not mentioned in the book.) All three approaches are discussed and critically reviewed in three successive chapters of Part I. For all

of them, different axiomatizations of probability are discussed in painstaking detail. Since the exposition is quite condensed in several places, the text requires a very careful reading at times.

The book argues that the objective interpretation of probability is problematic in the social sciences, which by nature deal with unrepeatable phenomena. The author's criticism could be extended even further, for example to mention the '*p*-value fallacy' (Goodman 1999), whereby hypothesis testing in the tradition of Neyman and Pearson is confused with reporting of exact *p*-values advocated by Fisher. The book also mentions differences in inference from finite populations and infinite super-populations; this part of the discussion would have gained in clarity had it referred to a systematic classification of sampling procedures dependent on the type of population and target parameters (Hartley and Sielken 1975). For practitioners of quantitative social science, these are two important pitfalls to be aware of.

On the other hand, the author points out that epistemic interpretations are also not flawless. The subjective viewpoint can be criticized from the point of view of current knowledge on rationality and preferences. The logicist approach, in turn, is argued to be very sensitive to the language used. These problems notwithstanding, Part I concludes by stating—following Laplace—that probability is the only way to describe imperfections in our knowledge. The author suggests striving towards unity in probability either by exploring new axiomatizations, like the one attempted by Kevin H. Knuth, or by adopting a pragmatic approach. With regard to the latter, it is a pity that the book does not mention Chris Chatfield's (2002) formalization for the sake of completeness.

Part II starts by making a link between social enquiries and the notion of dispersion, understood either as the *spread* of a given characteristic, or the *heterogeneity* of populations under study. The book then discusses how dispersion became a part of applied statistical research in the 1700s, only to be removed from the spotlight in the next century owing to a proliferation of detailed information from population censuses. This was closely linked with rejection of the epistemic notion of probability at the time. As the author explains, the rejection was short-sighted, since epistemic probability is far better suited than the objective alternative to the study of heterogeneous populations and interdependent phenomena. Nonetheless, for a long time, demography was mainly a descriptive discipline, with the 'return of dispersion' not occurring until the 1980s with event history methods and probabilistic projections.

The final chapter of Part II examines closely the links between population studies and probability. The paradigm of demography is defined as the analysis of demographic events (births, deaths, and migrations), and their interconnections among 'statistical individuals', that is, among people seen through the lens of statistical analysis. The discussion then turns to how demography evolved from being based on a cross-sectional macro-level approach, first to longitudinal studies of individual event histories, and then to a multi-level synthesis, of which the author is one of the main proponents. He argues that for the multi-level approach, epistemic probability and Bayesian hierarchical models are the best suited.

All three approaches have their problems. Cross-sectional analysis risks falling prey to the ecological fallacy, small-sample issues, and a problematic interpretation of 'hypothetical cohorts'. Event-history analysis is sensitive to the atomistic fallacy and unobserved heterogeneity, while the multi-level synthesis is sensitive to the correct choice of levels and the presence of feedback effects. After a quite compressed discussion of martingales and Dirichlet processes in the context of the

longitudinal approach, Part II concludes with a summary of the intimate links between probability and the population sciences, and, for the latter, an examination of the the notions of causality and the cumulativity of knowledge.

In the final chapter—General Conclusion—the author describes the use of probability within sociology and artificial intelligence to illustrate how 'most social sciences aim beyond the mere observation of statistical regularities' (p. 245). This discussion segues into intriguing sections on causality and prediction in social science, with some mention of new and promising methods, both statistical and computational. In this very thought-provoking chapter, the author notes the natural tensions between empirical and agent-based computational approaches—the latter, causally mechanistic, seemingly almost the polar opposite of the former. Modern complex systems science takes this view, proposing that the social realm (among others) is in fact a social *system*, meaning that it can only be examined as a combination of interacting processes occurring on multiple levels simultaneously. Models constructed from this perspective are thus largely theoretical in nature, and seemingly at odds with empirical, statistical approaches.

As the author points out, the empirical slant of social science during the twentieth century is far from unique, given that the biological sciences often display a similar orientation. That being said, in recent years biology has led the charge in moving away from the 'semantic view' of models as merely tools used to understand theories. More recent work advocates a 'model-based science' approach, in which systems that do not clearly exhibit specific laws of nature are understood primarily through the study and use of models. Peter Godfrey-Smith (2006) provides a useful summary of this approach, with the earlier origins very much visible in the work of Richard Levins (1966).

Model-based science has been highly influential for a growing community of social simulation researchers who view society as a complex system, not amenable to clearly-defined laws of behaviour. This type of work is still growing and developing, but its popularity demonstrates that there is a desire in the research community to bring 'model-based science' into the social science frame, and in so doing attempt to understand the processes driving human society. As this desire grows, we see a body of work developing that is focused on understanding the gaps between empirical and model-based paradigms in greater detail; some studies have already proposed frameworks for reconciling those differences (Silverman et al. 2011).

As part of this drive for integration, recent developments have illustrated the potential of advanced statistical methods for the analysis of complex computational models. In particular, Gaussian process emulators, which allow for a comprehensive statistical analysis of uncertainty in such complex models, demonstrate great promise for probing the often opaque depths of simulations (Kennedy and O'Hagan 2001). Because these methods connect more directly with theory-driven simulation approaches in the social sciences, we suspect that the seemingly-immutable dividing lines between model-based science and empirical social science will start to blur significantly. We can only hope that any future survey of these developments is as in-depth and accomplished as it is in this volume.

The book is vividly written and has been skilfully translated from the French by Jonathan Mandelbaum. The bibliography is impressive, with around 750 items, many of which, written in French, may not be familiar to an Anglophone reader. The book also contains a brief glossary of the

key terminology. On the whole, the volume is very carefully typeset, and typographical mistakes are few and minor, and mainly related to the retention of French notation in some formulae and symbols. For example, on page 78 belief function is referred to once as *Bel* and once as *Cr* [*croyance?*], while on p. 171 there is a 'si' instead of 'if', and on p. 54, in the definition of plausibility, Φ probably refers to an empty set, $\varnothing$. A demographic purist would also probably grumble about 'immigration rates' and 'net emigration rates' (p. 203) not being rates in a proper sense owing to the problem of defining appropriate populations at risk. Still, for a volume of its size and ambition, the overall level of precision is outstanding.

In sum, this book is a very welcome compendium on the history and perspectives of probability and the social sciences that can be fully recommended, especially to academics and doctoral students engaged in a quantitative social science. The main barrier to its use, and one beyond the control of the author, is the price: in September 2012, the online catalogue of Springer listed the hardcover version at £126.00 and the e-book at £119.99. A reasonably priced paperback student edition would enable a much wider audience to afford this remarkable volume.

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