PSYCHOMETRIKA—VOL. 76, NO. 2, 360–362
APRIL 2011
DOI: 10.1007/S11336-011-9205-9

BOOK REVIEW

J.-P. FOX (2010) *Bayesian Item Response Modeling: Theory and Applications*. New York: Springer. 313 pages. US$69.95. ISBN: 978-1441907417

Item response theory (IRT) models have been widely applied to address measurement issues in education, psychology, surveys, and health. An IRT model relates the probability of an item response to item and person characteristics with strong assumptions. However, the real measurement world is much more complicated than the standard IRT models can deal with. The complications due to such factors as multidimensionality, local dependence, and complex sampling design call for extended IRT models. The Bayesian Markov Chain Monte Carlo (MCMC) methods prove to be a viable and flexible solution in parameter estimation of extended IRT models like multidimensional IRT models (Beguin & Glas, 2001; Segall, 2002; Yao, 2003), testlet models (Bradlow, Wainer, & Wang, 1999), and multilevel IRT models (Fox & Glas, 2001; Maier, 2001). The estimation of extended IRT models using MCMC requires knowledge in IRT models, Bayesian framework, mathematics, and computer programming skills. A reference book which provides a comprehensive synthesis of the related knowledge and skills is needed for researchers who wish to attempt to develop an extended IRT model to solve a specific measurement problem and estimate model parameters. The book 'Bayesian Item Response Modeling' by Fox (2010) fulfills this need.

This book covers the parameter estimation of standard and extended IRT models using the Bayesian simulation based MCMC method. There are many Bayesian data analysis books, but this is the first book purely devoted to the Bayesian estimation of IRT models. The first five chapters provide the basics for IRT models, Bayesian theorem, and the MCMC estimation of IRT models. The last four chapters focus on parameter estimation related to extended IRT models, the multilevel IRT (MLIRT) models, mixture MLIRT models, MLIRT models for random DIF analysis, multivariate MLIRT models, random item response models, and extended models with covariates at different nested levels in modeling response data related to sensitive topics in survey research. In general, the models elaborated in each of the last four chapters are somewhat related to MLIRT.

The author should be first credited for the clarity in introducing the IRT models. An introduction to standard IRT models in Chapter 1 lays out the basics of the IRT framework. In later chapters, whenever an extended IRT model is introduced, it is elaborated on by first presenting the rationale for the model, followed by the setup of the model. This gives readers a clear setting in which each of the extended IRT models can be applied.

Another contribution of the book is a systematic introduction to the Bayesian MCMC methods adapted to the IRT model estimation. The discussion of prior information, constructing and updating posterior and posterior inference highlights the key components in the Bayesian theorem. Further discussion related to different types of priors highlights the importance of priors. The other key issues related to the MCMC estimation methods are discussed in detail as well such as the number of chains, convergence check, model comparison, item and person fit. The author should be particularly credited for the discussion related to the IRT model identification, which is not frequently discussed but obviously an important issue in the IRT model estimation using the MCMC method. However, it would be more informative if the author had discussed the application settings of each method for scale identification and possible impacts on model parameter

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estimation. Further, the introduction to the basic elements in the Bayesian MCMC estimation of IRT models scatters in five chapters. It took time to extract key information from these chapters to figure out what the key elements are needed for successful implementation of the MCMC estimation of IRT models. In particular, the Bayesian approach introduced in Chapter 1, following the introduction to the standard IRT models, is somewhat abrupt. It would provide readers with a clear picture of the key sequenced elements in the Bayesian MCMC estimation of IRT models if a similar order to the one presented by Kim and Bolt (2007) were followed: the Bayesian theorem, choice of priors, number of chains, initial value setting, sampling options, convergence check, inferences based on posterior distribution (consideration of autocorrelation and thinning), model comparison and fit check, item and person fit check.

The author clearly presents seven MCMC estimation schemes for standard and extended IRT models starting in Chapter 4. The presentation of each of the MCMC schemes lists the sampling steps to follow, which provides useful information to those audience members who are skilled at programming. The first three schemes are related to the basic algorithms for IRT model estimation using a Metropolis–Hastings (M–H) within Gibbs sampling, a Gibbs sampling with data augmentation, and an M–H within Gibbs sampling with data augmentation. These schemes are adapted for each extended model discussed in detail in later chapters.

The MCMC estimation method is computationally intensive. Computer programming is an important component in successful implementation of this procedure. The author did refer to the necessity of programming skills and stated that computer codes are provided on a website for the book (http://www.jean-paulfox.com/). Upon the completion of this review, only three S+ codes are provided, related to the three unidimensional IRT models for binary responses. There is no R code available. Some WINBUGS codes are provided to some chapters' examples and illustrations. It is recommended that all the relevant codes be made available to readers on the website to make learning of the Bayesian IRT estimation complete. It is further suggested that in the future edition, codes be put at the end of the chapter and annotations be provided to explain the steps so as to help less experienced readers in learning programming while reading the codes. It would be also very valuable to learners if tips and traps to avoid in programming, especially those related to WINBUGS, could be provided. Furthermore, if three programs are used for illustration, it would be great if each model estimation code could be presented in each of the three programming languages. A lot of computational information is provided in the book, but most of the codes about implementation of the procedures are not available.

Some exercise questions require math derivation and proofs, but the book does not provide enough background information to let readers demonstrate the skills. In a future edition, the author could provide necessary background knowledge in supplementary chapters or appendixes. This book is not a self-contained textbook for beginning learners of Bayesian estimation of IRT models without strong computational statistics background. To complete the exercises a reader needs strong computer programming skills, math skills, and knowledge in Bayesian theory. Based on personal communication with the author, keys to the exercise questions will be provided on the book website, which is believed to be helpful to readers to better understand the technical detail. It is noted that some relatively important information is buried in exercises. Like on page 81—when talking about imputation procedure, the author refers to exercise for detail. It would be better to provide detailed description of the procedure in the chapter text and refer to it in exercises.

The author stated that "the motive for writing this book is to give an introduction to the Bayesian methodology for modeling and analyzing item response data". Evidently, this is not an introductory book to Bayesian estimation of IRT models. This is not a book for beginners who intend to learn Bayesian estimation of IRT models, because the book places much emphasis on the theoretical and technical detail in mathematical derivation, proof, and demonstration. The topics are dealt from a computational perspective, not from a practical applied perspective. To

fully benefit from this book a reader needs to be well equipped with the IRT framework and measurement issues in extending the standard IRT models in the relevant situations as presented. In addition, a reader needs to have adequate knowledge in probability, statistics, and matrix algebra, as the author stated in the preface. It is also strongly believed that computational math skills are necessary to fully understand the technical detail in the book and to complete the exercises. The audience of the book is mostly like the readers of Psychometrika. Overall, it is a good book for advanced learners to grasp the theoretical and technical detail of Bayesian MCMC estimation of extended IRT models adapted to a specific measurement setting.

UNIVERSITY OF MARYLAND, COLLEGE PARK *Hong Jiao*

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Published Online Date: 10 MAR 2011