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Design and Analysis of Experiments with SAS

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Chapman & Hall/CRC, Boca Raton, FL, 2010.
ISBN 978-1-4200-6060-7. 596 pp. USD 99.95 (P).
http://lawson.mooo.com/

This is essentially a book on applied design and analysis of experiments with detailed examples, including example SAS code. According to the book's preface, the target audience consists of statistics graduates or advanced undergraduates with a solid knowledge of basic statistics and linear models in matrix notation (even with generalized inverses) as well as some familiarity with SAS. Members from this audience, including experienced mathematicians or statisticians with the required theoretical background, will indeed benefit most from the book. John Lawson also recommends the book for students from other fields where experimentation is needed. These readers may also learn a lot from the book, if they already have some familiarity with SAS and concentrate on the examples. However, they may have difficulties understanding some aspects, depending on their ability to follow or ignore the mathematical formulae.

After an introductory chapter on basic concepts – which seems a little difficult to follow in some places without prior knowledge about facts that are covered in later chapters – the book starts with completely randomized one-factor experiments and continues covering a broad variety of experimental situations: full and fractional factorial designs, randomized block designs, incomplete and confounded block designs, split-plot designs, cross-over and repeated measures designs, response surface designs, mixture designs, robust parameter designs, and – very briefly – sequential procedures. There is one notable omission: designs for computer experiments (e.g., latin hypercube designs) are not covered.

A typical chapter of the book covers both creation of designs and analysis of the resulting experimental data. At the end of every chapter, the chapter's content is summarized, and some exercises are provided. Usage of the SAS language is explained based on SAS 9.2 program code for most tasks that are discussed in connection with examples; the code makes ample use of new features of SAS 9.2 (e.g., `ODS` graphics, `PROC SGPLOT`). The book promises code for SAS 9.1.3 on the book's website, which appears to be still under construction; the SAS 9.1.3 code was not yet available. The book guides readers through its content by a design selection roadmap that is first presented at the end of the introduction – at that point not yet understandable – and is revisited at the end of every chapter except the two final

ones. At the top level, that roadmap distinguishes between designs for estimating variances and designs for estimating factor effects. Chapter 5 is devoted to the study of variances and covers special designs for that purpose. It also discusses the SAS analysis procedures PROC GLM, PROC VARCOMP and PROC MIXED, all from SAS/STAT (SAS Institute Inc. 2008), which can deal with variance components and mixed models. The other chapters deal with different kinds of designs for estimation of factorial effects. These are further subdivided mainly according to the underlying randomization pattern (blocking on one or several factors, large or small blocks, split-plot). The book strongly emphasizes the fact that the experimental setup influences the adequate way of analyzing the experimental data, in particular regarding the error structure of an experiment, and provides appropriate ways for analyzing split-plot experiments. This is one of its strengths. As this topic is not very well-known among applied experimenters (at least in industrial experimentation), I would have preferred even more recurrence to Chapter 5 in later related chapters, e.g., the split-plot chapter. Emphasis of the book is on the principles and practical pitfalls of experimentation and data analysis rather than on the mathematical background. The book's strongest point is its wealth of practical examples from a wide range of fields, such as agriculture, industrial production, psychology, pharmacology etc. The multitude of examples seems in some places overdone: I would have preferred more emphasis on details of some examples, even at the expense of reducing the diversity of examples. However, in general, the examples are very helpful for grasping the ideas behind applied experimentation. Apart from the examples, the book also provides some less-known design creation knowledge, e.g., on blocking mixed level factorial designs and orthogonal arrays. Mathematical background, where covered, is rigorously but concisely presented. Mathematical formulae only make up a very small portion of the book and are not subject to the end of chapter exercises that the book provides. The main target audience is expected to be familiar with most of the mathematical background, so that the concise formulae in the book are sufficient. Alternatively, readers can consult other books in parallel for more mathematical detail or can read the book as a collection of examples and practical advice, ignoring the mathematical aspects. As was already mentioned, SAS syntax is introduced on an as needed basis whenever an example requires a certain design generation or analysis feature. This approach mostly integrates nicely into the flow of reading, and readers are presented with design creation examples using a DATA step, the SAS procedures PLAN (from SAS/STAT, cf. SAS Institute Inc. 2008), OPTEX and FACTEX (both from SAS/QC, cf. SAS Institute Inc. 2010), the ADX graphical user interface (also from SAS/QC), and also the %Mktex macro suite by Kuhfeld (2010). While data and program examples support the message well, the book is difficult to use for quick reference. It would be desirable for the book's website – and eventually a future edition – to support this task by

- an abbreviation index (especially of abbreviations used for design types),
- an annotated example index from which readers can quickly look up where to find an example for which purpose,
- a synopsis of the various SAS tools for generating and analyzing designs.

Especially with regard to the last bullet point, the current version of the book lacks concise one-stop shop information about uses and limitations of each SAS tool. As a minor issue, it is slightly irritating for a routine SAS user that the book does not stick to the conventional notation for SAS products and statements (e.g., ods instead of ODS or SAS Stat instead of

SAS/STAT, `proc glm` instead of `PROC GLM`). In spite of some criticisms, I consider the book a very useful addition to the library of anyone with an already strong understanding of linear models, some familiarity with SAS, and interest or experience in applied experimentation. The SAS details of planning and analyzing experiments are taught by example, and readers learn where to look for solutions to their experimental or analysis needs. I even consider the book's example based approach useful for statistically skilled readers who want to use software other than SAS for design and analysis of experiments. Applied experimenters without a strong statistical background or at least interest will benefit from individual examples, but probably not so much from the overall flow of the book. If they want to use SAS for experimentation, a text like Ramirez and Ramirez (2001) may be more helpful for quickly getting a grasp on using the SAS `ADX` interface. Readers mainly interested in instructions for usage of SAS code for experimental design can take the book as a starting point, but will certainly have to consult other resources in addition (e.g., the SAS manuals).

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