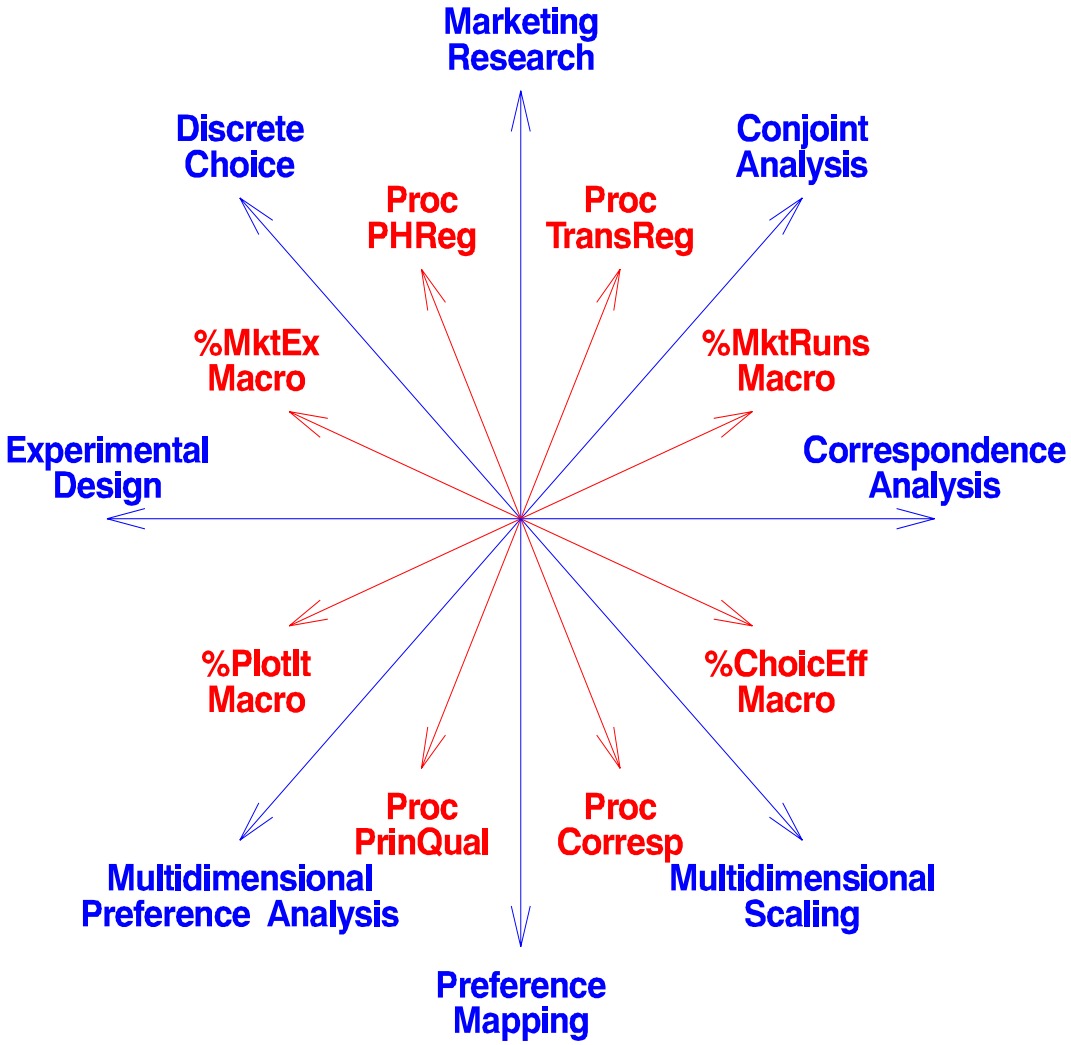
Marketing Research Methods in SAS

Experimental Design, Choice, Conjoint, and Graphical Techniques



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SAS 9.2 Edition
MR-2010

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Preface

Marketing Research Methods in SAS discusses experimental design, discrete choice, conjoint analysis, and graphical and perceptual mapping techniques. The book has grown and evolved over many years and many revisions. For example, the section on choice models grew from a two-page handout written by Dave DeLong in 1992. This edition was written for SAS 9.2 and subsequent SAS releases.

This book was written for SAS macros that are virtually identical to those shipped with the SAS 9.22 release in 2010. All of the macros and most of the code used in this book should work in SAS 9.0, 9.1, and SAS 9.2. However, some features, such as the standardized orthogonal contrast coding in the `%ChoicEff` macro, require SAS 9.2 or a later release. To be absolutely sure that you have the macros that correspond to this book, you should get the latest macros from the Web. All other macros are obsolete. Copies of this book and all of the macros are available on the Web (reports beginning with "MR-2010" at `http://support.sas.com/resources/papers/tnote/tnote_marketresearch.html`). This book is the October 1, 2010 edition, and it uses the macros that are dated July 25, 2010.

I hope that this book and tool set will help you do better research, do it quickly, and do it more easily. I would like to hear what you think. Many of my examples and enhancements to the software are based on feedback from people like you. If you would like to be added to a mailing list to receive periodic e-mail updates on SAS marketing research tools (probably no more than once every few months), e-mail Warren.Kuhfeld at sas.com. This list will not be sold or used for any other purpose.

Finishing a 1309-page book causes one to pause and reflect. As always, I am proud of this edition of the book and tools, however it is clear that I have stood on the shoulders of giants. The following people contributed to writing portions of this book: Mark Garratt, Joel Huber, Ying So, Randy Tobias, Wayne Watson, and Klaus Zwerina. My parts could not have been written without the help of many people. I would like to thank Joel Huber, Ying So, Randy Tobias, and John Wurst. My involvement in the area of experimental design and choice modeling can be traced to several conversations with Mark Garratt in the early 1990's and then to the influence of Don Anderson, Joel Huber, Jordan Louviere, and Randy Tobias. I first learned about choice modeling at a tutorial taught by Jordan Louviere at the ART Forum. Later, as I got into this area, Jordan was very helpful at key times in my professional development. Don Anderson has been a great friend and influence over the years. Don did so much of the pioneering work on choice designs. There is no doubt that his name should be referenced in this book way more than it is. Joel Huber got me started on the work that became the `%ChoicEff` macro. Randy Tobias has been a great colleague and a huge help to me over the years in all areas of experimental design, and many components of the `%MktEx` macro and other design macros are based on his ideas and his work. Randy wrote PROC OPTEX and PROC FACTEX which provide the foundation for my design work. My work on balanced incomplete block designs can be traced to conversations with John Wurst.

Don Anderson, Warwick de Launey, Nam-Ky Nguyen, Shanqi Pang, Neil Sloane, Chung-yi Suen, Randy Tobias, J.C. Wang, and Yingshan Zhang kindly helped me with some of the orthogonal arrays in the `%MktEx` macro. Brad Jones advised me on coordinate exchange. Much of our current success with creating highly restricted designs is due to the difficult and very interesting design problems brought to me by Johnny Kwan. I have also learned a great deal from the interesting and challenging problems brought to me by Ziad Elmously.

There are a few other people that I would like to acknowledge. Without these people, I would have never been in the position to write a book such as this. From my undergraduate days at Kent State, I would like to thank Roy Lilly*, Larry Melamed, Steve Simnick and especially my adviser Ben Newberry. From graduate school at UNC, I would like to thank Ron Helms, Keith Muller, and especially my adviser Forrest Young*. From SAS, I would like to thank Bob Rodriguez, Warren Sarle, and all of my colleagues in SAS/STAT Research and Development. It is great to work with such a smart, talented, productive, and helpful group of people.

On a more personal note, I was diagnosed with prostate cancer in 2008. Most prostate cancers are not very aggressive. Someone forgot to tell mine that. My Gleason Score was 9. A Gleason Score is a measure of prostate cancer aggressiveness that ranges from 2 to 10. A 9 is almost as scary as they come. Thanks to modern medicine, early detection, and a brilliant and gifted surgeon using the latest technology, I am doing very well. Advocates of early testing and screening are trying to catch cases like mine early, while there is still time for a cure. In my case, every indication is that they were successful and surgery alone got it all. I get my PSA checked every three months now, and PSA since the surgery has consistently been undetectable, which is perfect. I have been cancer free for over two years now and am in the best shape of my life. I hope that all of you, men and women, get your regular physical exams and health screenings and see your health care provider if you notice any changes in your body and how it functions. Yes, I know it's not fun. Do it anyways! It saved my life; it might save yours too. I would like to thank a few of my friends who helped me through this period and the other difficult times that I went through in that year: Woody, Mike, Sara, Benny, Deborah, Gina, and Peg. You are my guardian angels. You gave me hope, help, and support, and you were there when I needed you the most.

Finally, I would like to thank my mother*, my father*, my sister, and my stepfather Ed*, for being so good to my Mom and for being such a wonderful grandfather to my children. I dedicate this edition of the book to my children, Megan and Rusty, and to Donna, who helped me learn how to live and love again.

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October 1, 2010

*It is sad that so many people that I acknowledge have passed away since I started working on this book. I wish I could thank all of these people for their role in helping me to get to where I am today.

About this Edition

The 2010 edition of **Marketing Research Methods in SAS** is a partial revision of the 2009 book. I did not have time to rewrite everything that I would have liked to rewrite. I do many different things professionally, way more than most readers of this book know. Those other things take most of my time, and it is hard to find the large block of time that I need to completely modify a piece of work this size every time there is an enhancement or innovation in the design macros. In this edition, I added new material and also added some guidance in the ensuing paragraphs about how to navigate through this book.

This edition has explicit instructions about how to contact Technical Support when you have questions or problems. See page 25 for more information. While I have never minded getting your questions, they really need to go to Technical Support first. I am not always in the office. Sometimes I am out backpacking without any contact with the outside world. Contacting Technical Support will ensure that your question is seen and addressed in a timely manner.

This edition contains some major new features that were not in the 2005 edition and one major new feature that was not in the 2009 edition. With this 2010 edition, the `%ChoicEff` macro now allows you to specify a restrictions macro. You can use it to specify within alternative restrictions, within choice set (and across alternative) restrictions, and even restrictions across choice sets. You can specify restrictions directly with the alternative-swapping algorithm. You no longer need to make a choice design with the `%MktEx` macro or with the choice-set-swapping algorithm in the `%ChoicEff` macro when there are restrictions.

Most of this book is about experimental design. In particular, most of it is about designing choice experiments. This is a big topic with multiple tools and multiple approaches with multiple nuances, so hundreds of pages are devoted to it. This can be intimidating when you are first getting started. The following information can help you get started:

- If you are new to choice modeling and choice design, and you want to understand what you are doing, you should start by reading the "Experimental Design: Efficiency, Coding, and Choice Designs" chapter, which starts on page 53. It is a self-contained short course on basic choice design, complete with exercises at the end.
- If you just want to jump in and get started designing experiments, see the examples of the `%ChoicEff` macro starting on page 808. This section describes all of the tools that you need to design almost any choice experiment. Many other tools and approaches exist and are described in detail elsewhere in the book, but you almost certainly can get by with the subset described starting on page 808. However, if you are going to approach choice modeling intelligently, you need to understand the coding and modeling issues discussed in the experimental design chapter and elsewhere throughout this book.
- If you want to understand the choice model and the classic approach to choice design, see the "Discrete Choice" chapter starting on page 285. While this chapter contains lots of great information on many topics related to choice modeling, and it uses an approach in most examples that is in many cases optimal or at least good, most of that chapter uses an approach that seems to be less often used now days.

The process of designing an experiment for a linear model is generally straight-forward since software, such as the %MktEx macro, exists for finding an optimal (or at least efficient) design for the specified model. In contrast, the process of designing a choice experiment is guided more by heuristics than hard science. You can only design an optimal experiment for a choice model if you know the parameters, and if you knew the parameters, there would be no reason to design the experiment. Much of the early work in choice design took a linear model design approach, which is discussed in detail in the design chapter starting on page 53 and the "Discrete Choice" chapter starting on page 285. In this approach, you make a design that is orthogonal and balanced (or at least nearly so) in all of the attributes of all of the alternatives and rearrange that into a choice design. This approach has much to recommend it, particularly in the context of alternative-specific designs and designs with complicated effects such as availability and cross effects. It is not the optimal approach for generic designs and simpler design problems.

In previous editions, I referred to this approach to designing choice experiments as the "linear design" approach. With this edition, I have banished that phrase from this book. That phrase has always been problematic and confusing. With this edition, I now use phrases like "linear model design" and "factorial design" interchangeably to refer to designs that will be used for a linear model such as a conjoint analysis. I no longer refer to a design constructed by the %MktEx macro that is converted to a choice design by the %MktRoll macro as a "linear design." Instead, I use the term "linear arrangement" as a short-hand for "linear arrangement of a choice design" to refer to a design that will ultimately be used for a choice design, but is currently arranged with one row per choice set and one column for every attribute of every alternative. The linear arrangement of a choice design can be constructed and evaluated by pretending that it will be used for a linear model with one factor for every attribute of every alternative. This is one way in which you can make a choice design, and it is discussed in detail in this book.

If you had to pick one approach to solve all of your design problems, and you did not have time to learn about all of the other ways you could go about designing a choice experiment, here is what I would recommend. Use the %MktEx macro to make a candidate set of alternatives, and use the %ChoicEff macro to create a choice design from it. If there are any restrictions on your design, use the restrictions= option in the %ChoicEff macro to impose the restrictions. The restrictions= option in the %ChoicEff macro is new with this edition of the book and macros. Restrictions can be within alternative, within choice set (and across alternative), or even across choice sets. You can impose restrictions to prevent certain combinations of alternatives from occurring together, to minimize the burden on the subjects, to eliminate dominated alternatives, to make the design more realistic, or for any other reason. I have not eliminated the hundreds of pages of this book that are devoted to other ways to make choice designs, because those pages contain a lot of useful information. Rather, I simply point out that you can selectively devote your attention to different parts of the book and concentrate on using the %ChoicEff macro with a candidate set of alternatives for most of your choice design needs.

Each of the last few editions has relied much more heavily on the %ChoicEff macro than preceding editions did. The %ChoicEff macro is heavily used both for design construction and for design evaluation. You should always use it to evaluate designs before data are collected. This has always been good advice, but with the addition of the standardized orthogonal contrast coding in PROC TRANSREG (which the macro calls) plus some new options and output, the %ChoicEff macro now provides a clearer picture of choice design goodness for many choice designs. In particular, it provides a measure of design efficiency on a 0 to 100 scale for at least some choice designs. See page 81 for more information.

A big part of this book is about experimental design. Efficient experimental-design software, like some other search software, is notorious for not finding the exact same results if anything changes (operating system, computer, SAS release, code version, compiler, math library, phase of the moon, and so on), and the `%MktEx` and `%ChoicEff` macros are no exception. They will find the same design if you specify a random number seed and run the same macro over and over again on the same machine, but if you change anything, they might find a different design. The algorithms are seeking to optimize an efficiency function. All it takes is one little difference, such as two numbers being almost identical but different in the last bit, and the algorithm can start down a different path. We expect as things change and the code is enhanced that the designs will be similar. Sometimes two designs might even have the exact same efficiency, but they will not be identical. The `%MktEx` and `%ChoicEff` macros, and other efficient design software take every step that increases efficiency. One can envision an alternative algorithm that repeatedly evaluates every possible step and then takes only the largest one with fuzzing to ensure proper tie handling. Such an algorithm would be less likely to give different designs, but it would be *much* slower. Hence, we take the standard approach of using a fast algorithm that makes great designs, but not always the same designs.

For many editions, I regenerated every design, every sample data set, every bit of output, and then made changes all over the text to refer to the new output. Many times I had to do this more than once when a particularly attractive enhancement that changed the results occurred to me late in the writing cycle. It was difficult, tedious, annoying, error prone, and time consuming, and it really did not contribute much to the book since you would very likely be running under a different configuration than me and not get exactly the same answers as me, no matter what either you or I did. Starting with the January 2004 edition, I said enough is enough! For many versions now, in the accompanying sample code, I have hard-coded in the actual example design after the code so you can run the sample and reproduce my results. I am continuing to do that, however I have not redone every example. Expect to get similar but different results, and use the sample code if you want to get the exact same design that was in the book. I would rather spend my time giving you new capabilities than rewriting old examples that have not changed in any important way.

In this and every other edition, all of the data sets in the discrete choice and conjoint examples are artificial. As a software developer, I do not have access to real data. Even if I did, it would be hard to use them since most of those chapters are about design. Of course the data need to come from subjects who make judgments based on the actual design. If I had real data in an example, I would no longer be able to change and enhance the design strategy for that example. Many of the examples have changed many times over the years as better design software and strategies became available. In this edition, like all previous editions, the emphasis is on showing design strategies not on illustrating the analysis of the data.

The orthogonal array catalog is essentially complete up through 143 runs,* with pretty good coverage from 144 to 513 runs, and spotty coverage beyond 513 runs. New arrays are being discovered regularly. If you know of any orthogonal arrays that are not in my catalog, please e-mail Warren.Kuhfeld at sas.com. I would particularly like to hear from you if you know how to make any of the arrays that are missing. Also, if you know how to construct any of these difference schemes, I would appreciate hearing from you: D(60, 36, 3); D(102, 51, 3); D(60, 21, 4); D(112, 64, 4); D(30, 15, 5); D(35, 17, 5); D(40, 25, 5); D(55, 17, 5); D(60, 25, 5); D(65, 25, 5); D(85, 35, 5); D(60, 11, 6); D(84, 16, 6); D(35, 11, 7); D(63, 28, 7); D(40, 8, 10); and D(30, 7, 15). The notation D(r, c, s) refers to an $r \times c$ matrix of order s. You can always go to `http://support.sas.com/techsup/technote/ts723.html` to see the current state of the orthogonal array catalog.

*There are a few missing designs in 108 runs. I would welcome help in making them.

ODS Graphics is used throughout the book. With ODS Graphics and SAS 9.2, statistical procedures produce graphs as automatically as they produce tables, and graphs are now integrated with tables in the ODS output. See 1247 for the section of the book that says the most about ODS Graphics. Also see "Chapter 21, Statistical Graphics Using ODS" in SAS/STAT documentation for more on ODS Graphics: `http://support.sas.com/documentation/`. You can learn more about ODS Graphics in my new book, **Statistical Graphics in SAS: An Introduction to the Graph Template Language and the Statistical Graphics Procedures**. You can learn more about the book at `http://support.sas.com/publishing/authors/kuhfeld.html`.

I hope you like this edition. Feedback is welcome. Your feedback can help make these tools better.

Getting Help and Contacting Technical Support

SAS Technical Support can help you if you encounter a problem or issue while working with the market research design macros or procedures in this book. However, you can help Technical Support greatly by providing certain details of your problem.

A new track will be initiated when you contact Technical Support about a specific problem, and notes added to that track as you work through the problem with your support specialist. For this reason, you should avoid starting multiple tracks on the same topic.

You can expect to hear back from a support specialist within one business day, but this does not necessarily mean that your question will be resolved by then. You might be asked to provide additional information to help solve your problem.

Opening a Track via the Web

You can contact Technical Support at the Technical Support Web site, which can be opened by using the link below. Working through a problem with your technical support specialist via Web and email is recommended for usage questions relating to this book.

`http://support.sas.com/ctx/supportform/index.jsp`

Opening a Track via the Phone

You can contact SAS Technical support via phone. We recommend this approach for short questions only. Please consult the SAS Technical Support Web site by clicking on the link below to obtain the appropriate Technical Support phone numbers for US and international users.

SAS Support Phone Numbers
919.677.8008 (US)
`http://www.sas.com/offices/intro.html` (International Support via Worldwide SAS Offices)

Important Information to Provide SAS Technical Support

Providing the following pieces of information to Technical Support can significantly shorten the time necessary to understand and solve your problem:

• **Your Contact Information.** Provide your full contact information: name, phone number, email address, and site number.

• **Information about your SAS Version and Market Design Macros.** Please include information about the version of SAS that you have installed and are using. You can find this information under Help → About SAS.

Please include information about the version of the macros that you have installed and are using. You can find this information by submitting the following statement before running any of the macros: `%let mktopts = version;`.

Example:

```
1? %let mktopts = version;
2? %mktex(2 ** 3, n=4)
```

Produces:

```
MktEx macro version 25Jul2010
MktRuns macro version 25Jul2010
Seed = 4247959
MktOrth macro version 25Jul2010
```

Note that some macros call other macros, and all must be the same version.

• **Information about your Design.** Please describe your design fully:

1. identify the type of design you want to generate (for example, choice, MaxDiff, conjoint, partial profile)
2. the number of factors, the number of levels associated with each factors
3. the number of runs (or choice sets) in the final design
4. the number of alternatives in a choice design
5. the model you want to estimate
6. if your model has constraints, define the desired constraints

• **Details about your Problem.** Include the program statements that you have tried to generate the design. Did you see an warning or error message in connection with your problem? If so, please attach a copy of the message to your technical support inquiry, and include a copy of the SAS .log file for the analysis.

Concluding Remarks

I hope you like this book, the new options, the new presentation style, and the new and improved macros. In particular, I hope you find the `%MktEx` and `%ChoicEff` macros to be very powerful and useful. My goal in writing this book and tool set is to help you do better research and do it more quickly and more easily. I would like to hear what you think. Many of my examples and enhancements to the software are based on feedback from people like you. If you have comments or suggestions for future revisions, write Warren F. Kuhfeld, (Warren.Kuhfeld at sas.com) at SAS Institute Inc. My goal to provide you with enough examples so that you can easily adapt aspects of one or more examples to fit your particular needs. When I do not succeed, tell me about it and I will try to add a new example to the next revision. Please direct questions to the Technical Support Division (see page 25) and suggestions to me. Please email me. I would like to hear from you!

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