Role of Optimal Design for Quality Improvement in the 21st Century: Panel Discussion

Organizer:

Ramón León

University of Tennessee

Session Schedule

- Introductions
- Opening Commentary (10 min. each)
- Follow-up Remarks (3-4 min. each)
- Floor Discussion (15 min.)

Panel Members

- Christopher Nachtsheim, U. of MN
- G. Geoffrey Vining, VA Tech
- C.F. Jeff Wu, GA Tech
- Bradley Jones, SAS Institute
- Dennis Lin, Penn State U.

Chris Nachtsheim, U. of MN

"Optimal design is now an indispensable tool for practitioners that complements classical tools and reduces barriers to the use of DOE for quality improvement."

Geoff Vining, Virginia Tech

These comments will emphasize the many diverse characteristics of a truly good design.

Role of Optimal Design

- Nancy Reagan Said It Best
  - Half Joking
  - Half Serious
- Debate from the 1970s
  - Box
  - Kiefer

Role of Optimal Design

- Satisfactory Distribution of Information
- Fitted Value as Close as Possible to True
- Lack of Fit
- Allow Transformations
- Allow for Blocking

Role of Optimal Design

- Allow Sequential Assembly
- Provide Internal Estimate of Error
- Insensitive to Outliers
- Require “Minimum Number” of Runs
- Provide Data Patterns that Allow Visual Appreciation

Role of Optimal Design

- Ensure Simplicity of Calculation
- Behave Well when Errors in the Factors
- Few Levels for Factors
- Provide Check of “Constancy of Variance”
- Projection Properties

Key Points

- Experimentation Is an Iterative Process
  - Not a One-Shot Deal
  - Each Phase Builds upon What Is Learned

Key Points

- “All Models Are Wrong; Some Models Are Useful”
  - Should Not Have Too Much Dependence on the Model
  - Lack of Fit
  - Projection Properties

Summary

- Optimal Designs Can Provide Insights
- Useful for Constrained Regions
- Take Them with a Grain of Salt
  - Not an “End All”
  - Need to Be Able to Justify Locations
  - Need to Consider Multiple Numbers of Runs

C. F. Jeff Wu, Georgia Tech

Some optimal design literature is useful. This commentary will highlight what is useful and what is less so.

Some Thoughts on Optimal Designs

- Exact optimality more useful and relevant than approximate (i.e., continuous) optimality.
- Major theoretical advance: Kiefer's general equivalence theory for characterizing approximate (i.e., continuous) optimal designs. In spite of its elegance, not very useful for finding exact optimal designs.
- However, Kiefer's universal optimality theorem is elegant and useful for understanding why balanced combinatorial designs (e.g., block or square designs) are optimal. For nearly balanced designs, theoretical work by C. S. Cheng and others are mandatory for finding and understanding efficient designs.

Some Thoughts on Optimal Designs (cont'd)

- *D-,G-,I*-optimality based on a *single* model, performance not guaranteed over a variety of models. Performance is highly *model-dependent.* (Criticism by Box et al.)
- Long history of optimal design algorithms (Fedorov, Wynn, Nachtsheim, etc.) Real impact started to be felt with advances in computing. Fast algorithms for finding optimal designs (e.g., block, regression, fractional factorial, space-filling designs) are now common features in design software.
- Algorithms make more impact than theory; generally *applicable to any models*.
- Bigger impact when used in conjunction with or as a supplement to a combinatorial or reasonably uniform design (irregular design region, follow-up experiment, sequential design).
- Generally useful as a benchmark.

Brad Jones, SAS Institute

“Classical designs are a subset of optimal designs. However, that subset is inadequate to address every problem that arises in practice.”

Dennis Lin, Penn State U.

These comments address the role of experimental design in scientific study and how various designs come to play.