Selection and Screening Procedures to Determine Optimal Product Designs

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Abstract

To compare several promising product designs, manufacturers must measure their performance under *multiple* environmental conditions. In many applications, a product design is considered to be seriously flawed if its performance is poor under any level of the environmental factor. For example, if a particular automobile battery design does not function well under some temperature conditions, then a manufacturer may not want to put this design into production. Thus, in this paper we consider the overall measure of a given product's quality to be its *worst* performance over the environmental levels. We develop statistical procedures to identify (a near) the optimal product design among a given set of product designs, i.e., the manufacturing design associated with the greatest overall measure of performance. We accomplish this for intuitive procedures based on the split-plot experimental design (and the randomized complete block design as a special case); split-plot designs have the essential structure of a product array and the practical convenience of local randomization. Two classes of statistical procedures are provided. In the first, the δ-*best formulation* of selection problems, we determine the number of replications of the basic split-plot design that are needed to guarantee, with a given confidence level, the selection of a product design whose minimum performance is within a specified amount, δ, of the performance of the optimal product design. In particular, if the difference between the quality of the best and 2*nd* best manufacturing designs is δ or more, then the procedure guarantees that the best design will be selected with specified probability. For applications where a split-plot experiment involving several product designs has been completed without the planning required of the δ-best formulation, we provide procedures to construct a "confidence subset" of the manufacturing designs; the selected subset contains the optimal product design with a prespecified confidence level. The latter is called the *subset selection formulation* of selection problems. Examples are provided to illustrate the procedures.

Keywords: Indifference-zone selection; Least favorable configuration; Optimal product design; Restricted randomization; Robust design; Statistical screening; Subset selection.