Optimality of Matched-Pair Designs in Randomized Controlled Trials*

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Abstract

This paper studies the optimality of matched-pair designs in randomized controlled trials (RCTs). Matched-pair designs are examples of stratified randomization, in which the researcher partitions a set of units into strata based on their observed covariates and assign a fraction of units in each stratum to treatment. A matched-pair design is such a procedure with two units per stratum. Despite the prevalence of stratified randomization in RCTs, implementations differ vastly. We provide an econometric framework in which, among all stratified randomization procedures, the optimal one in terms of the mean-squared error of the difference-in-means estimator is a matched-pair design that orders units according to a scalar function of their covariates and matches adjacent units. Our framework captures a leading motivation for stratifying in the sense that it shows that the proposed matched-pair design additionally minimizes the magnitude of the ex-post bias, i.e., the bias of the estimator conditional on realized treatment status. We then consider empirical counterparts to the optimal stratification using data from pilot experiments and provide two different procedures depending on whether the sample size of the pilot is large or small. For each procedure, we develop methods for testing the null hypothesis that the average treatment effect equals a prespecified value. Each test we provide is asymptotically exact in the sense that the limiting rejection probability under the null equals the nominal level. We run an experiment on the Amazon Mechanical Turk using one of the proposed procedures, replicating one of the treatment arms in DellaVigna and Pope (2018), and find the standard error decreases by 29%, so that only half of the sample size is required to attain the same standard error.

KEYWORDS: Matched-pair design, stratified randomization, randomized controlled trial, ex-post bias, treatment effect, stratification, pilot experiment, matched pairs

JEL CLASSIFICATION CODES: C12, C13, C14, C90