

Peter M. Steiner

## How to Use Pretest Measures of the Outcome for Causal Inference with Observational Data: ANCOVA, Gain Scores, Deviation Scores, or Fixed-Effects Dummies?

Pretest-posttest designs with a nonrandomized comparison group are frequently used for causal inference with observational studies. The pretest measure plays an important role in nonrandomized pretest-posttest designs because the pretest has a great potential to remove confounding bias. In analyzing pretest-posttest data, researchers may use the pretest as a covariate in ANCOVA or in a fixed-effects approach via gain scores, deviation scores, or fixed-effects dummies (repeated measurements ANOVA). However, all these strategies for identifying and estimating a causal effect are based on quite different assumptions. Using graphical models, this talk first shows that ANCOVA and fixed-effects analyses rely on completely different mechanisms for removing confounding bias. While conditioning on the pretest in ANCOVA aims at blocking spurious associations due to unobserved confounders, fixed-effects analyses try to offset time-invariant confounding by creating an artificial association in opposite direction. Given the different mechanisms for removing confounding bias, we then show that the identification of causal effects via fixed-effect methods is insensitive to measurement error in the pretest, bias-amplification, and collider bias, while ANCOVA is susceptible to all three issues. We will also graphically investigate the differences between gain scores, deviation scores, and fixed-effects dummies, and discuss scenarios in which these approaches succeed or fail to identify the causal effect.