Two-Stage Calibration for GAMLSS: Distributional Regression with Validation Data under Unmeasured Confounding

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Abstract

This paper introduces a Two-Stage Calibration (TSC) procedure for Generalized Additive Models for Location, Scale, and Shape (GAMLSS), aimed at correcting unmeasured confounding in large observational studies. By leveraging a small validation subsample where the confounder is measured, the TSC method calibrates the full conditional distribution, including location, scale, skewness, and kurtosis, to achieve unbiased estimation while maintaining efficiency. Theoretical results establish the consistency and asymptotic normality of the TSC-GAMLSS estimators, and a nested nonparametric bootstrap is proposed for valid inference. A real data application to the National Health and Nutrition Examination Survey (NHANES) data demonstrates the practical utility of TSC-GAMLSS in estimating systolic blood pressure distributions while adjusting for body mass index (BMI) as a confounder.

Keywords: TSC-GAMLSS, unmeasured confounding, observational studies, bootstrap.