

Regression discontinuity designs for random objects

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Regression discontinuity designs (RDDs), quasi-experimental designs for observational studies to estimate causal effects of an intervention or treatment at a cut-off point, have been widely applied in various fields of data science. We propose an extension of RDDs, where we extend the customary scenario of scalar responses and aim at causal inference for a general class of complex non-Euclidean outcomes. Specifically, the outcomes considered extend beyond scalars or vectors and include networks, compositional data, and functional data, as well as other types of random objects situated in geodesic metric spaces. For this extension, we express the causal effect at the cutoff point as a geodesic from the local Fréchet mean of the untreated outcome to the treated outcome, which reduces to the ordinary average treatment effect and thus to the well-established approach for RDDs in the special case of scalar or vector outcomes. Our estimation method is based on local Fréchet regression, a regression method for non-Euclidean responses that corresponds to local linear regression for the special case of scalar responses. The proposed approach is supported by theory, and we establish the convergence rate of the geodesic RDD estimator. We apply the proposed method to assess the changes caused in daily CO concentration curves by the introduction of a metro system in Taipei and in UK voting behavior as quantified by compositional data after wins by the conservative party.