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## Combining Functional PCA and Nonparametric Estimation for Complex Structural Equation Models

### Communication Info

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### Abstract

Structural Equation Models (SEM) [1] provide a framework for modeling relationships between observed variables ( $\mathbf{x}$  and  $\mathbf{y}$ ) and latent constructs ( $\eta$  and  $\xi$ ) through a measurement model ( $\mathbf{x} = \Lambda_x \xi + \delta$  and  $\mathbf{y} = \Lambda_y \eta + \varepsilon$ ) and a structural model ( $\eta = B\eta + \Gamma\xi + \zeta$ ).

Classical SEM assumes multivariate finite-dimensional observations and linear structural relations. However, many modern datasets are functional, where observations are realizations of stochastic processes  $X_i(t)$ . To address this limitation, we incorporate Functional Principal Component Analysis (FPCA) into the measurement model [2]. Each functional indicator is represented through the expansion [3],

$$X_i(t) = \mu(t) + \sum_{k=1}^K c_{ik} \phi_k(t),$$

where  $\phi_k(t)$  are eigenfunctions and  $c_{ik}$  are functional scores used to construct the latent representations.

Furthermore, we replace the linear structural equations with a nonparametric specification [4] [5],

$$\eta_j = f_j(\cdot) + \zeta_j,$$

allowing for nonlinear dependencies among latent variables. The performance of the proposed approach is demonstrated through multiple simulation studies implemented in R.

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