A hierarchical multidimensional graded response model with application to the study of sustainability perception

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Abstract

Hierarchical multidimensional item response theory (IRT) models have been developed to incorporate a general trait and more than one dimension of specific traits through different latent structures. In this study, we propose to insert a hierarchical multidimensional structure in the Samejima's graded response model, an IRT model used to score assessments and questionnaires composed of items with multiple ordered response categories. Specifically, the hierarchical multidimensional structure inserted in the model admits that each specific latent trait related to a respondent is a linear function of the general latent trait. In order to estimate the parameters of the proposed model, we use a Bayesian approach through the No-U-Turn Sampler algorithm, a Markov chain Monte Carlo method. Simulation study is conducted to evaluate the parameter recovery in different scenarios constructed by varying the number of individuals and items. The results indicated that NUTS algorithm properly recovers all parameters and is accurate for all simulated scenarios. In order to demonstrate the practical applications of the proposed model, we consider actual data about sustainability perception of the Paraná III Basin residents in Brazil. Fifty-two items applied to 2,519 respondents are considered to assess a general trait and three dimensions of specific traits: economics, environmental, and social. The results suggest that (a) the model is appropriate to the data; (b) compared with the unidimensional graded response model, the proposed model better describe the data, providing useful information about the dimensions of specific traits and the relationship between them and the general trait; and (c) the use of a model with a hierarchical multidimensional structure should be based on the context of the data.

Keywords: Bayesian estimation; environmental sustainability; hierarchical MIRT model; latent variable modeling; multidimensional IRT.