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Alternative Definitions Of Effects/Contributions In Path Analysis With Multidimensional Blocks

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Abstract:

Path analysis is a statistical technique used to describe the directed dependencies among a set of variables. It is an extension of multiple regression and is often used to test hypotheses about the relationships between variables. In path analysis, a node represents a variable, and the paths between nodes represent the hypothesized causal relationships. Each path has an associated coefficient that quantifies the strength and direction of the relationship. When path analysis involves blocks of variables, it corresponds to structural equation modeling, which allows for the analysis of complex relationships among observed and latent variables. In univariate path analysis, the effects of one node on another are well-defined. However, when nodes are multivariate, meaning they consist of multiple variables or dimensions, the problem becomes more complex and less intuitive. Previous attempts to address this issue have not provided a clear and comprehensible solution. This study introduces a novel definition of effects (called contributions to avoid confusion), grounded in simple orthogonalization techniques and extended to flexible regression models. The aim is to establish an intuitive framework for defining path effects in multidimensional blocks, which remains applicable in unidimensional scenarios. This approach seeks to enhance the clarity and utility of path analysis in more complex, multivariate settings. The methodology involves three distinct regression models, incorporating an input block, an output block, and multiple blocks influencing the output block. This leads to the formulation of several key contributions: total contribution, unique contribution, interaction, and additional contribution. Each of these contributions is carefully defined to capture the intricate relationships between the blocks. The study presents findings from both simulations and real-world data, highlighting the practical implications of the proposed definitions. Special attention is given to cases where rank deficiency poses challenges, demonstrating how the new framework can address these issues effectively. A comprehensive definition of path effects/contributions for multidimensional blocks is provided, along with an analysis of its strengths and weaknesses. This new approach offers a transparent and intuitive solution to a previously complex problem, paving the way for more effective path analysis in multivariate contexts.