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Structural Equation Modelling for Individual-Based Simulation

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Abstract: Simulation modelling and individual-based modelling in particular is widely applied to analyse socio-ecological systems (SES). However, the degree of complexity of SES and the corresponding characteristics of individual-based models challenge their analysis. In particular, the analysis might be aggravated by characteristics such as a high number of entities and parameters, interdependent relations as well as several layers of effects. In addition, the analysis has to cover sometimes multivariate simulation model outputs. Further challenges concerning the analysis of these complex models and their results are their subsequent understanding and communication, which are crucial but often neglected tasks in simulation modelling. Overall, these challenges affect the credibility of results and may also impede the validation and verification of simulation models. To address this, we propose an integrated statistical modelling approach based on structural equation modelling using the partial least squares algorithm (PLS-SEM). It has been recently suggested as a new metamodeling technique for agent-based modelling. This method integrates models' entities, their parameters and their conceptual relations as well as the resulting simulation model output. Based on this, we can estimate and evaluate highly networked systems in metamodels to depict their underlying characteristics. In this sense, the resulting metamodel is able to expose the complex behaviour and relationships of the simulation model and further improves the understanding of SES. Furthermore, this method can be conveniently applied by means of standard software and provides a consumable graphical presentation of the models' entities, their parameters and their relations to stakeholders. Overall, the resulting link between the simulation model behaviour and the thereby generated data displayed in a graphical language considerably supports the understanding and communication of individual-based simulation models and their results.

Keywords*:* Simulation Model Analysis; Metamodelling; Visualizing complex data; Structural Equation Modelling; Communication