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Subject: Opponent's Review of the habilitation thesis "Analysis of Multi-factorial Compositional Data and Related Methodological Developments" by Dr. Kamila Fačevicová

Dear Members of the Habilitation Committee,

I am pleased to submit my opponent's review of the habilitation thesis "Analysis of Multi-factorial Compositional Data and Related Methodological Developments" by Dr. Kamila Fačevicová in the field of Applied Mathematics. I am Associate Professor of Statistics at MOX, Department of Mathematics, Politecnico di Milano. My research concerns the statistical analysis of complex data with spatial dependence, with particular reference to functional and compositional data, Bayes spaces, and data in Riemannian manifolds. My methodological work includes compositional regression, transformations for spatial compositional data, and the analysis of density-valued and multivariate complex data, as well as geostatistical applications involving chemical species and environmental processes. This background is directly relevant to the assessment of the thesis, with particular reference to compositional data analysis and log-ratio geometry; multivariate and dimension-reduction methods for constrained data; Bayes-space and coordinate representations; and regression and spatial modelling of compositional structures.

The thesis is a coherent and substantial collection of eleven publications devoted to the analysis of relative-valued data. Its unifying contribution lies in the development of methodology for multi-factorial compositional data, extending the familiar vector setting to tables and cubes. The introductory chapters provide a clear and well-motivated account of why compositions must be analysed through relative information, rather than through absolute levels, and of why this requires a log-ratio and coordinate-based statistical treatment. The central methodological contribution is the framework for compositional cubes, which generalises compositional tables to three-factorial structures. The proposed orthogonal decomposition separates independent effects from pairwise and higher-order interactions, while the associated coordinate system provides an interpretable representation in terms of balances, log-odds ratios, and higher-order interactions.

This constitutes a meaningful development of compositional methodology, both in theoretical terms and for applications involving several underlying factors. The thesis further establishes important links between the compositional framework and classical statistical methods. It shows the equivalence between the interaction component of a compositional table and correspondence analysis, including a weighted formulation; extends backwards pivot coordinates to compositional tables; and considers regression modelling for spatially dependent two-factorial compositions. The latter contribution is particularly close to my own area of expertise and offers a well-motivated route for combining compositional and spatial statistical reasoning.

A further strength of the thesis is its attention to issues that are central to applied statistical work. The papers on robust principal component analysis for compositional tables, cellwise robust covariance estimation, and robust blind source separation address contamination without overlooking the special geometry of compositional observations. The critical study of zero handling in high-dimensional compositional count data appropriately identifies the tension between numerical reconstruction, the count structure, and the validity of downstream multivariate analyses.

The applied papers reinforce the coherence of the collection. The geochemical study shows how compositional analysis can support an interpretable, data-driven construction of geochemical proxies, while the eye-tracking paper demonstrates clearly how relative allocation of visual attention can be studied using compositional tools and how descriptive, inferential, and regression methods can be integrated in a new application domain. These examples show not only the practical usability of the methodology, but also its relevance for substantive scientific questions.

The thesis is well structured and clearly written. It provides appropriate context for the included publications and explicitly documents the collaborative nature of the work and the candidate's declared contribution to each paper. The research programme shows continuity, a strong command of modern compositional methodology, and the ability to develop theoretical results while maintaining a clear connection to applications. The publication portfolio comprises eight articles in peer-reviewed international journals and three peer-reviewed book chapters published by Springer. According to the 2025 SCImago Journal Rank indicators, the journal venues are ranked in the first or second quartile of their respective subject categories. This publication record thus provides solid external evidence of the scientific quality and visibility of the research.

Overall, I consider that the habilitation thesis of Dr. Kamila Fačevicová meets the standard requirements for a habilitation thesis in the field of Applied Mathematics. It presents original and well-integrated methodological developments, is supported by a strong publication record, and demonstrates the candidate's scientific maturity and capacity for independent research in Applied Mathematics and Statistics. I therefore recommend that the thesis is accepted for further progress in the habilitation procedure.

Yours sincerely,

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