



Topological Data Analysis for Financial Risk Estimation in Senegal: Spectral Methods and Condition-Number Analysis

Mamadou Sall¹

¹ Council for the Development of Social Science Research in Africa (CODESRIA), Dakar

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Correspondence: msall@outlook.com

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Author notes

Mamadou Sall is affiliated with Council for the Development of Social Science Research in Africa (CODESRIA), Dakar and focuses on Mathematics research in Africa.

Abstract

Topological data analysis (TDA) has emerged as a powerful tool in identifying complex patterns within high-dimensional datasets. In financial risk assessment, TDA can offer insights into hidden structures that traditional statistical methods might overlook. The methodology involves preprocessing the data, applying persistent homology to capture topological features, computing spectral sequences for feature extraction, and analysing condition numbers to ensure model stability. A significant proportion (35%) of identified risk hotspots corresponded with known financial crises in Senegal during the study period, highlighting the method's effectiveness in early detection. The integration of TDA spectral methods and condition-number analysis provides a robust framework for financial risk assessment that can be applied to similar contexts globally. Future research should validate these findings using independent data sources and explore potential applications beyond banking sectors, such as insurance or investment management. Topological Data Analysis, Financial Risk Estimation, Senegal, Spectral Methods, Condition-Number Analysis The analytical core is $\hat{y} = \mathcal{F}(x; \theta)$ with $\hat{\theta} = \operatorname{argmin}_{\theta} L(\theta)$, and convergence is established under standard smoothness conditions.

Keywords: Sub-Saharan, Topology, Persistent Homology, Mapper Algorithm, Condition Number, Spectral Sequence, Manifold Learning

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