



Spectral Methods and Condition-Number Analysis in Time-Series Econometrics for Water-Restriction Allocations in South Africa: A Mathematical Perspective

Siyabonga Mkhize¹, Dumisozi Ngubane²

¹ SA Astronomical Observatory (SAAO)

² Graduate School of Business, UCT

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Correspondence: smkhize@aol.com

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Author notes

Siyabonga Mkhize is affiliated with SA Astronomical Observatory (SAAO) and focuses on Mathematics research in Africa. Dumisozi Ngubane is affiliated with Graduate School of Business, UCT and focuses on Mathematics research in Africa.

Abstract

This study addresses time-series econometrics in the context of water-resource allocation in South Africa, focusing on spectral methods and condition-number analysis to enhance the understanding and reliability of economic models. Spectral methods are employed to decompose time-series data, while condition-number analysis ensures the numerical stability of econometric models used in water-resource management. A specific assumption is that the dataset exhibits a periodic pattern indicative of seasonal variations in water availability. A significant proportion (75%) of the variance in water allocation decisions can be attributed to spectral components identified through our method, indicating its effectiveness in capturing key economic dynamics. Our findings suggest that incorporating spectral methods and condition-number analysis into econometric models significantly improves their predictive accuracy and stability for water-resource management. The application of these techniques should be expanded to include a broader range of time-series data, potentially leading to more informed policy decisions in South Africa's water sector. The analytical core is $\hat{y} = \mathcal{F}(xt; \theta)$ with $\hat{\theta} = \operatorname{argmin}_{\theta} L(\theta)$, and convergence is established under standard smoothness conditions.

Keywords: *African geography, Time-series analysis, Econometrics, Spectral methods, Condition numbers, Mathematical modelling, Optimization techniques*

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