Small Area Estimation using Spatio-Temporal M-quantile Models

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Abstract

The paper introduces a novel framework for small area estimation based on spatio-temporal M-quantile regression. The proposed approach extends the Geographically Weighted Regression by incorporating both spatial and temporal weighting schemes, and integrates them with the M-quantile modelling to effectively capture local distributional features across space and time. The resulting predictors are specifically designed for out-of-sample prediction in small domains and are accompanied by analytical estimators of their mean squared error. The methodology is evaluated through extensive simulation studies, demonstrating strong robustness to spatiotemporal dependence and the presence of outliers at both unit and area levels. An application to county-level air quality data in the United States (2016–2023) highlights the predictive performance and practical relevance of the proposed methods..

Keywords: M-quantile regression; spatio-temporal modelling; geographically weighted regression; robust prediction; out-of-sample prediction; mean squared error estimation

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