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LONG ABSTRACT

Air quality and traffic restriction in Milan: a counterfactualanalysis based on a Matrix Completion Approach

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Policymakers implement interventions to reduce traffic-related pollution, particularly in northern Italy and the Po Valley, where air quality is a critical concern. Several studies propose quantitative methods to assess the effectiveness of these interventions (e.g., Maranzano et al., 2020). However, none has already utilized a Matrix Completion (MC) approach. MC is a machine-learning technique, traditionally, used to impute missing values within a data set (e.g. Input-Output matrices, as done in Metulini et al. 2023). It works by formulating an optimization problem that minimizes the difference between predicted and observed values (approximation error) while controlling the complexity ofthe reconstructed data. In this article, we propose to assess the impact of a traffic restriction policy in Milan's "Area B" using MC as a counterfactual method. Counterfactual methods estimate what would have happened without this intervention. We aim to estimate air quality in "Area B" if the traffic restrictions had not been implemented. We achieve this by creating a data matrix where each row represents a timeseries of air quality data for a specific monitoring station (either within "Area B" or a neighboring area not affected by the policy). The time frame encompasses both pre- intervention and post-intervention periods.

This fact creates a clear distinction between stations impacted by the intervention ("treated") and those not ("untreated"). Our approach involves artificially hiding the data for stations belonging to "Area B" during the intervention period. We then leverage MC to estimate these missing values. The impact of the traffic restriction is then quantified by comparing the actual air quality measurements during this period with the estimated values derived through MC. We apply this method to air quality data and relevant covariates (e.g. temperature and wind speed) obtained from the Lombardy Regional Agency for Environmental Protection (ARPA Lombardia). Specifically, we employ the nuclear norm matrix completion methodfor panel data with covariates, proposed by Athey et al. (2021). A key advantage of this approach resides in its ability to estimate the intervention's impact across the entire "Area B" in a single step. This contrasts with traditional methods that estimate the impact for each station individually. To validate the proposed methodology for this specific application, we perform cross-validation using a subset of the data where the traffic intervention had not yet been implemented

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