

Advanced spatial modelling for analysing regional emissions: a spline approach to the environmental kuznets hypothesis

Andrea Furková^a 

^a Faculty of Economic informatics, University of Economics in Bratislava, Slovak Republic

Email: andrea.furkova@euba.sk

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Abstract: The objective of this study is to analyse regional disparities in greenhouse gas (GHG) emissions (Crippa et al., 2023) across NUTS 2 (Nomenclature of Territorial Units for Statistics, level 2) regions of the European Union in 2022 using advanced spatial econometric models combined with spline functions. The study focuses on testing the Environmental Kuznets Curve (EKC) hypothesis and expands the analytical framework by incorporating spatial dependencies and nonlinear relationships between economic growth and environmental impacts. The specific goals are to identify nonlinear links between GDP per capita and GHG emissions, quantify spatial dependence and spillover effects across regions, and examine additional socio-economic factors, such as urbanization, industrial structure, and education level, that may be relevant for regional environmental policymaking. The methodological framework combines traditional spatial econometric models, such as spatial autoregressive models, which allow capturing spatial interactions between regions and detecting spillover effects (Fahrmeir et al., 2021), with flexible semiparametric approaches based on spline functions (Mínguez et al., 2022). These splines allow for modelling localized nonlinearities without assuming a specific functional form, providing the ability to reveal subtle patterns in the data that might remain hidden in purely linear models. Optimization procedures are applied to select the appropriate penalty for spline smoothing, ensuring the right balance between model complexity and fit, using data-driven criteria such as generalized cross-validation. This comprehensive approach not only enables testing the EKC hypothesis but also assesses the extent to which regional policies and intervention strategies can contribute to achieving the European Union's climate targets outlined in major policy documents such as the European Green Deal and the "Fit for 55" legislative package, ultimately providing valuable input for designing more effective and geographically tailored environmental measures (European Commission, 2021).

REFERENCES

- Chi G and Zhu J (2019) Spatial regression models for the social sciences. Thousand Oaks, CA: SAGE Publications, Inc.
- Crippa M et al. (2023) GHG emissions of all world countries. Luxembourg: Publications Office of the European Union.
- European Commission (2021) 'Fit for 55': Delivering the EU's 2030 climate target on the way to climate neutrality. Brussels: Publications Office of the European Union. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0550> (April 1 2025)
- Fahrmeir L, Kneib T, Lang S and Marx B D (2021) Regression models, methods and applications. Berlin and Heidelberg: Springer.

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