

Exploring the Longitudinal Associations Between Environmental Regulation Intensity and Carbon Emissions from Rural Residential Buildings in China Based on a Hierarchical Linear Model

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Abstract : Amid the growing challenges of global climate change and ecological crises, China has set ambitious carbon neutrality and carbon peaking targets to address these environmental issues. Environmental regulation, as a policy tool, plays a crucial role in this effort, and its effective implementation is essential for decarbonization. However, most existing studies on environmental regulation tend to focus on a single level of analysis, failing to account for the interactions across multiple levels. Additionally, there is a lack of longitudinal studies on the implementation effects of provincial environmental regulations at lower levels of government. This study aims to examine the longitudinal relationship between the intensity of provincial environmental regulation and carbon emissions from rural residential buildings at the municipal level, using hierarchical linear modeling. It also explores heterogeneity based on economic development levels and the characteristics of environmental regulations. Data on socio-economic conditions and rural residential construction in 1,020 villages across 117 municipalities in 26 provincial administrative regions of China were collected through field surveys. The total carbon dioxide emissions were then calculated. Next, government work reports from each province were collected, and the frequency ratios of relevant keywords were processed using Python to quantify the environmental regulation intensity of provincial governments. Subsequently, null models, slope models, intercept models, and complete models were sequentially constructed using the HLM method to explore the link between provincial environmental regulation intensity and municipal carbon emissions from rural residential buildings. Finally, provinces were grouped based on their economic zoning characteristics and year-to-year changes in environmental regulation intensity. The heterogeneity of each province category was analyzed and compared. The results reveal that provincial environmental regulation moderates carbon dioxide emissions from rural residential buildings by influencing nine predictor variables, such as the presence of kitchens and flush toilets in rural housing. Heterogeneity analysis shows that in the more economically developed eastern coastal regions, an increase in the proportion of rural housing renovation leads to reduced carbon emissions, and the intensity of environmental regulation negatively moderates this effect, which further promotes carbon reduction. In contrast, in the central and western regions, an increase in environmental regulation intensity appears counterproductive to carbon reduction in this regard. Provinces where the intensity of environmental regulation has remained stable over time are better able to achieve the desired effects. This finding highlights the opportunity for policymakers to design targeted interventions for specific geographical areas and to pay particular attention to the factors contributing to relatively poor policy implementation. This study helps policymakers gain a better understanding of how the intensity of environmental regulation affects CO₂ emissions, providing insights for the development of more effective policies aimed at achieving carbon reduction goals.

Keywords : carbon dioxide emissions, environmental regulations, economic differences, hierarchical linear model, longitudinal associations

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