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"Gheorghe Asachi" Technical University of Iasi, Romania

SPATIO-TEMPORAL EVOLUTION AND POLICY PATHWAYS FOR ENHANCING CARBON EMISSION EFFICIENCY IN THE CHENGDU–CHONGQING URBAN AGGLOMERATION

Yang Yang[1]*, Bui Thanh Khoa[2]

[1]Business School, Geely University of China，Chengdu 641423，China
[2]Industrial University of Ho Chi Minh City, Ho Chi Minh City 727000, Viet Nam

Abstract

In the context of intensifying global climate challenges and the implementation of China's "dual-carbon" initiative, enhancing carbon emission efficiency (CEE) has become a central priority for achieving sustainable regional development and balancing economic growth with environmental protection. This study provides a comprehensive analysis of the spatiotemporal evolution and underlying mechanisms of CEE across 16 cities in the Chengdu–Chongqing urban agglomeration over the period 2007–2023. Employing a non-expected output-oriented Super-SBM model in combination with a suite of econometric techniques—including fixed-effects regressions, mediating-effects analysis, and instrumental variable models—we capture both the direct and indirect influences of industrial structure rationalization on CEE. The results indicate that CEE in the region follows an overall upward yet fluctuating trajectory, with significant and persistent disparities between cities. Industrial structure rationalization emerges as a critical driver, exerting a strong direct effect on improving CEE while simultaneously enhancing it indirectly by lowering energy intensity. Moreover, the upgrading of human capital and deeper integration into the global economy are shown to further strengthen efficiency improvements, highlighting the multifaceted nature of the transition toward low-carbon development. By integrating empirical evidence with theoretical insights, this research not only deepens the understanding of CEE dynamics in inland urban agglomerations but also provides practical guidance for formulating differentiated, city-specific carbon reduction strategies. The findings emphasize the importance of coordinated industrial restructuring, energy efficiency improvements, and openness policies as complementary pathways to advancing the green transformation of emerging metropolitan clusters in China and beyond.

Key words: carbon emission efficiency, carbon reduction policies, Chengdu-Chongqing urban agglomeration, rationalization of industrial structure, SBM model

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* Author to whom all correspondence should be addressed: E-mail: yangyang@guc.edu.cn; Phone: +86 18911919072