

## A MULTIDIMENSIONAL MACHINE LEARNING STUDY OF ENVIRONMENTAL INNOVATION AND ESG INTEGRATION IN BRICS ECONOMIES

### AUTHORS

Midrar Ullah, Xiaoxia Huang, Liukai Wang, Subhan Ullah, Pervaiz Akhtar

### EXECUTIVE SUMMARY

Environmental, social, and governance (ESG) performance has developed as a critical axis of business strategy, specifically within countries enduring institutional transformation and coping with extreme environmental exposures. This empirical study considers the degree to which environmental innovation improves ESG outcomes in BRICS economies (Brazil, Russia, India, China, and South Africa). Using a dataset from Refinitiv Eikon covering the 2009 to 2023 data, this study applies elastic net regression and a comprehensive stacked ensemble learning framework combining random forest, gradient boosting, ridge regression, and support vector machine (SVM) models to evaluate the predictive capability of environmental innovation with governance and firm-specific determinants. We find that environmental innovation positively influences ESG performance, suggesting environmental innovation is not only strategic, but also an important driver of corporate sustainability initiatives in emerging markets. Results reveal that institutional quality and CEO power moderate the relationship between environmental innovation and ESG. These insights feature the economically significant and contingent value of sustainability investments and offer actionable inferences for corporate leaders and policymakers.



### KEYWORDS

- CEO power
- Corporate sustainability
- Environmental innovation
- ESG performance
- Ethical initiatives
- Institutional quality
- Machine learning
- Sustainability targets

### RESEARCH RELEVANCE

- Environmental innovation is a statistically significant predictor of ESG performance across BRICS economies (Brazil, Russia, India, China, and South Africa), confirming its direct role in strengthening corporate sustainability.
- The study leverages stacked ensemble machine learning to deliver more robust ESG predictions.
- Institutional quality amplifies or constrains the ESG benefits of environmental innovation, indicating strong governance environments enhance sustainability payoffs.
- CEO power meaningfully moderates outcomes, showing that leadership structure can accelerate or weaken the translation of innovation into ESG performance.
- Sustainability investments deliver economically material yet context-dependent value, underscoring that ESG gains vary by firm and institutional conditions.

### BIBLIOGRAPHIC INFORMATION

Ullah, M., Huang, X., Wang, L., Ullah, S., & Akhtar, P. (2025). A Multidimensional Machine Learning Study of Environmental Innovation and ESG Integration in BRICS Economies. *Business Strategy and the Environment*. Advance online publication. <https://doi.org/10.1002/bse.70432>

*“Across BRICS economies, environmental innovation—enhanced by strong institutions, balanced CEO power, and advanced ensemble analytics—emerges as a decisive yet context-dependent driver of ESG performance and sustainable value creation.”*

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