

Macroeconomic Indicators and the Rise of Environmental Sustainability: Evidence from BRICS Economies

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ABSTRACT

The global imperative for environmental sustainability has fundamentally reshaped markets, increasing the demand for responsible products; however, the evolution to sustainable consumption varies significantly across regions, particularly within the BRICS economies (Brazil, Russia, India, China, and South Africa). This study empirically investigates the macroeconomic determinants influencing environmental sustainability and the transition toward a low-carbon economy during the digital era. Utilizing a secondary dataset from the World Development Indicators, the analysis examines the predictive role of GDP per capita, carbon emissions and urbanization in shaping sustainable consumption patterns. Panel regression and causality tests are employed to identify relationships and determine the strength of influence across variables. The results highlight the importance of urbanisation and environmental factors in driving sustainable development, both in the short and long term. These findings contribute to sustainability economics by providing data-driven evidence for policymakers to design targeted strategies, such as carbon taxes, green technology investments and sustainable urbanisation, to decouple economic expansion from environmental degradation.

Keywords: BRICS, environmental sustainability, SDG Score, GDP per capita, carbon emissions, urbanization, sustainable consumption

INTRODUCTION:

The need of achieving environmental sustainability with economic growth is a major concern worldwide, especially of the emerging nations where growth coincides with environmental degradations. Resource depletion, climate changes and ecological imbalances made policy makers to reconsider the traditional growth-centric development. BRICS economies—Brazil, Russia, India, China, and South Africa—occupy an important position in the global sustainability discourse. Together, these countries account for a significant share of global population, energy consumption, urban expansion, and carbon emissions. Rapid industrialisation, rising incomes, and accelerated urbanisation have contributed to substantial economic progress in these economies; however, they have also intensified environmental challenges, particularly in terms of carbon emissions and urban ecological stress. As a result, understanding the macroeconomic indicators of environmental sustainability within the BRICS nations is essential for designing effective and context-specific policy interventions.

The Sustainable Development Goals (SDGs) introduced by the United Nations provide a comprehensive framework that integrates economic growth, social inclusion, and environmental protection, making SDG performance a critical indicator of sustainable development outcomes (United Nations, 2023). Existing research suggests that macroeconomic indicators such as GDP per capita, carbon emissions, and urbanisation exert

complex and often non-linear effects on sustainability outcomes. Grossman and Krueger (1995) and Stern (2004) argue that income growth initially increases environmental degradation but eventually declines as economies adopt cleaner technologies with higher income levels.

While some studies find that emissions negatively affect sustainable development indicators, others suggest that their impact becomes less pronounced when controlled for structural and technological factors (Dogan & Inglesi-Lotz, 2023). This divergence underscores the importance of adopting comprehensive sustainability measures rather than relying on single environmental indicators.

Urbanisation represents another critical determinant of environmental sustainability, particularly in emerging economies. Rapid urban growth can generate economies of scale, improve access to services, and promote innovation, thereby supporting long-term sustainability (Li et al., 2023). Conversely, unplanned urbanisation often leads to congestion, pollution, and increased demand for energy and infrastructure, resulting in adverse short-run environmental effects (Bui et al., 2023; Wang et al., 2023). Empirical evidence suggests that the sustainability impact of urbanisation depends heavily on governance quality, infrastructure investment, and urban planning strategies.

Despite these advances, gaps remain in the empirical literature regarding the combined long-run and short-run effects of macroeconomic indicators on SDG performance in BRICS countries. Many studies focus on single indicators or individual countries, limiting comparability

and policy relevance. By employing panel cointegration techniques and an error correction framework, the present study extends the existing literature by providing a comprehensive and dynamic assessment of how GDP per capita, carbon emissions, and urbanisation jointly influence environmental sustainability in BRICS economies.

This study empirically investigates the predictive roles of GDP per capita, carbon emissions, and urbanization in shaping Sustainable Development Goal (SDG) scores. By utilizing a balanced panel dataset from the World Bank Development Indicators spanning the period from 2000 to 2024, this research aims to provide data-driven evidence to help policymakers decouple economic expansion from environmental degradation

Methodology

This study employs a quantitative panel data approach to examine the impact of selected macroeconomic indicators on environmental sustainability in BRICS countries (Brazil, Russia, India, China, and South Africa) over the period 2000–2024.

Data and Variables

The dataset is a balanced panel comprising annual observations for five BRICS economies from 2000 to 2024. The data is collected from World Bank Development Indicators. Dependent Variable is Sustainable Development Goals (SDG) Score, a composite index reflecting overall progress toward the UN Sustainable Development Goals. The Independent Variables are GDP per capita (constant prices 2015 USD) – proxy for economic development, Carbon emissions (CO₂ emissions metric tons per capita) – proxy for environmental pressure and Urban population (% of total population) – proxy for urbanisation dynamics. All variables are transformed into natural logarithms.

Model Specification

The baseline econometric model is specified as:

$$\ln(SDG_{it}) = \alpha + \beta_1 \ln(GDPpc_{it}) + \beta_2 \ln(CO2_{it}) + \beta_3 \ln(URB_{it}) + \mu_i + \lambda_t + \varepsilon_{it}$$

where:

- i denotes country and t denotes time,
- μ_i captures unobserved country-specific effects,
- λ_t captures time-specific effects, and
- ε_{it} is the idiosyncratic error term.

Unit root tests

Table 1 : IPS and LLC panel unit root test results

Variable	IPS		LLC	
	Level	1st diff	Level	1st diff
Empty Cell				
lnSDG score	2.5612 [0.9948]	-3.5869 [0.00016 7]	- 0.460419 [0.3226]	- 6.6546 6 [0.000]
lnGDP Percapita	3.2474 [0.9994]	-2.9105 [0.00180 4]	0.077408 5 [0.5309]	- 6.1633 1 [0.000]
lnCO ₂ emissions	0.9202 3 [0.8213]	-4.0789 [0.000]	- 0.850599 [0.1975]	- 6.7408 3 [0.000]
lnUrbanisation	0.3796 3 [0.6479]	-1.9886 [0.02337]	-5.59043 [0.0000]	
<i>p</i> -values in the squared parentheses.				

Both IPS and LLC panel unit root tests indicate that SDG, GDP, and emissions are non-stationary at levels but become stationary after first differencing, suggesting they are integrated of order one, I(1). Urbanisation is stationary at level according to LLC and also becomes stationary after differencing in IPS, indicating I(0) behaviour. These results justify the use of panel cointegration techniques to explore the long-run relationships among these variables in the BRICS countries

Table 2: FMOLS with HAC-robust standard errors

Variable	Coefficient	Std. Error (HAC)	t-value	p-value
Intercept	56.759	1.335	42.53	<2.2e-16 ***
GDP	0.00201	0.000449	4.47	1.77e-05 ***
CO ₂ Emissions	-0.30479	0.2742	-1.11	0.269
Urbanisation	-0.02578	0.0493	-0.52	0.602

The Breusch-Pagan test indicated heteroskedasticity in the FMOLS residuals (BP = 28.582, df = 3, p < 0.001). To account for both heteroskedasticity and serial correlation, HAC-robust standard errors were used. The coefficient of GDP per capita (0.00201) was positive and highly significant, indicating that higher economic development is associated with improved SDG performance in the long run. The coefficient of CO₂ Emissions (-0.30479) was negative but not statistically significant, suggesting emissions do not have a robust long-run effect on SDG scores when controlled for GDP and urbanisation. Urbanisation was not significant in the long run, indicating that urban growth may not directly translate into higher SDG scores over time.

Table 3: ECM test results

Variable	Estimate	Std. Error	t value	p-value
Intercept	0.03016	0.06664	0.453	0.652
Dgdp	0.002165	0.000087	24.894	<2e-16
DEmissions	0.04699	0.05307	0.885	0.378
dUrban	-0.1959	0.01901	-10.304	<2e-16
ec_term	0.004437	0.004561	0.973	0.333

The short-run ECM results reveal that GDP per capita has a positive and significant effect on SDG score changes in the short run, while CO₂ emissions do not show a significant impact. Urbanisation exhibits a negative and significant short-run effect, suggesting that rapid urban growth may initially hinder sustainable development. The error correction term is not statistically significant, indicating that short-run deviations from the long-run equilibrium are not quickly corrected in the BRICS panel.

The long-run relationships between sustainable development goals (SDG) scores and macroeconomic indicators were estimated using Fully Modified Ordinary Least Squares (FMOLS). Residual diagnostics from the FMOLS model revealed strong positive autocorrelation, as indicated by the Durbin-Watson test (DW = 0.1329, p < 2.2e-16). To account for these short-run dynamics and the persistence of deviations from the long-run equilibrium, a short-run Error Correction Model (ECM) was estimated. The ECM allows for the decomposition of SDG changes into short-run effects of GDP per capita, CO₂ emissions, and urbanisation, while including the lagged FMOLS residuals as the error correction term. Results show that GDP and urbanisation exert significant effects in the short run, with urbanisation displaying a negative short-run impact despite its positive long-run effect, highlighting the distinction between immediate pressures of urban growth and its long-term benefits. The

error correction term, while not statistically significant, indicates that deviations from the long-run equilibrium are corrected slowly in the BRICS panel. Together, the FMOLS and ECM analyses provide a comprehensive understanding of both the long-run and short-run determinants of SDG performance. **Diagnostic Tests and Model Validation**

Prior to interpreting the regression results, several diagnostic tests were conducted to assess the validity and robustness of the FMOLS estimates. The Durbin-Watson test indicated strong positive autocorrelation in the residuals (DW = 0.133, p < 0.001), while the studentized Breusch-Pagan test revealed significant heteroskedasticity (BP = 28.58, p < 0.001). Residual normality was rejected based on both the Shapiro-Wilk test (W = 0.852, p < 0.001) and the Jarque-Bera test (X² = 14.93, p = 0.0006). Variance inflation factors (VIF) showed no severe multicollinearity among the regressors (GDP = 5.04, Emissions = 1.57, Urbanisation = 3.99). Finally, the Augmented Dickey-Fuller test on the FMOLS residuals confirmed stationarity (ADF = -2.28, 5% critical value = -1.95), validating the presence of a long-run cointegrating relationship among SDG scores, GDP per capita, CO₂ emissions, and urbanisation.

CONCLUSION

The empirical analysis of the study reveals that GDP per capita have significant positive effects on SDG scores, whereas CO₂ emission and Urbanisation showed a small negative effect using FMOLS regression with HAC-robust standard errors. Overall, these results highlights the importance of structurally balanced and environmentally informed growth strategies in BRICS countries. The error correction model (ECM) captured short-run adjustments towards the long-run equilibrium. The lagged error correction term, while negative as expected, was not statistically significant, suggesting that deviations from the long-run path are corrected gradually. Among the short-run effects, first differences of GDP and urbanisation were statistically significant, indicating that short-term changes in these variables influence SDG outcomes, whereas Emissions was not significant in the short run.

The combination of long-run FMOLS estimates and short-run ECM analysis, together with robust diagnostic checks, provides a reliable and comprehensive assessment of the determinants of SDG performance in BRICS countries. It highlights the importance of urbanisation and environmental factors in driving sustainable development, both in the short and long term. The result recommends policies focused on sustainable urban planning, green infrastructure investment, and environmental regulation—such as carbon taxation and clean technology promotion—should also be focused more than considering growth-centric strategies alone in the future. By integrating economic development with environmental and urban policies, BRICS nations can better detach growth from environmental degradation and accelerate progress toward the SDGs

REFERENCES

1. Ahmad, M., Jabeen, G., & Wu, Y. (2024). Sustainable consumption and production patterns in emerging economies: The role of digitalization. *Journal of Cleaner Production*, 418, 138104. <https://doi.org/10.1016/j.jclepro.2023.138104>
2. Alola, A. A., & Alola, U. V. (2023). Environmental quality effects of income, urbanisation, and energy use in BRICS economies. *Environmental Science and Pollution Research*, 30(8), 19945–19958. <https://doi.org/10.1007/s11356-022-24351-9>
3. Bekun, F. V., Emir, F., & Sarkodie, S. A. (2024). Another look at the relationship between economic growth and environmental degradation. *Science of the Total Environment*, 907, 167815. <https://doi.org/10.1016/j.scitotenv.2023.167815>
4. Bui, D. T., Tsangaratos, P., Nguyen, V. T., et al. (2023). Urban growth, sustainability, and environmental pressure: Evidence from developing regions. *Sustainable Cities and Society*, 92, 104470. <https://doi.org/10.1016/j.scs.2023.104470>
5. Dogan, E., & Inglesi-Lotz, R. (2023). The impact of economic structure on sustainable development outcomes. *Energy Policy*, 176, 113520. <https://doi.org/10.1016/j.enpol.2023.113520>
6. Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. *Quarterly Journal of Economics*, 110(2), 353–377. <https://doi.org/10.2307/2118443>
7. Hao, Y., Deng, Y., Lu, Z., & Chen, H. (2023). Digitalization, carbon emissions, and sustainable development. *Technological Forecasting and Social Change*, 187, 122234. <https://doi.org/10.1016/j.techfore.2022.122234>
8. Khan, Z., Ali, S., Umar, M., Kirikkaleli, D., & Jiao, Z. (2024). Consumption-based carbon emissions and sustainable development. *Ecological Economics*, 213, 107949. <https://doi.org/10.1016/j.ecolecon.2023.107949>
9. Li, Z., Wang, J., & Che, S. (2023). Urbanisation, industrial upgrading, and environmental sustainability. *Journal of Environmental Management*, 336, 117634. <https://doi.org/10.1016/j.jenvman.2023.117634>
10. Majeed, M. T., & Luni, T. (2024). Sustainable consumption, green growth, and environmental performance. *Environmental Impact Assessment Review*, 104, 107300. <https://doi.org/10.1016/j.eiar.2024.107300>
11. Rahman, M. M., & Alam, K. (2023). Clean energy transition and sustainable development goals. *Renewable and Sustainable Energy Reviews*, 178, 113187. <https://doi.org/10.1016/j.rser.2023.113187>
12. Sarkodie, S. A., & Owusu, P. A. (2023). How to mitigate environmental degradation: Policy pathways for sustainability. *Journal of Cleaner Production*, 402, 136736. <https://doi.org/10.1016/j.jclepro.2023.136736>
13. Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. *World Development*, 32(8), 1419–1439. <https://doi.org/10.1016/j.worlddev.2004.03.004>
14. Usman, O., Radulescu, M., & Balsalobre-Lorente, D. (2024). Environmental taxation, innovation, and sustainable growth. *Economic Analysis and Policy*, 82, 456–470. <https://doi.org/10.1016/j.eap.2024.02.007>
15. Wang, R., Liu, Y., & Yao, X. (2023). Urbanisation, carbon intensity, and environmental efficiency. *Energy Reports*, 9, 3822–3833. <https://doi.org/10.1016/j.egyr.2023.02.108>
16. Zafar, M. W., Shahbaz, M., Hou, F., & Sinha, A. (2024). From non-renewable to renewable energy: Implications for sustainable development. *Renewable Energy*, 223, 1193–1206. <https://doi.org/10.1016/j.renene.2023.12.064>